Contributions to a neurophysiology of meaning: The interpretation of written messages could be an automatic stimulus-reaction mechanism before becoming conscious processing of information.

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Abstract

Background. Interpretation is the process through which humans attribute meanings to every input they grasp from their natural or social environment. Formulation and exchange of meanings through natural language are basic aspects of human behaviour and important neuroscience subjects; from long ago, they are the object of dedicated scientific research. Two main theoretical positions (cognitivism and embodied cognition) are at present confronting each other; however, available data is not conclusive and scientific knowledge of the interpretation process is still unsatisfactory. Our work proposes some contributions aimed to improve it.

Methodology. Our field research involved a random sample of 102 adults. We presented them a real world-like case of written communication using unabridged message texts. We collected data (written accounts by participants about their interpretations) in controlled conditions through a specially designed questionnaire (closed and opened answers). Finally, we carried out qualitative and quantitative analyses through some fundamental statistics.

Principal Findings. While readers are expected to concentrate on the text's content, they rather report focusing on the most varied and unpredictable components: certain physical features of the message (e.g. the message's period lengths) as well as meta-information like the position of a statement or even the lack of some content. Just about 12% of the participants' indications point directly at the text's content. Our data converge on the hypothesis that the components of a message work at first like physical stimuli, causing readers' automatic (body level) reactions independent of the conscious attribution of meaning. So, interpretation would be a (learned) stimulus-reaction mechanism, before switching to information processing, and the basis of meaning could be perceptual/analogical, before propositional/digital. We carried out a first check of our hypothesis: the employed case contained the emerging of a conflict and two versions ("H" and "S", same content, different forms) of a reply to be sent at a crucial point. We collected the participants' (independent) interpretations of the two versions; then, we asked them to choose which one could solve the conflict; finally, we assessed the coherence between interpretations and choice on a 4-level scale. The analysis of the coherence levels' distribution returned that, with regards to our expectations, incoherence

levels are over-represented; such imbalance is totally ascribable to “H” choosers. “H” and “S” choosers show significant differences ($p << 0.01$) in the distributions of coherence levels, what is inconsistent with the traditional hypothesis of a linear information processing resulting in the final choice. In the end, with respect to the currently opposing theories, we found out that our hypothesis has either important convergences or at least one critical divergence, joined with the capacity to encompass they both.

Abstract

Background. Even though the interpretation of natural language messages is generally conceived as a conscious processing of the message content, the influence of unconscious factors is also well known. What is still insufficiently known is the way such factors work. We have tackled interpretation assuming that it is a process, whose basic features are the same for the whole humankind, and employing a naturalistic approach (careful observation of the phenomenon in conditions the closest to “natural” ones, -and precise description before and independently of data statistical analysis).

Methodology. Our field research involved a random sample of 102 adults. We presented them with a complete real world-like case of written communication using unabridged message texts. We collected data (participants' written reports on their interpretations) in controlled conditions through a specially designed questionnaire (closed and opened answers), then treated it through qualitative and quantitative methods.

Principal Findings. We have proposed a hypothesis, upheld by field observations and some experimental results, about where and how unconscious factors could act. Where: in the three-step process we propose, the second step (we named it "disassembling") presents special features indicating the possible action of unconscious factors. How: disassembling appears to be an automatic reaction to the words/expressions of the read message; thus, words and expressions would also function like physical stimuli, rather than like symbols only. Such hypothesis, once confirmed, could help explaining some links between the cultural (human communication) and the biological dimension (stimulus-reaction mechanisms as the basis for meanings) of humans.

Introduction

Human-environment interactions have something special, with regards to the other animals' interactions: human behaviour is not restricted to appropriate reactions; it encompasses also entail conscious knowledge, which entails i.e. the attribution of meanings (semantic aspect) to the incoming signals and stimuli. The other animals can perform sophisticated reactions to the environmental inputs; however, it seems they do not "understand" them (Gruber et al., 2015), even though they certainly can socially exchange some learnings through imitation (about this, a classic study in Mainardi, 1988, and some recent examples of reserach researches ~~in~~ by Baciadonna, McElligott & Briefer, 2013; Carter et al., 2014; Suchak et al., 2014).

Interpretation, namely the operation through which the meaning is attributed, is a still widely unknown process. A specific difficulty is represented by natural language, i.e. the main instrument through which human species (the only one endowed with such capability in Nature) formulates and exchanges meanings and consciously understands things. Natural language and its use which has been studied almost since the dawn of humankind with researches ranging from the ancient rhetoric (for example, Geymonat, 1970; Barthes, 1970; Perelman, 1977) to the most recent approaches integrating complementing linguistics with biology and neuroscience (for example Zuberbühler, 2005; Locke, 2009; Stekelenburg & Vroomen, 2012). Nevertheless, none of the hypotheses proposed up until the present times can be considered capable to exhaustively solve the problem of interpretation (some general reflections on this subject's such complexity in Deacon, 2012). Even though natural language has been traditionally

approached under its profile of symbol-based consciously processed system, t~~T~~he way it natural language works cannot be reduced to a simple coding-decoding procedure. By On the one hand, a one-to-one correspondence among written signs (or spoken sounds) and words does exist; by on the other hand, no such correspondence can be found between any word/expression and the meaning attributed to it. This led a famous Italian linguist to label natural language as structurally "equivocal" (De Mauro, 2003)[1]. Messages are (or, at least, they appear) made up just of words; however, understanding a message always goes far beyond the message's its words[2]. The available data does not give definite answers to the researchers' questions; in fact, interpreting the interpretation process is a challenge that modern science has not yet won. O our field research intends to bring some contributions to such endeavour.

Research lines and ideas: a synthetic overview. The available scientific literature is so wide to make it impossible prevent, inside the boundaries of our work, an exhaustive analysis. However, a rapid survey is sufficient to reveal some trends, the first of which is the accelerating extension of these studies from the pure humanistic disciplines to science field towards the field of science. Even a "hard" natural science like physics has generated (from since XIXth Century) a "psychophysics" branch, originally aimed to scientifically study the relationship between perceptions and

[1] De Mauro, 2003 states that natural language is "equivocal" in etymological sense: from Latin *aeque vocare* (to name [different things] in the same way). That means: a same word can be used to refer to different meanings and different words can be used to indicate the same meaning.

[2] Material regarding the attempts to explain human communication and the questions of meaning and interpretation is really countless. Specific works will be indicated within the manuscript. Taking linguistics apart, we make reference to Pettigiani & Sica, 2003 for a review (in Italian) of psychological main approaches; Krauss & Fussell, 1996 for a wide survey from the perspective of social psychology.

sensations, recently extended to the direct investigation of knowledge processes (see ahead). Another trend, thanks to the extraordinary development of technology and informatics, is the enhancement of the studies that explore interpretation inside the neural processes of the brain cortex: the neuron-level research and the wide use of advanced imaging techniques bear witness for this.

All this considered, we can roughly outline a picture with two main scientific research lines, the first of which can be named **Mind-centred approaches** and can be synthesized as follows. Understanding/interpretation is ~~totally~~ based on abstract (conceptual) knowledge. Information feeds are Incoming information is provided through the body (perception) but is the "mind"[3] that processes stimuli and incoming signals inputs at symbolic level, transforming turning them in into propositional representations in the brain ~~cortex~~ and understanding them in terms of concepts. The answer to the inputs (reaction) is based on such comprehension and is shaped as a command to some effectors (typically the motor system). Knowledge is the result of a sort of computation; the mind is separated from the body and rules it. The role of the motor system is totally passive.

The second research line can be named **Body-centred approaches** and can be synthesized as follows. Understanding/interpretation is attained through a motor reaction of the body that can instantiates understanding or, at maximum at least, co-exists with conceptual knowledge. When an external stimulus/signal is perceived, it is firstly

[3] We will not enter the disputed question of mind, its existence, its nature and its relationships with the body in general and the brain in particular. For a first level of delving further into the this subject: by on the one hand, the early survey of Sperry, 1952; by on the other hand, the more recent works of Marcus, 2004; Rose, 2005; Zeki, 2010. In the context of this our Introduction, the "mind" is simply intended as a factor which, by following some theoretical positions, totally controls body through different functions with respect to functions that differ from biological processes.

"understood" through a motor reaction which is automatic, involuntary and based on "mental maps" that are motorial, not (or not only) propositional. Understanding is a sort of motor experience that goes along with conscious (rational) information processing; the body is not detachable from the mind and can drive it. The role of the motor system is active and decisive for understanding.

The main features of the first group's theories are synthesized in some recent works like, for example, Zipoli Caiani, 2013 (Chapters 1 and 2); Ferrari & Rizzolatti, 2014 (specially Pag. 2); Gallese, 2014 (specially Pag. 2, with the concept of ontological reductionism); Pulvermüller et al., 2014 (specially Introduction and Fig. 1)[4]. In addition to this, a browsing of the literature unveils a wide series of theories that, even if they differ in many details albeit different, consider the mind (see Footnote 3) through the metaphor of the computer, or even of simpler mechanisms. The range goes from the merely mechanical (and naïve) theories of psychoneural isomorphism (Sperry, 1952, pp. 293-294) and those inspired by the first electronic computers (Newell, Shaw & Simon, 1958), to the various I.P. (information processing) models (Massaro & Cowan, 1993) and current cognitive science positions (Negri et al., 2007; Mahon & Caramazza, 2008; Mahon & Caramazza, 2009). The shared concept is that information is essentially processed in a linear and unidirectional sequence, based upon a functional (besides the anatomical) separation among sensory, associative and motor areas of the brain cortex (for a general presentation and discussion see also Rizzolatti & Sinigaglia, 2006, Chapter

[4] The last three works (Ferrari & Rizzolatti, 2014; Gallese, 2014; Pulvermüller et al., 2014) are ascribable to the theories of the second group; nonetheless, they are cited also here because contain particularly clear synthesis of the opposite field positions. Ahead in the text we will describe a mirror-case (Hickok, 2009).

1, specially pages 20-22; for a synthesis of the cognitivism cognitivist paradigm see Gallese, 2000, page 27). The motor system is conceived as a merely operative instrument, totally dependent on the output from associative areas. For precision's sake, we must add that our description is a simplification: there are theories and ongoing research lines that can be included in this first group while they, nonetheless, take motor processes into a special account. For example, the current formulations of Common Coding principle (Prinz, 1997; Hommel et al., 2001) and Ideomotor principle (Pezzulo et al., 2006; Sauser & Billard, 2006; Melcher et al., 2008).

The second group of theories (the body-centred ones) can be traced back, at least, to XIXth Century, up to the works of Lotze, 1852 (cited in Rizzolatti & Sinigaglia, 2006) and James, 1890, which present reflections on the relationships between perception and action. Other philosophers followed came after[5], up until a new series of neurophysiological studies appeared in the second part of XXth Century[6]. Such researches gathered evidence that the sequential processing theory and the supposed totally passive role of motor system's passive role are untenable. In addition, a leap ahead has probably been accomplished with the discovery of mirror neurons (di Pellegrino et

[5] Some special mentions about the philosophers: Mach, 1897, in particular pages 1-8 (on the relationship between scientific knowledge and perceptual experience of physic world), pages 15-17 (a famous example on subjectivity of perspective) and pages 93-95 (sense organs as active elements of perception, fine-tuned through experience, rather than as passive receptors); Poincaré, 1902 [2003], especially Chapter 4 (on the relations between geometrical space and "representative", i.e. perceptual, space); Poincaré, 1908 [1997], Part I, specially pages 52-63 (phenomenology of a mathematical discovery and the role of sensitivity and aesthetic feeling); Merleau-Ponty, 1965, particularly Part II (with special regards to introduction chapter, on the impossibility to have a knowledge of the environment that is independent of the body experience).

[6] Some special mentions about the neurophysiological studies: Sperry, 1952, especially pages 299-300 about on the relationships between perceptions and ideas; Jeannerod et al., 1995; Liberman & Wahlen, 2000; Fowler, Galantucci & Saltzman, 2003.

al., 1992) and the related following studies on them (for example Gallese, 2000; Rizzolatti & Craighero, 2004; Iacoboni et al., 2005; Rizzolatti & Sinigaglia, 2006). According to this theory, understanding (at least, understanding of motor acts) would be firstly attained through a motor reaction of the body, "immediately and automatically"[7]. Cognition would be "embodied".

Embodiment of cognition, and its consequences on knowledge and interpretation process, are the object of a heated scientific dispute lively scientific debate . Some parts of our work will touch such question; then, it is worth referring to an example, in order to clarify out the different positions. In a review that critically examines the mirror neuron-based approach to cognition well exemplified in Hickok, 2009 the author proposes an example, aimed to dispute the embodied cognition hypothesis (direct reference to Rizzolatti, 2001). He invites to Imagine someone pouring a liquid from a bottle into a glass: Then, he continues arguing that, by following that the embodied cognition hypothesis, an observer can "embodily" understand such action since, thanks to his mirror neurons, he undergoes a motor reaction "as if" himself was actually pouring (by the way, such reaction does not turn into any actual movement, it remains virtual). This said, the author replies However, that pouring "could be understood as *pouring*, *filling*, *emptying*, *tipping*, *rotating*, *inverting*, *spilling* (if the liquid missed its mark) or *defying/ignoring/rebelling* (if the pourer was instructed not to pour)…" (see Hickok, 2009, page 1240, italic by the author). Such example, in our opinion, well represents the crucial point: the scientifically evident automatic reaction that instantiates embodied

[7] We are intentionally employing the words "immediately and automatically": they are typically used in describing the mirror-systems' working.

cognition does not explain the whole process of interpretation, and the attribution of a conceptual meaning seems to have a different nature. Thus, we have either scientific evidence of embodied cognition or daily-life experience of scattered conceptual interpretations; can these two visions be conciliated or are they alternative? And which one can actually account for the field observations?

The contrast between these two positions has not yet been solved even though, with respect to its beginning, the debate has grown up far further. In particular In the few last years, the hypotheses based on the mirror neurons discovery have been refined, for example through the concepts of Mirroring mechanisms (MM) and Embodied simulation (ES) (Gallese, 2005, 2006, 2007, 2008, 2009a; Gallese et al., 2009; Gallese & Sinigaglia, 2011a; Ferri, Gallese & Costantini, 2011; Marino et al., 2011; Gallese & Sinigaglia, 2012; Ferrari & Rizzolatti, 2014; Gallese, 2014). About this the ongoing dispute, a summary and a state-of-the-art outline can be found in Zipoli Caiani, 2013 ; apart from this, and one of the most interesting documents is a forum (Gallese et al., 2011) inside which the most delicate and controversial questions are widely debated. The main ones, with regards to the subject of our work, are the following four: goal-dependency of mirror reactions, with references provided by upholders (Umiltà et al., 2008; Cattaneo et al., 2009; Rochat et al., 2010) and detractors (Range, Viranyi & Huber, 2007; Hickok, 2009; Hickok & Hauser, 2010; Muller & Cant, 2010); the nature of motor representations in the brain cortex and the hypothesis that action understanding obtained through mirror neurons would be a form of knowledge qualitatively different from the propositional and abstract ones (widely discussed in Gallese et al., 2011); the interpretation of the human

ability to understand actions that cannot be performed, like the barking of a dog (Rizzolatti & Sinigaglia, 2006; Hickok, 2009; Rizzolatti & Sinigaglia, 2010); the interpretation of neuropsychological evidence about the relationship among motor impairments and action recognition underperformances (with works that uphold one position, for example Moro et al., 2008; Pazzaglia et al., 2008, or the other, for example Negri et al., 2007; Hickok, 2009).

Experimental research involving language. Such kind of research is closer to our work, which employed written messages; thus, it is worth (rapidly) delving further into some of its main aspects. Theoretically, the divergence between cognitivist and embodied cognition approaches can be synthesized as follows (for further reference see, for example, Bedny et al., 2008; Rizzolatti & Fabbri-Destro, 2008; Goldman & de Vignemont, 2009; Gallese, 2011; Gallese & Sinigaglia, 2011b; Bedny et al., 2012): cognitivism upholds the sequential processing idea, i.e. cognition would be the result of perception (the sound of a spoken message as well as the sight of written words) followed by the symbolic processing of what perceived (turning the spoken or written words into their meanings) followed by a reaction (typically, but not exclusively, a motor one). Oppositely, the embodiment theories uphold the concept of direct connections among cortical sensorial and motor areas ("sensorimotor grounding" of cognition, Guan et al., 2013). Namely, the perceived spoken or written words would trigger a motor

reaction and would be mentally represented also in a motor, rather than a purely conceptual, way. In this sense, cognition would be embodied[8].

From a technical slant, the two research lines tend to privilege different laboratory approaches: cognitivist field frequently engages the noun-verbs dissociation problem, studying it through researches on cortically damaged, selectively impaired patients; such studies are mainly aimed to define the nature of concept representations in the brain cortex (lexical or semantic, lexico-semantic dissociation issue), and to cortically map them (for example Crepaldi et al., 2006; Arévalo et al., 2007; Moseley & Pulvermüller, 2014; Gallese, 2014). One specific question addressed by some researches is "how does the brain code and generate semantic cognition?" (for example Patterson, Nestor & Rogers, 2007; Pobric, Jefferies & Lambon Ralph, 2010; Hoffman & Lambon Ralph, 2011); the answer proposed by the cited works is the "hub-and-spoke" model, with a special role played by the ATL, Anterior Temporal Lobe.

Conversely, the embodied cognition theorists mainly go searching for the connections between language and its motor correlates, one well-known of which is the ACE (Action-sentence Compatibility Effect), often checked through measuring and comparing the reaction times collected during language-and-action combined match-advantage experiments (see for example Vitevitch et al. 2013; Horchak et al., 2014). Such studies are frequently carried out through neuroimaging works (for example

[8] Such embodiment, inside the same embodied cognition field, can be conceived in different ways: it can stand alone, *per se* resolving the problem of knowledge ("sensorimotor processing underlies and constitutes cognition", Guan et al., 2013), or can be a "motor representation" that accompanies conscious knowledge processes (the two kinds of knowledge proposed by Gallese, for example in Gallese et al., 2011; see also Gallese, 2014).

Tettamanti et al., 2005; Aziz-Zadeh et al., 2006; Speer et al., 2008; Aziz-Zadeh & Damasio, 2008).

It is interesting to note that, beyond their important differences, cognitivism and embodiment research share at least one common aspect: they both use, in laboratory experiments, words and short phrases isolated from every contexts (see, for example, Bedny et al., 2008; Bedny et al., 2012, especially the Method sections; for some critical reflections about the question, Pulvermüller et al, 2014, specifically Pag. 80, Chapter 7). We guess there is a possible implicit concept upholding such approach: the idea that the meaning is an intrinsic feature of words, something embedded inside them, and that interpretation consists in extracting it (actually, the verb "to extract" is overtly used in scientific publications, for instance Mahon & Caramazza, 2011).

On About some recent trends. In the end, it is worth dedicating a mention to mentioning a recent specialised research field of inside psychophysics, in which researchers investigate cognition and semiosis through probabilistic models (Chater, Tenenbaum & Yuille, 2006; Ingram et al., 2008; Tenenbaum et al., 2011), in particular applying the Bayesian inference to reproduce mental processes and describe it through algorithms (Griffiths, Kemp & Tenenbaum, 2008; Bobrowsky, Meir & Eldar, 2009; Perfors et al., 2011; Fox & Stafford, 2012). Such concepts are currently in use also in the Artificial Intelligence (AI) field[9]. Inside such research field, A specific peculiar sector

[9] The origins of Artificial Intelligence (AI) studies can be traced back to the Thirties and the works of Alan Turing on a possible "intelligent machine". About the origins, see Leavitt, 2007, chapters 6 and 7, and Turing, 1950 (the original work of Alan Turing). About the "Turing test" (testing the ability of distinguishing humans from computers through exchanging written messages exchanges) see a journalist's account in Christian, 2012. Some materials about recent research threads lines, closer to

concentrates on what follows interpretation, that is confrontation among different "apprehensions" (conscious perceptions); the result of such confrontation is a "judgement", i.e. decision and conceptualization (Arecchi, 2010a; 2010b; 2010c; 2011a). New concepts are introduced to investigate semiosis: semantic and non-semantic complexity (Arecchi, 2008), deterministic chaos (Guastello, 2002; Arecchi, 2011b), inverse Bayesian inference (Arecchi, 2010d), creativity as NON-bayesian process (Arecchi, 2010e), quantum dynamics (Arecchi & Kurths, 2009; Nathan et al., 2012) and the reference to Gödel's incompleteness theorem as a limit to the possibility of understanding cognition "from inside" (since given that, while studying cognition, we become a system that investigates itself)[10].

Method

Methodological aspects. All this matter has not yet been adequately cleared; one reason There are two main reasons why the question of interpretation and meaning has not yet scientifically solved, the first of which is that there are still structural obstacles of technical and ethical nature[11]. Another difficulty The second main reason is the

our article's topics (like machine learning and natural language or image interpretation), can be found in Mitchell, 1997; Menchetti et al., 2005; Mitchell, 2009; Khosravi & Bina, 2010; Verbeke et al., 2012.

[10] See Goldstein, 2006 for a popular-scientific coverage about Gödel and his theorem; Leavitt, 2007, chapters 2 and 3, for a particularly clear synthesis of the theorem and its genesis (in connection with the *Entscheidungsproblem*, i.e. the "decision problem").

[11] About the technical difficulties of data collecting: experimental techniques used on macaque monkeys (electrodes direct insertion inside single neurons) return very accurate measuring measurements, but on small brain cortex surfaces. About the ethic difficulties: these those techniques are almost impossible to be used on humans, and only indirect techniques as fMRI (functional Magnetic Resonance Imaging), MEG (Magnetoencephalography), PET (Positron Emission Tomography) or TMS (Transcranial Magnetic Stimulation) are systematically employed. They cover wider brain cortex surfaces but with inferior accuracy; moreover, they present difficulties with regards to instrument positioning and image interpreting. For a survey of these difficulties see

complexity of natural language (its "equivocal" nature, see De Mauro, 2003 and Footnote 1), usually overcome through a laboratory approach, i.e. studying interpretation isolated from the interpreting organism and employing simple stimuli (single words, simple and very short phrases; for instance Bedny & Caramazza, 2011). Such approach entails limitations (underlined, for example, in Pulvermüller et al., 2014, specifically Pag. 80, Chapter 7) that might undermine the research conclusions. In short: a message is not just a bunch of words, and the question of interpreting a message cannot be considered as satisfactorily cleared through adding up the interpretations of isolated words. On the contrary, studying interpretation in the actual conditions it is usually performed (interpretation of *messages*) could bring something new to our knowledge. The methodological aspect is crucial, and we delved a little further into it. Some of the mirror neurons discoverers and theorists have expressly tackled such aspect and highlighted that one strong point of the neurophysiological research that led to such discovery is the researchers' preference for a naturalistic-like approach: they let

In field experiments, researchers who capitalise on the existence of mirror neurons intentionally favour a ~~On field, the mirror neurons discoverers intentionally privileged a~~ naturalistic-like approach, letting the observed macaque monkeys freely interact with available objects, rather than stimulate them with selected artificial stimuli only (Rizzolatti & Sinigaglia, 2006, p. 3; in addition, about the reductionism question and the distinction between methodological and ontological reductionism, see Gallese,

Rizzolatti & Sinigaglia, 2006, chapters 2, 6, 7, and Rizzolatti & Vozza, 2008, *passim*. A recent thread line of research is investigating the connections among single neurons activity and the total effects detectable through indirect techniques (see Iacoboni, 2008, chapter 7). In addition to all this, data interpretation and comparing are intrinsically difficult, given the differences in macaque and human brain cortex and the associated problem to check of identifying reliable correspondences.

2000, p. 26, and Gallese, 2009b; Gallese, 2010). Opposite to these stances, However, their approach has been also criticized (Pascolo & Budai, 2013). which disputes the monkeys' actual freedom in the experiments and the same existence of mirror neurons in humans. From our point of view About the naturalistic-like approach, we had in our background two works about on interactions inside online collaborative groups (Maffei, 2006; Maffei, Cavari & Ranieri, 2007) which let us appreciate the potential of scientific observation in real world-like conditions on real-world communication cases.

Method

We set two objectives for our research: (1) To understand the process of interpretation (i.e. how messages in natural language are turned into meanings by receivers) as it works in real conditions, and design a structural model in order to adequately represent it; (2) To produce a first check of the formulated hypothesis. Consequently, we have divided our research into two parts: the first one is referred to Messages #1, #2 and #3 of the case and to Questions #1 and #2 of the questionnaire; it is mainly (even though not only) qualitative, investigates the process of taking into account a message and turns into a hypothesis (a model of the interpretation process). The second part is referred to Messages #4/H, #4/S and #5 of the case and to Questions #3, #4 and Final of the questionnaire; it is quantitative, focused on a decision to be taken about a reply to send, and represents a first check about our hypothesis. See SI Section 4 for the messages' and the questions' texts. In order to achieve these objectives, we have tried a naturalistic approach; designing observations in conditions the closest as possible to the

natural ones this means, first, that a phenomenon must be carefully observed and precisely described in conditions the closest to “natural” ones (natural conditions = the way and the contexts in which the phenomenon usually manifests). Second, it means that observation and description must precede analysis, being carried out independently of it. In such approach, the role of the observers is critical, either if they are involved in or external to the phenomenon. In our research, we have employed 102 observers of the first kind (the sample) and 5 (the authors) of the second one; this way, we have collected 102 self-reports (participants' answers to a specially designed questionnaire) and worked out one analytical report (our research) about interpretation. On these bases, we designed field research on a We ~~have~~ challenged our randomly selected sample of 102 adults ~~sample random~~ challenging them with a real world-like written communication case, using complete and unabridged message texts and collecting the participants' interpretations. through a specially designed questionnaire. Further details about method in the Supporting Information, Section 0; a full documentation of the survey process, containing research guide-lines, case description and research protocol, as well as the questionnaire, in the Supporting Information (SI) Sections 1, 2, 3, 4 and Section 5 with Tables S1, S2. In addition: a description of the sample, and of the sub-samples drawn from it for control purposes, in SI Section 6 with Tables S3-S5; some quantitative aspects of collected data in SI Section 7; quality check of the collected data, their compliance with the research necessities and their suitability in SI Sections 8 and 9 with Tables S6, S7 and Fig. S1-S3.

It is worth specifying that the study of meaning and interpretation at behavioural as well as neuronal level implies the use of indirect techniques: the meaning is not something that can be directly measured and interpretation is a process that occurs inside the brain and/or the body in ways that cannot be directly observed; for this, just indirect approaches are available. Our research represents no exception; our indirect approach has been based on the participants' accounts for their own interpretations immediately after they had read the submitted messages. Naturally, such conscious accounts cannot be considered an exact report of the actual interpretation process, given the possibility that they are unconsciously biased. Indeed, by one hand, we have employed these data to investigate correlated but different aspects; by the other hand, we have checked them with other data and analyses in order to verify their real contribute to the research's goals.

Our work is not a clinical trial and no experimentations on the participants took place. Our sample was not recruited in hospitals or any other institution; we gathered it through the conductors' personal relationship network (details on sampling and survey modalities in SI Section 3, particularly points 10.-13.). In addition, no personal data was collected or anyhow involved in the survey, and verbal informed consent was requested and obtained by participants on the basis of a written presentation of the survey and its modalities. Through our questionnaire, we just collected, in a strictly anonymous way (details here below and in SI Section 3), the participants' opinions about an exchange of written messages, in order to investigate the process of message interpretation. The submitted case was a fiction closely resembling some real cases the authors had dealt with in their professional activities; its contents were totally neutral with regards to the

participants' lives and environments and did not touch any sensitive subject. For these reasons, our research did not involve any critical issue related to ethics[12]; we anyway requested, and obtained, the approval of The Ethics Committee for Scientific Research of the Association ARPA-Firenze gave its approval either to the research design or to the informed consent procedure. Further details related to method, sampling and ethical aspects can be found in the Supporting Information (SI, from now on), Sections 0, 1 and 3. The Committee held a dedicated session to our research (in 2012, april 2[d]) and its approval was given through a formal decision documented by the session's official report, signed by all the Committee's members and filed in the Association's archives.

About the **informed consent** of participants, it was necessary not only for ethical, but also for technical reasons: since the answers to the questionnaire's questions were handwritten by participants (directly on the submitted forms), the research should have been impossible without a conscious, voluntary participation to the survey. Participants (all of them were adult) received written information about the research through the title-page of the questionnaire (SI Section 4), being invited by the conductors to carefully read it. After such reading, their consent was requested and obtained verbally. The reasons why we did not collect written consent lie on the sampling and data collection procedure, designed to fully guarantee the participants' anonymity (see also the research protocol in

[12] An authoritative confirmation comes from the Cornell University (2013) "IRB Decision Tree" (https://www.irb.cornell.edu/documents/IRB%20Decision%20Tree.pdf) which reports (top right area of the first page) the following example of research that does NOT require an IRB approval: "*The focus of the project is only on products, methods, policies, procedures, organizations: e.g., interviewing transportation staff and officials about parking or transportation policies and procedures*". Our research exactly matches such example: we have not studied the sample's members personal characteristics; rather, we have collected their opinions about some specific (totally neutral) objects (the messages presented in the research's questionnaire) through gathering the answers they provided, willingly and anonymously, to the questionnaire.

SI, Section 3). By one hand, the technical features of data collection and the personal relations among participants and conductors prevented any possibility of unwilling contribution. By the other hand, a written consent would have implied a general database, whose creation and management would have increased the risks of an accidental information diffusion. Instead, our procedures made it impossible for everyone, all along the research work (and the same is at present and will be in the future), either to trace back participants by starting from the filled questionnaires or to recreate the participants' database. Along with its approval of the research guide-lines, the Ethics Committee for Scientific Research of the Association ARPA-Firenze approved also this informed consent procedure.

Materials and procedure/1: the sample. Our research plan has been based on two main assumptions: first, that interpretation is a process, rather than a single operation; second, the process has the same basic (structural) universal characteristics ~~for the whole humankind~~. The rationale of our sampling was based on such assumptions: according to our objectives, we focused on the reconstruction and understanding of the process, rather than on sample features. Thus, the sample representativeness (for example with respect to Italian people), as well as its social feature balance, were less critical; from an extreme point of view, it could be sufficient that the sample members would belong to human species. Operatively, we gathered our random sample through selecting only Italian language native speakers, all adult, striving to reach a reasonable balance about gender and student/worker conditions. Further details (the procedure we used to randomize the sample included) can be found in SI, Section 6; the results are presented in Tables 1-3.

The total sample (Table 1) results slightly imbalanced with regards to gender (women exceed men), education (Graduates/Post-graduates exceed High-school degree granted members) and employment (students/unemployed exceed employed members). For these reasons, even though social features balance is less relevant in our work, we have selected more homogeneous sub-samples from the total sample, in order to verify our analyses every time it turned out necessary. The first sub-sample ("AGE", Table 2) is exclusively composed by people over 29 years-old (60 members); the second one ("EMPLOYMENT", Table 3) is exclusively composed by employed people (65 members).

Materials and procedure/2: the case. The main operative instruments through which we have implemented our naturalistic-like approach (further details in SI, Section 0) are the case and the questionnaire. The case we submitted to the sample (it is fully detailed and documented in SI, Sections 2, 4 and 5) is a fictional piece very close to a real cases the authors had professionally dealt with (the messages are drawn from actual messages and the outlined relationship between the characters has been actually observed). Exactly, this case is an online (via e-mail) interaction between two colleagues (no previous relations between them) having different roles and ranks in the same organization; the two characters are a female employee (XX) and a male professional (the "architect" YY, Project Account for the installation of a heating plant in XX's office). Their interaction consists (from its start to its end) in exchanging 5 e-mails, 3 of which (Messages #1, #3 and #5) are sent by XX, which starts and ends the interaction, and 2 (Messages #2 and #4) by YY. Such exchange (whose subject is the work-in-

progress of a heating plant) can be divided into two phases, during the first of which (Messages #1, #2 and #3) a conflict emerges that will be solved through a special version of the fourth message (sent by YY); the solution of the conflict is confirmed by the last (fifth) message, in which XX declares her satisfaction. A synthesis of the first three messages is the following (further details and a full documentation can be found in SI, Section 4):

Msg #1 (XX to YY) – *A 67 word e-mail to the Project Account about the installation of the heating plant in her office. She requires an inspection, claiming about "flaws" in the present state of the works. Flaws are no better detailed. She declares she is also speaking on behalf of some colleagues and uses the expression: "we would be pleased if, at least once, someone of our Corporation could come here and control…".*

Msg #2 (YY to XX) – *A brief (48 words) answer of the Project Account in which the regularity of the Project progress is declared. The message ends with the phrase: "at the moment, the progress substantially complies with the chronogram".*

Msg #3 (XX to YY) – *A 136 words reply in which XX declares herself totally unsatisfied. Her message presents two main features: (i) some minor flaws are listed; (ii) she expresses what resembles an actual threat against YY, in the case he would not take measures (she specifically refers to a hypothetical "waste of public money", given that the Project funding involved public resources).*

Now the conflict is on and the second phase starts: YY prepares a reply to XX's Msg #3 (namely, he prepares the first version, the "H" one, of Msg #4). The label "H"

has been used because such version is a “hard” reply; a YY's colleague suggests him a softer version (the “S” one) in order to avoid exacerbating the conflict. YY accepts the advice, he sends Msg #4/S to XX and the case ends with the conflict resolution (XX's satisfaction declared in Msg #5). Full-text versions of Messages #4/H, #4/S and #5 are displayed in Table 4; see also SI, Section 5 and Tables S1, S2, for details about the rationale of the two alternative messages.

Materials and procedure/3: the questionnaire and the survey. The questionnaire has been the instrument through which we have challenged the sample with the case; it is fully documented in SI, Section 4. The survey has been divided into two phases, following the interaction structure; in the first phase (Questions #1 and #2), we asked the participants to interpret the first three messages and to indicate which “concrete elements” of those messages their interpretations had been based on. In the second phase, we submitted them (separately, see SI, Section 3, for details about submission modalities, counterbalancing of “H” and “S” message submitting included) the two versions of Msg #4 and asked them (Questions #3 and #4) to give their separate interpretations. Finally, after submitting Msg #5 (that ends the interaction), we asked them (Final Question) to indicate which of the two versions (the original “H” or the colleague's suggestion “S”), in their opinion, had been actually sent in order to elicit the final answer.

The data collection rationale. Our peculiar management of the survey and, specifically, of the participants/survey conductors relationship (SI, Section 0, for details) allow us to exclude that participants' answers are intentionally distorted or insincere. Given this, what data did we exactly collect in our survey? In the first phase (Questions

#1 and #2) we collected the participants' conscious reports on their interpretations. Naturally, the reports we gathered cannot be considered as reliable descriptions of the "true" interpretation process; rather, they are descriptions of the participants' subjective (conscious) experiences about interpretation. We thought that, even though the link among these conscious accounts and the true process is unknown, the answers could allow us to observe, in a naturalistic-like way, the behaviours associated to the interpretation process. On this basis, we could probably detect enough clues in order to formulate a hypothesis on the deeper "true" process of message interpreting. In other words: we tried an indirect approach given that the interpretation process cannot be directly observed.

In the second phase (Questions #3, #4 and Final Question), we investigated the relationship between the interpretation of a situation and a consequent decision to be made; such decision was the selection, between the original and the suggested version of Msg #4 ("H" and "S" versions, from now on), of the one capable to solve the case (i.e. to elicit the final Message #5). Our thought was that the consistency between interpretation and the following decision could give us either further clues for a deeper understanding of the interpretation process or elements for checking our hypothesis.

Results from the first part of the research: observing and hypothesizing

The first level of our analysis regarded our research's first part and yielded something expected and something unexpected. We remind recall that each questionnaire's question submitted to the sample sent two inputs to the respondents: at

first, they participants were requested to freely interpret some aspects of the submitted messages; then, they were requested to account for their own interpretations through indicating the "concrete elements" on which these were founded. We will describe separately our analyses related to the first and the second kind of data.

Data related to the first input provided, through a qualitative analysis, the main expected outcome: the scatter of the participants' interpretations. Data from the second input provided, through a quali-quantitative analysis, the main unexpected outcome: the possibility of an intermediate, unpredicted step following text decoding and preceding text content processing.

Analysis of the answers to the questions' first input: qualitative analysis. These answers have fully confirmed the our predictions~~an expected feature~~: demonstrating a wide range of differences/'scatter' in ~~scatter of the~~ respondents' interpretations. About interpretation scatter, we have quoted an example (taken from Hickok, 2009) in our Introduction. In addition, some descriptions, referred to special cases and entailing divergence of interpretations, can be found in Bara & Tirassa, 1999; Sclavi, 2003; Campos, 2007[13]. Inside our research, the answers to Question #2 provide us a specific example. Firstly, we asked participants if, through comparing Message #3 to with Message #1, they found the attitude of XX (the sender) towards YY (the receiver) being changed (SI Section 4 for the messages' and questions' texts Method Section and SI, Section 4 for the texts of the messages; SI, Section 4 for the question full-texts). Then, to

[13] Specifically Exactly: Bara & Tirassa, 1999, pp. 4-6 (communicative meanings as joined constructions); Sclavi, 2003, pp. 93-98 (the "cumulex" play); Campos, 2007, pp. 390-394 (analysis of a real historical communication event case).

519 the 61 who answered "YES" (60% of the sample), we asked to specify how they would
520 define the new XX's attitude. They provided 83 specifications: 64 stated XX's position
521 as strengthened, 12 as weakened and 7 unchanged (although these seven, too, had
522 answered "YES" to the first part of Question #2). In addition, we can find completely
523 opposing statements in these specifications and we can see that scattering covers very
524 different aspects of the XX-YY interaction (behaviours, emotions and so on, Table 5).

525 Such a phenomenon is well known and can be observed for all the messages and
526 for any part of them, even if accurately selected: it is impossible to find parts of a
527 message that are interpreted in the same way by all the participants. The observed
528 interpretation scatter can be represented through a "megaphone-shape" picture (Fig. 1):
529 receivers take into account the same information but their final interpretations diverge[14].
530 Even though these observations are common and undisputed, the problem why this
531 happens remains to be explained. We named this phenomenon "classic interpretation
532 scatter" and tried to delve further into it. We made a first attempt using a semantic
533 approach: we considered the respondents' answer texts like semantic sets to be
534 investigated through pre-defined categories of meaning. After several tries, we
535 abandoned such approach realizing that, whatever category set we used, too many
536 exceptions, not-decidable cases and ambivalences we found (what confirms the
537 "equivocal nature" of human language, see Footnote 1).

[14] In the exact same way of the example drawn from Hickok, 2009 and presented in Introduction: in that case a physical action is described as interpretable in very different ways (by different observers as well as by only one who is observing from different points of view). However, there is no question about the action *per se*. In our case, the reading of the same message by different people evokes very different interpretations; however, the message information content of the message cannot be under question disputed, (being the message typed and having a unique editing).

Analysis of the answers to the questions' second input: quali-quantitative analysis. These answers contain This analysis refers to the "concrete elements" respondents have indicated as the basis of their interpretations. We approached it by carefully and sequentially reading the answers (more than once), and splitting their content into homogeneous categories. It is worth noting that, in so doing, the answers have been tackled like something *physical*, rather than semantic (i.e. independently of their content and meanings). Such an operation was performed by one of the authors, then discussed and shared with the others; its result consisted in We found the following macro-categories presented in Table 6. of concrete elements: (1) Summaries of the message texts and syntheses of their information content, presented through respondent's own words; (2) Quotations between double quotes, referred to selected words, full phrases (or parts of them) or periods. Such kind of indications have been provided also through pointing the beginning and the ending word of the quoted strings ("from… to…"). The string length could cover up to a whole paragraph of the message (from a keyboard "Enter" to the following). (3) Incidental strings, meaningless *per se*. Such strings were extracted from original full phrases and quoted isolated from the rest. (4) Complement/accessory parts of the text: punctuation marks[15], personal or professional titles used in the opening, the salutes used in the closing etc. (5) Items unrelated to the text semantics or to the message content; a tight selection is presented in Table 6. The list

[15] In one of the two pilot-sessions of the survey, one message contained an exclamation mark; it was specifically identified, and noted as a meaningful component *per se*, by one of the participants. For this reason, it was removed in order to limit influencing respondents. In fact, other respondents successively picked up, from questionnaires now bereft of that exclamation mark, quotation marks (used in certain passages of the submitted messages) as a meaningful component *per se*.

is indefinite, given that each item generally appears at low frequency while the range of possible items is extremely widespread. Items of this kind are actually unpredictable; even the *lack of some content* can be focused and reported as a source of meaning (Table 6, final row). (6)References to some overall effects produced by the message on the participant (see SI Section 8.a, final part, for details). In fact, in this kind of answers, participants state they cannot indicate any "concrete element"; the meaning they have attributed derives from a "general impression" received from the message, from the message's "general tone".

In such analysis we have tackled the answers like something *physical*, rather than semantic, and have treated their texts independently of their content and meaning. Doing so, we have seen that the meaning can spring from parts of the message bereft of any intrinsic content, from aspects external to the text and even from the lack of content itself. In short: whichever the message, the source of its meaning can lie anywhere; this was unexpected. In truth, the idea that the interpretation of a message is a question far overtaking its pure words is widely investigated with regards to spoken communications; this is reasonable if we consider the possible added signals, like non-verbal language and context stimuli, in such situation (see, for example, Horchak et al., 2014, specially the concept of "situated cognition", and Gibson, Bergen & Piantadosi, 2013). It has been quite surprising to discover it in written communications, that are totally bereft of such added signals; there was something else, in this matter, and it did not seem a simple question of added information. Indeed, our impression that the meaning attributed to a message can lie "anywhere" should be taken into a literal account: it seems impossible to

previously write up a "complete" list of the features that could become sources of meaning, given that any new reader can introduce new subjective criteria and detect new sources, totally unpredictable for the other readers.

The question now is: how does all this work? How can we describe, and model, the process of interpretation, subjected to such uncertainty? In order to answer these questions we named "components" the items indicated in the answers to the questions' second input and went back to the questionnaires in order to tally the components present in our survey. We have tallied a total of 1,319 components clearly indicated by participants and we have displayed in Table 3 their absolute and relative amounts.

In order to verify our statement, we firstly carried out some distribution analyses about the components... Secondly, we have further checked our quantitative analysis; we considered that references to full sentences or periods (20.9% in the total) could be another way used by participants for indicating contained information. However, even in such case the sum of the two components would occupy just one third (exactly, 33.1%) of the total indicated components. Still unsatisfied,

In synthesis: our observations do not match the concept of interpretation like a sequential taking into account of the message's content along with its conscious processing. Rather, the emerging picture is the following:

The resulting picture was unexpected, ~~being a clue~~suggesting that the understanding of a message could be determined (not only slightly swayed) by factors unlinked to its text and content (Table 7). This was specially surprising because we had used written messages only, bereft of added signals like non-verbal language and context

stimuli that affect verbal communication (see, for example, Horchak et al., 2014, specially the concept of "situated cognition", and Gibson, Bergen & Piantadosi, 2013). Our observations led to us to hypothesize that every aspect of even a written message (and even immaterial like an e-mail), regardless of its nature and its intrinsic semantic value, could be treated as a meaningful element of the message. The most interesting observation is about the references to the *lacks of information* as "concrete elements" (Table 7, final row): how can an information content act through its absence? In short: following the reports of the participants, interpretations seemed largely independent of the information content of the messages.

In order to delve further into such matter, we named "components" the categories of the indicated concrete elements and, at first, we tried to estimate their amount. Given that our focus remained on the process, rather than on the sample features, our goal was to provide a rough estimate. Such an estimate was important mainly in relative terms: in case of relative small non-content (non-information) amounts, we would have to abandon this part -of our research. But those amounts were not small. Our analysis of the 1,319 detected components is displayed in Table 8; the indications that clearly focus on the information content constitute only a small minority (around 12%, see Table 8, "%" row, "Cont." column) while references to different text components reach, on the whole, about 65% (Table 8, "%" row, sum of the first five column totals). The indications referred to some overall effects of the message represent about 15% of the total. About the meaningless components (void of content *per se*, mere "form" components), their

622 relative amount can be estimated in at least 35% (holding together symbols, incidental
623 passages, other components and grammatical notations).

624 The proportion of the information content components on the total is very low;
625 even if we sum their relative amount (12,1%) to the indications of sentences or periods
626 (20,9%, a possible alternative way for referring to the information content) we reach just
627 1/3 of the total (33%). The question was important and we carried out a further check: we
628 carefully re-examined the filled questionnaires about with reference to the information
629 content component. We found out (Table 9) that one half of the sample (51 people)
630 expresses, among the others, at least 1 reference to such component (no recordable
631 similar hint recordable by the other half). However, only 7 respondents provide a
632 balanced or prevalent amount of indications (50%, or more, of the personal individual
633 total) about information content. Among them, only one reaches 100%. Our conclusion
634 was that, in fact, references to the information content are a definite minority in
635 participants' indications. In order to complete the picture, we checked the distribution of
636 the indicated components, searching for possible imbalances that could contradict our
637 findings. Such analyses return a picture without any significant imbalance Nothing
638 emerged: on the one hand, the distributions of the provided indications result uniform
639 with respect to the different questions (Fig. 2) and almost regularly shaped with respect
640 to the types of the components (ranked approximately by physical dimensions, Fig. 3).
641 On the other hand, the sample distributions related to the amount of the component types
642 employed (Fig. 4), and to the total indications provided by each respondent (Fig. 5),
643 result in "bell curve" shapes.

We can try to synthesize this part of our analysis outlining the behaviours revealed by the respondents' answers to the second input of the questions: first, the interpretation process looks to be starting like a selective and subjective picking up of (or focusing on) the most different components, rather than being a systematic, conscious scanning of the text's content. Such behaviour is widely scattered: in the whole research, with regards to each specific message, it is impossible to find two identical combinations of focused on components in participants' answers. Second, readers seem to make no distinction among intrinsically meaningful or meaningless components: the meaning they attribute can derive from any "chunk" of the text or from any other text or non-text element arbitrarily chosen. Readers seem to interpret a message indifferently picking up meaningful and meaningless components and subjectively combining them. While reading and text decoding go ahead sequentially, readers go on freely (randomly, from an external observer's point of view) isolating "chunks" of the text (as well as other components and even external context aspects) and selecting them as the foundation of the message's meaning. Third, while the final meaning attributed to the message is justified through the selected indicated components, no reason (at all, in any cases) is provided for that selection: in the respondents' accounts participants' answers, the focused components suddenly appear; they are presented just as "given", and without any doubt[16].

[16] The unique doubt expressed in the whole research is the following: 1 participant (out of 102) declares uncertainties in his final choice (between Msg #4/H and #4/S) writing that the final effect could be obtained with both the messages under choice. It must be noted that, with regards to the other questions, also this special participant's answers, too, are totally doubt-free, like the rest of the participants' ones.

At this point, we named "disassembling" the observed selective focusing and took two measures. At first, we hypothesized a new image for the interpretation process, inverted with respect to the "megaphone-shape" (Fig. 1) one. Our argument was that, if scatter manifests itself in the beginning (scattering of focus), a "funnel-shape" picture (Fig. 6) could be more suitable: people that select one same component are expected to interpret it in very similar ways. Secondly, we picked up from our data an example of disassembling and decided to carry out an in-depth analysis of it.

A disassembling example in detail and a perceptual hypothesis. Question #1 requests requested evaluations with regards related to sender-receiver positions and to the relationship between them, on the basis of Messages #1 and #2 (see Method Section and SI, Section 4, for the messages' texts). We found out that 53 people (52% of the sample) had quoted an expression the sender (the employee "XX", see Method Section and SI, Sections 2, 4) used in Message #1[17]: she premised her request of a technician inspection with the words "we would be pleased if at least once…". This simple expression, apparently trivial, (also short (8 words in a 67 word message) and in no way highlighted in comparison to with the rest of the text,), has collected 68 quotations (15 people expressed two, see Footnote 17). Then, respondents have given interpreted such specific passage in at least 22 divergent interpretations different ways, summarized in Table 9 Table 10.

This means that focusing on the same component does not imply convergent interpretations. As much as to say that the interpretation scatter manifests at both levels:

[17] The 53 people have expressed reported their interpretations answering Question #1-a (23), #1-b (15) or both the questions (15). See SI Section 4 for the questions' full texts.

the disassembling (scattering of focusing on components) and the following attribution of meaning (each sub-group, focused on a same component, provides scattered conscious interpretations). This means also that the "funnel-shape" picture, too, must be revised: what we observed could be better expressed through an "hourglass-shape" picture (Fig. 7). In fact, disassembling and classic interpretation scatter would co-exist and manifest themselves **in sequence**. We notice that the expression we are considering appears to be a minor element in Message #1 text, something incidentally expressed; it is composed using common words and bears no inherent information content (once the passage gets isolated from the rest of the message, it is impossible to attribute it a definite meaning). In short: it is a mere form component. So, how could respondents select such incidental passage? And what did they, exactly, grasp in it? What is more, given that the following interpretations are scattered, what did respondents, exactly, interpret, having started from an identical, spontaneous selection?

Now, the message we have used in our research was always the same, invariable with regards to written form as well as to information content. Thus, if the interpretations of the readers are so scattered, this cannot depend on the message itself, it must depend on the readers: they evidently give an active contribution in attributing meanings, they are not passive symbol decoders. Nothing new, so far: our observations confirm old ideas, for example the ones that the constructivist hypothesis proposed many years ago (Watzlawick, 1984). The question is: how can this happen? By one hand, respondents explain through the outcomes of "disassembling" the conscious attribution of meaning that follows; by the other hand, no accounts report about the source of disassembling.

The selective focusing manifests “immediately and automatically”, apparently preceding and feeding the conscious processing that follows, and that is all.

At this point we felt we had elements enough to draw a conclusion and propose a hypothesis. The first part of the observed process (“disassembling”) does not resemble any information processing, symbol treatment or sign decoding; it rather looks like a **perceptual scheme**. We mean that, if we hypothesize that the components are focused because they firstly act like “physical” **stimuli**, triggering automatic reactions off (“body” level) in the receivers, then the observed phenomena will become comprehensible. The main points of our hypothesis are the following:

- Considering interpretation as a process, decoding of written signs must be its first step, for turning them into words. Decoding is the “technical” aspect of reading, not directly linked to meanings and just feeding the following steps.
- Along with the sequential decoding, words and the other message components would immediately act like stimuli, triggering a receiver’s automatic reaction off (“body” level). This would be the second step, i.e. disassembling. Its results would be different from a person to another given that the capacity of a component to act like a stimulus depends on the subjective reactivity of each receiver.
- Then, the conscious processing of the collected inputs would start. Being the steps set in a cascade, the “input” on which this third step would be carried out should (mainly, at least) consist of the automatic reaction’s outcomes, not of the source message’s content.

Our hypothesis is that the interpretation process structure can be represented with a three-step (three sub-processes) model like the one in Fig. 8. It gives account of how respondents focused on the incidental passage and what they grasped from it: they automatically reacted to a stimulus (presumably through some unconscious connections with previous experiences that had involved something similar) and such stimulus oriented the following conscious process. …...

In synthesis: interpretation process would firstly consist in a re-experiencing of past situations through an analogical resounding at body-level, thanks to a stimulus-reaction mechanism triggered off through perception. Such reaction would feed forward (presumably through proprioception) the following attribution of conscious meaning to the subjective experience (rather than to the source message).

Now, the picture we are facing is the following: first of all, focusing on the same component does not entail convergent interpretations. In other words: we have two levels of scatter, one at "disassembling" stage (scatter of focusing on the components) and the other at the following stage, when the conscious meaning is attributed to the focused components. Thus, the correspondent metaphor cannot even be the "funnel" (Fig. 6); rather, it could be an "hourglass-shape" one (Fig. 7). Secondly, we have to take into account that the expression "we would be pleased if at least once..." bears no notable features: common words, in no way highlighted and having no inherent meanings (once the passage gets isolated from the rest of the message, it is impossible to attribute a definite meaning to it). So, how and why has it been focused by the sample members?

A third element is a behavioural feature systematically (all cases) observed: on the one hand, respondents explain their interpretations (the conscious meanings they attributed) through the disassembling outcomes (i.e. using the components they focused on). On the other hand, they did not explain the reason why they exactly focused on those components. The selective focusing manifests “immediately and automatically”, priming the attribution of a conscious meaning. At the end, a last consideration: we have submitted identical copies of the same messages to the participants; thus, if the interpretations of the sample are so scattered, it cannot depend on the messages. Rather, it must depend on some active contributions of the readers; evidently, they are not passive symbol decoders. Nothing new, so far: our observations are consistent with old ideas, for example the ones that the constructivist hypothesis proposed many years ago (Watzlawick, 1984).

Our interpretation of such picture is the following. Analysing the participants' reported behaviours, we have the impression that there are ~~to be facing~~ two different processes. This contrasts with the current approaches, which research on interpretation tacitly assuming that there is a unique operation to be explained through the experiments in terms of INPUT/OUTPUT (message IN/meaning OUT with the brain as the processor). If we, oppositely, assume that interpretation could be a discontinuous process, made up of different operations, our observations become understandable. We mean: phenomenologically, the interpretation of a natural language message starts with the perception of physical stimuli (i.e. spoken sounds or written signs). Such stimuli cannot be considered as the starting of the interpretation process, given that they are just

socially shared symbols in place of words. We can name this first step "decoding". After decoding, symbols turned into words enter the actual process of interpretation, namely the object of our observation; from this point on, we hypothesize a double-step process (two sub-processes, Fig. 8). Disassembling should be the first step (second after decoding), followed by the conscious attribution of meaning; the observation that mainly upholds such hypothesis is the existence of a double level of scattering (see the "hourglass-shape" picture, Fig. 7).

In addition, we assume that these steps have different natures; we base such assumption on the observation that, in their answers, participants never account for disassembling. Conversely, the disassembling outcomes are used to give reason of the following step (the conscious attribution of meaning) that seems to be, literally, leant against them. On these bases, we can assume that the last step corresponds to the conscious, rational processing of the focused components; but what is the nature of disassembling step? Our hypothesis, based on the presented observations and reflections, is that it is a perceptual, not a conceptual-logic, step. The components would act like "physical" stimuli, triggering automatic reactions off ("body" level) in the receivers. We mean: the receivers would not consciously recognize the meaning of one component before focusing on it[18]; simply, they would focus on those components suitable to trigger their reactions off.

[18] It is worth noting that, in such hypothesis, the process would turn into an infinite regress: if disassembling represents the conscious basis of the attribution of meaning, which could the disassembling conscious basis be? And which could be the conscious basis of the conscious basis of disassembling? And so on. A starting point of different nature is anyhow needed.

One last question remains: if a reader reacts to a given component, even though it appears to be meaningless/contentless, we need to identify what, exactly, that reader perceives. exactly, how can we precisely identify what a reader picks up when he/she selectively focuses on meaningless/contentless components? We think we can label identify it as **the fact that** one of these components is present in the message; it can be considered some meta-information to which readers can automatically react even though it is not embedded inside the message words (Table 10) (Table 11). This can clarify the aspect of the incidental passage ("...we would be pleased if at least once…") which triggered the participants' reaction off: the fact that XX had (redundantly) placed it in at a certain point of the her message[19].

Results from the second part of the research: checking the hypothesis

Our research's second part represents a first check about our hypothesis. We This second part of our research is based on data drawn from the second part of the questionnaire. Such part starts by submitting to participants two alternative versions of a possible reply to Message #3: the original message, #4/H, and the colleague suggested one, #4/S (see Table 4 for the full text messages; SI, Section 5 and Tables S1, S2 for details about the reasons of the alternative). Then, we asked them participants were requested to, firstly (Questions #3 and #4), interpret (independently) independently interpret the two versions in terms of their effects on XX; secondly (Final question), to

[19] It is particularly interesting to note that the expression "the fact that…" is spontaneously used by several respondents in their answers. For example, in the collected questionnaires we can find expression like the following: "the fact that the arguments are presented through a dotted list"; "the fact that XX is referring to public money".

choose between them the one the version suitable, in their opinion, to origin elicit the final XX's answer (Message #5, that seals the positive ending of the case; see SI Section 4 for messages' and questions' full texts; SI, Section 5 and Tables S1, S2 for details about the reasons of the alternative). Our rationale was the following: the participant's choice could come as a result of the text information's conscious processing (cognitivism stance) or as an automatic reaction independent of every conscious processing (embodied cognition stance). In the first case (our "Hypothesis 0"), the final choices should be outcomes of the interpretations given to the messages; thus, they should result somehow correlated with them. In the second case, no correlation, or a different kind of correlation, should be found (our "Hypothesis 1"). The problem emerged of measuring such correlation now was how to assess such correlation.

The coherence between interpretation and choice. Firstly, we displayed (Table 11) (Table 12) the choices indicated by the sample members (SI Section 6 and Tables S3-S5 for the sub-samples description) and found out a strong imbalance between "S" and "H" indications. Secondly, we compared the interpretations of Message #4/H (the original) with those of Message #4/S (the suggested one; see SI Section 4 Table 4 for messages' full texts full text messages). Source data (opened answers) was purely qualitative. However, answers were easily classifiable into two main categories: predictions for the message inducing a solution of the case (easing or overcoming, anyhow solving the emerging conflict between the interlocutors); predictions for the message inducing a surge, or escalation, in the conflict. We created the dummy variable "Expected effects" and assigned it two values to it: "+" in the first condition; "-" in the

second one. Then, we labelled each questionnaire with two new symbols: one referred to Message #4/H (H+ or H-) and one to Message #4/S (S+ or S-). Methodologically, the labelling has been carried out by one of the authors and, independently, by two external persons; the answers were almost all well characterized and the assessment of the very few cases in which the opinions diverged have been rapidly discussed and shared.

The combination of the two symbols indicates reports the combined predictions each participant expressed about the effects of the two versions on XX: H+/S+ (both the messages versions solving the conflict), H+/S- (Message #4/H easing the conflict while Message #4/S escalating it), H-/S+ (the opposite), H-/S- (both escalating). Finally, we arranged the symbols into a dichotomous table (Table 12) (Table 13). There is a clear convergence on combined prediction "H-/S+"; the Chi-squared test highlights, at this first stage, that some correlations between "H" and "S" interpretations could exist (p = 0.002, total sample; p = 0.016, sub-sample "AGE"; p = 0.004, sub-sample "EMPLOYMENT"). we set significance level to 5% and found out that, at this first stage, statistic tests highlight (even though not all cases result significant) that some correlations between "H" (the original message) and "S" (the suggested one) interpretations could exist (Chi-squared test: p = 0.029, total sample; p = 0.166, sub-sample "AGE"; p = 0.038, sub-sample "EMPLOYMENT"; Fischer's Exact test: p = 0.043, total sample; p = 0.219, sub-sample "AGE"; p = 0.064, sub-sample "EMPLOYMENT"). Given that the messages' presentation sequence was counterbalanced (see SI, Section 3, Point 9), it is unlikely that the respondent's first interpretation can drive the second; probably, some other factors drives both of them.

Then, we cross-checked the combined predictions with the final choices (Table 13) (Table 14). The most frequent combined prediction (H-/S+) appears to be strongly associated to "S" choice; indeed, the significance tests (Chi-squared) show that some further, stronger relations do exist between combined predictions and choice ($p = 0.000$, total sample; $p = 0.001$, sub-sample "AGE"; $p = 0.000$, sub-sample "EMPLOYMENT") (Chi-squared test: $p = 0.001$, total sample; $p = 0.035$, sub-sample "AGE"; $p = 0.009$, sub-sample "EMPLOYMENT"; Fischer's Exact test: $p = 0.002$, total sample; $p = 0.027$, sub-sample "AGE"; $p = 0.008$, sub-sample "EMPLOYMENT"). Such results led us facing the core-question related to our hypothesis: given the existence of some correlations between choice and combined predictions, which is its direction? We mean: do the interpretations (the predictions) drive the choice (cognitivism stance) or, oppositely, does the choice precede and somehow drive, or overcome, the interpretations (embodied cognition stance)?

To delve further into such subject, we created a "coherence indicator" starting from the following premises (SI Section 4 for messages' full texts) (Table 4 for full-text messages): (i) The final Message #5 clearly indicates XX's satisfaction; therefore, the conflict has come to its end. (ii) Now, let us figure a respondent whose answers to Questions #3 and #4 return a combined prediction H+/S- (the original Message #4/H solving the conflict, the suggested Message #4/S escalating it). Then, we expect that this respondent indicates Message #4/H in his final choice (answer to Final question). Such combination (H+/S- & "H" choice) would represent the maximum coherence level. (iii) If another respondent provides the same combined prediction but chooses Message #4/S

in his final choice (combination H+/S- & "S" choice), this would represent the minimum coherence level. (iv). Given the natural variability always recorded in human samples, we expected to find also intermediate coherence levels, based on the other possible combinations (H+/S+ and H-/S-). These could be also also be due to the predictable scattering of interpretations about the final Message #5: someone could interpret it as something different from the sign of the conflict's ending (what happened in a fistful of cases).

We defined four coherence levels, increasing from L (low) to LM (low-medium), MG (medium-great) and G (great); the scale is fully presented in Table 14 Table 15. In This way, it has been possible to study the final choice sample distribution with respect to the coherence levels (Table 15) (Table 16). The percent distribution histogram of for the whole sample (Figure 9, data from Table 15 Table 16) shows that the distribution is the expected one shape except for the frequency of the low coherence bin, over-represented. Actually, we expected L frequency to be null or very close to null; anyway, it should show result the lowest frequency of all. On the contrary, we found L values higher than the LM ones, and representing 11% 12.2% of the sample. The two sub-samples (right columns of Table 16) show fully comparable features.

At this point, we refined our analysis through separately analysing displaying separately distributions of "H" and "S" choosers; for the reliability of comparison, we excluded data referred to the respondents having just primary education levels (only 4 out of 102 in our sample). Data is displayed in Tables 16, 17, 18, 19, which show a surprising asymmetry whose significance is confirmed by Chi-squared tests (always

898 p<0.01 p<0.001). Graphic representations render even better such asymmetry: the total
899 sample histograms (Fig. 10, percent distributions from Table 16 Table 17) show that the
900 percent frequency of "S" (the suggested message) choosers (white bins) increases
901 regularly from L category to G, reminding (as expected) of certain power, or exponential,
902 curves. At the opposite Oppositely, the percent frequency of "H" (the original message)
903 choosers (grey bins) is arranged in an irregular, almost bimodal shape. We checked these
904 distribution shapes by using many different sub-samples (selection displayed in Fig. 11-
905 16), included the already mentioned "Age" (Fig. 15, data from Table 17 Table 18) and
906 "Employment" (Fig. 16, data from Table 18 Table 19) sub-samples. We always obtained
907 the same significant imbalance.

908 Now, Chi-squared tests and graphic representations clearly indicate the existence
909 of a correlation between the participants' choice and the coherence level; but what about
910 its strength and its direction? In order to investigate the strength, we calculated the odds
911 ratio. Our success item was the L level, our failure items were all the other levels of
912 coherence coherence levels. Using data from Table 16 Table 17, we can find ODDS1 =
913 0.346 0.417 ("H", the original message choosers, about 1 success for each failure every
914 about 2 failures) and ODDS2 = 0.028 ("S", the suggested message choosers, 1 success
915 every about 36 failures). The final result is ODDS RATIO = 18,9 25.5 which highlights a
916 strong correlation between the "H" choice and the L coherence level. As much as to say
917 that, if you choose message #4/H, it is much more likely (with respect to message #4/S
918 choosers) that your choice is inconsistent with your interpretations of the two messages.
919 About the direction of such correlation (the interpretations precede and drive the choice

or the choice is independent of interpretations), we think the first position is not tenable; indeed, it could be confirmed just in case of general consistence consistency between interpretations and choice.

All this contrasts our "hypothesis 0": the participants' choice does not seem to come as a result of the text information's conscious processing. Then, the choice should be independent of the previous interpretations, what upholds our "hypothesis 1". After this first conclusion, we set up a second indicator ("block preference" indicator) to further check our hypothesis. For text length reasons, we present details about the such indicator, its employment, and relative analysis in SI, Section 10 with Tables S8-S11. We found no contradictions with the previous results.

Discussion

We will start our discussion summarizing our main findings. Then, we will situate our work in the current scenario of scientific research; finally, we will discuss some possible consequences of our results and indicate the possible directions in which this study could be developed.

Summary of the research's main findings. The following points synthesize our interpretation of the interpretation process, upheld by our work's experimental outcomes (specified in italic).

- In all circumstances, the interpretation of natural language is a complex, global experience not reducible to the interpretation of isolated spoken or written words. *Reference to our qualitative analysis of the participants'*

answers to the first input of the questionnaire first part's questions (specifically: description of the message non-word and meta-information components, that prevail over verbal components and firstly orient the reader's interpretation).

- After decoding, a random, selective focusing on the most various and unpredictable components of the message ("disassembling") starts, preceding the conscious processing of the information content. *Reference to our qualitative analysis of the participants' answers to the first input of the questionnaire first part's questions (specifically: observations about the sudden appearance, extreme subjectivity and unexplained origin of the widely divergent and unpredictable selected components).*

- "Disassembling" looks like a stimulus-reaction mechanism, rather than an information treating process. *Reference to our quali-quantitative statistical analysis of a disassembling example (the case "we would pleased if at least once...") drawn from the participants' answers to the second input of the questionnaire first part's questions.*

- Each message component would at first work like a physical stimulus, rather than an information carrier; in other words, it would trigger an automatic reaction off (body level) before the conscious processing of information content starts. *Our hypothesis, consistent with the data we collected, suitable to give account for our observations and compatible with the current research scenario.*

- Since "disassembling" feeds forward the following step (conscious processing), it orients the attribution of meaning: conscious interpretation would be carried out on the body's reaction, rather than on the source information. *Reference to our quantitative statistical analysis of the participants' answers to the questionnaire second part's questions (coherence indicator, coherence level distributions and related significance checks; block preference indicator and related analysis).*
- After disassembling, the receiver's contact with the original message would be lost[20]. C*onsequence of the "in a cascade" setting of our model's three steps (further details, with direct references to recent scientific paper consistent with such conclusion, in next paragraph, which situates our work in the current scientific research scenario).*
- The final outcome of the whole 3-step process is the meaning consciously attributed to the incoming message and expressed by the receiver through natural language.

From a methodological slant, our work showed that studying the interpretation of natural language messages in natural-like conditions can effectively complement

[20] Our data led us to conclude that such contact can be recovered (like a sort of "fourth step" after the basic three of our model) only later and just in peculiar conditions; however, this is another story and, in this article, we will not delve further into it. In our research, one example of this can be the intervention of XX's colleague in the case. Even though the used case is a fiction, it is very close to observed real cases, in which the process can be described as follows: an expert, after **text decoding** (first step), detects an issue through **becoming alarmed** (automatic reaction, second step). Then, his/her feelings come to conscience and lead him/her to **consciously attribute** that text a negative assessment (third step). At this point, he/she starts the **in-depth analysis** of the case (our presumed "fourth step") through recovering the source message and studying it from a different point of view and through a different approach. The final result is the expert's solution of the case.

laboratory studies based on isolated words/phrases and contribute to a wider comprehension of the phenomenon. In the first part of our analysis, we have employed mainly qualitative methods and have hypothesized a discontinuity of the interpretation process, made up by three sub-processes having different natures (Fig. 8). Being the first (decoding) just a technical step (it turns the spoken or written symbols into words using the socially shared code system), the new and critical step appears to be the following one, i.e. our proposed "disassembling": the text of the message does not seem to be scanned sequentially, exhaustively from its beginning to its end, by the reader; rather, it seems to be scanned randomly, focusing on a very subjective selection of components that is different from a reader to another. The reported differences in such focusing represent the first of the two observed scatters.

The outcomes of disassembling are reported by participants as the basis for the following conscious attribution of meaning to the message; at the same time, no reason is provided, in any of the self-reports, to justify disassembling. For this, our hypothesis is that disassembling is an automatic reaction, out of conscious control, preceding and feeding forward the conscious attribution of meaning to the message (we have also noted that, in the opposite case, the analysis would turn into an infinite regress); at this level, the second, well known observed scatter manifests. If our hypothesis will be confirmed, this means that words are not mere symbols; they are also stimuli (they can act like *physical* stimuli) that trigger automatic reactions off in the receivers[21]. This would also

[21] Such ambivalence looks interestingly (or just curiously?) similar to what happens in certain physics phenomena like the double nature of light (waves/particles) or the uncertainty about some features of many atomic particles. In those cases, the ambivalence is solved just in the process of

mean that what would enter the conscious attribution of meaning sub-process would be the subjective reaction of the receiver, rather than the original message; our conscious direct contact with the real world would be prevented and we would actually attribute conscious meanings just to our automatic reactions.

In short: through the first part of our work, we have outlined what kind of phenomenon interpretation could be. Our work's second part has been designed in a way similar to a social psychology experiment; through it, we have worked downstream with respect to the interpretation process itself, investigating its effects on a consequent behaviour (the final choice); we found significant imbalances in the coherence between interpretation and choice. Roughly, we can label as "rational" the choices that show maximum coherence with the previous interpretations of the two messages (the original, Message #4/H, and the suggested one, #4/S); conversely, we can label as "irrational" the choices that show minimum coherence. ~~Well,~~We found that the irrational cases are significantly ascribable to "H" choosers rather than to "S" ones. In other words: the elements provided by interpretations appear insufficient to determine the choice; this means that other factors intervene. Such factors should be unconscious, otherwise they would be declared by at least some participants; in addition, they must have a different and stronger source from the conscious/rational analysis of the message content, otherwise their influence on the choice would not prevail.

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measuring the phenomena (Zeilinger, 2010, for a discussion about the case of photons, and von Baeyer, 2013 for a recent point of view about such ambivalence); in the case of words, something similar would happen, given that their nature would become evident just in relation to the receiver's reaction.

The main question is: why, in the decision process, do these factors significantly weigh just in connection with one choice and not with the other one? Further research is needed to find the answer. Provisionally, we think there are two possible hypotheses: (1) The two sub-samples follow different paths in interpreting natural language messages ("S" choosers would base their choices on rational information processing, which would precede action, while "H" choosers would react instinctively and choose before analysing the available information); (2) The two sub-samples actually follow the same path (automatic reaction preceding conscious information processing, in our opinion) and the difference they show is linked to the differences in their automatic reaction schemes ("S" choosers' reaction would privilege the attention to the relational aspects while "H" choosers' reaction would privilege the content aspects).

The link between the second and the first part of our research is, mainly, the common trait of the unconscious factor influence on either the interpretation process or the action that follows interpretation. With regards to the interpretation process, we have presented a hypothesis about where and how unconscious factors could act: in the three-step process we have proposed, we place them at the second step ("disassembling"); therein, disassembling appears to function like an automatic reaction to the words/expressions of the read message. With regards to the action that follows interpretation, about the unconscious factors that sway human behaviours, unhooking them from the conscious meaning attributed, we can hypothesize they are linked to some tracks left by disassembling in the reaction schemes of receivers.

Situating our work in the current research scenario. With respect to the dispute between the stance of cognitivism ~~stance~~ and the embodied cognition hypotheses, we think our research could be situated in a third position, for two reasons. The first reason is that, while these theories share (even though coming to opposite conclusions) the concept of natural language interpretation as a unique operation, we have seen it as a discontinuous process (three steps of different nature, "decoding" included). The second reason is that, in our model, two of the three sub-processes seem to be compatible, separately, with those two theories. We mean: the embodied concept features are akin to our second step ("disassembling"); the cognitivist hypothesis is clearly akin to our third step, (see Fig. 8).

Probably, we can better exemplify this through recovering the example (see Hickcok, 2009, page 1240) we presented in the Introduction. In our opinion, embodied cognition hypothesis looks at the that described act of pouring in its **purely motorial** nature; conversely, understanding it, for example, as "pouring" or "filling", requires the interpretation of a **situation** which is not limited to the act for itself *per se*. In order to attribute the "pouring" meaning, one must focus on the liquid flow direction (inside to outside, from the bottle); for the "filling" meaning, one must focus on the glass receiving the liquid; for the "emptying" meaning, one must focus on the bottle content's amount of liquid inside the bottle. An operation must be preceding the attribution of a conscious meaning: the previous, unconscious selection of a specific point of view, which is something closely resembling our "disassembling" step. The attribution of conscious

meanings should be preceded by the previous, unconscious selection of specific points of view (something closely resembling our "disassembling" step).

Scientific research of present times is, naturally, swayed by the confrontation between cognitive and embodied hypotheses. The "cognitive field" frequently engages the noun-verbs dissociation problem, studying it through researches on cortically damaged, selectively impaired patients; such studies are mainly aimed to define the nature of the concepts' representations in the brain cortex (lexical or semantic, lexico-semantic dissociation issue), and to cortically map it (for example Crepaldi et al., 2006; Arévalo et al., 2007; Moseley & Pulvermüller, 2014; Gallese, 2014). Conversely, the "embodied cognition field" mainly go searching for the connections between language and its motor correlates, one well-known of which is the ACE (Action-sentence Compatibility Effect), often checked through measuring and comparing the reaction times collected during language-and-action combined match-advantage experiments (see for example Vitevitch et al. 2013; Horchak et al., 2014). Such studies are frequently carried out through neuroimaging works (for example Tettamanti et al., 2005; Aziz-Zadeh et al., 2006; Speer et al., 2008; Aziz-Zadeh & Damasio, 2008).

We have already reminded, in the Method section, the methodological aspect we consider common to the two research lines: they both use, during the experiments, words and short phrases isolated from every context (see, for example, Bedny et al., 2008; Bedny et al., 2012, especially the Method sections; and, for some critical reflections about the question, the already cited Pulvermüller et al, 2014, specifically Pag. 80, Chapter 7). Such methodological aspect elicits a further consideration: there is a cross-

concept widely and implicitly shared by cognitivism and embodied theories, namely the idea that the meaning is something embedded inside words. These would work somehow like "carriers" of meaning and interpretation would consist in the "extraction" of meaning from words (actually, the verb "to extract" is overtly used in scientific publications, for instance Mahon & Caramazza, 2011).

The divergence between the two approaches can be synthesized as follows (for further reference see, for example, Bedny et al., 2008; Rizzolatti & Fabbri-Destro, 2008; Goldman & de Vignemont, 2009; Gallese, 2011; Gallese & Sinigaglia, 2011b; Bedny et al., 2012): cognitivism upholds the sequential processing idea, i.e. cognition being conceptual and resulting from a sequence of perception / symbolic processing of the incoming information / (motor) reaction. Oppositely, the embodiment theories uphold the concept of direct connections among cortical sensorial and motor areas ("sensorimotor grounding" of cognition, Guan et al., 2013). In this sense, cognition would be embodied[22]. Now, how could our work be positioned in such picture? In a third position, we would say. In fact, both theories are based on the implicit idea that human communication is a continuous, homogeneous process. On the contrary, we hypothesize discontinuity, with the interpretation process made-up of three discrete, in-a-cascade steps which can result compatible with both ideas.

Actually, in our opinion... We must add that such overlapping is just one aspect of the question; our proposal entails at least one important difference with respect to the

[22] Such embodiment, inside the same embodied cognition field, can be conceived in different ways: it can stand alone, *per se* resolving the problem of knowledge ("sensorimotor processing underlies and constitutes cognition", Guan et al., 2013), or can be a "motor representation" that accompanies conscious knowledge processes (the two kinds of knowledge proposed by Gallese, for example in Gallese et al., 2011; see also Gallese, 2014).

two theories: the discrete, in-a-cascade structure of our process implies a feeding chain, with the first step (decoding) that feeds the second (disassembling) which, in turn, feeds the final one. This results, after "disassembling", in the loss of the contact with the source message and in the conscious processing performed on the body-reaction signals (presumably received through proprioception). The real object of our (first level, see Footnote 18) knowledge would not directly be the outer world; rather, it would be our instinctive reactions to it (the outer inputs combined with our inner world). This is a relevant point, and we have selectively examined some of the available literature for a first check of it.

Apart from this, if we extend back our literature survey, we can find, for example, that conscious thinking following (rather than preceding) "body" reaction(s) can be traced back up to the hypotheses of Nineteenth Century philosopher and psychologist William James. In one of his examples (the "James's bear", see James, 1890, Chapter XXV), James explains his theory of emotions suggesting that, for example (our synthesis), we do not run away from a bear because we see it, we know it is very dangerous, so we are scared of it and, consequently, we consciously decide to run away (as common sense would sustain). Conversely, we feel like we are afraid because (consciously and successively) we discover our body having started a desperate run. In other words: what we call "emotion" is usually intended as a body reaction consequent to the rational processing of consciously perceived environmental stimuli; James suggests that the body reaction immediately follows perception immediately and what we call "emotion" is the consciousness of the new body state (a form of self-consciousness). We

are aware that James's James theory (exactly: James-Lange theory) has been criticized and opposed through several that alternative theories have been proposed (for example Cannon, 1927; Schachter & Singer, 1962); nevertheless, we do refer to it because recent scientific research and reviews seem to suggest some re-consideration of the matter (for example, Friedman, 2010). We will not deepen the question here; however, we feel that James-Lange's intuitions could deserve another chance.

In the Twentieth Century, we can find the Gregory Bateson's approach to human communication as a system and to the question of the receiver's active role; he uses a strictly formal presentation (see Bateson, 1972, in particular Chapter 4.8 on the logical categories of communication, founded on Russel and Whitehead's theory of logical types). In addition, we remind of recall a group of theories and models (some of which repeatedly expressly refer to Bateson's studies) that tackle the question mainly from a pragmatic slant: the so called "pragmatic models" (Berne, 1961; Watzlawick, Beavin Bavelas & Jackson, 1967; Bandler & Grinder, 1975). Conceived inside a psychoanalytic context, they all put perception and stimuli at the centre of their attention and reverse the relationship between action and thought using action (rather than thought) to induce training and therapeutic effects[23]. We find no important contradictions among our

[23] By On the one hand, it is worth mentioning a special work coming from NLP founders (Grinder & Bandler, 1979): it appears different from the work that founded this theory (Bandler & Grinder, 1975) and that has successively been developed by NLP specialists (for example Dilts, 1998). As a matter of fact, that work gives a central role to perception and to physical stimuli (not mediated by language) as a possible communication and therapeutic instrument (see, in particular, the concept of "sensorial anchors" in Grinder & Bandler, 1979). By On the other hand, we should remind a Watzlawick's work on the modern evolution of psychotherapy (Watzlawick, 1987) that represents a severe critic to the classic approach and reverses the relation between action and thought (an Italian translation is retrievable in Nardone & Watzlawick, 1990, Chapter 1). In the same Nardone & Watzlawick, 1990, see also chapter 2 on perception as one main source of psychopathology.

hypotheses and such models; rather, we find complementarity: they show how physical stimuli can act like messages; our results tell could show that words (even if only written) can act like physical stimuli. In addition, we can propose an explication of an unsolved point related to them: the biological foundations of the "aspect of relation" in human communication (Watzlawick, Beavin Bavelas & Jackson, 1967). On the basis of our results, this aspect could be exactly the body-level automatic reaction which precedes the conscious information processing.

About the relevance of unconscious processes in human behaviour, some fundamental clarification is provided by Custers & Aarts, 2010 through a review of experimental works that re-examines the disputed question of the passage from perception to action. The authors compare the traditional positions of Sensory-motor Principle (SMP, for example Massaro & Cowan, 1993; and, for a presentation and discussion about the sequential processing of stimuli conceived as the foundation of human/environment interactions, see also Rizzolatti & Sinigaglia, 2006, chapters 1, 2) and Ideomotor Principle (IMP, Stöcker & Hoffmann, 2004; Pezzulo et al., 2006; Melcher et al., 2008; and, for a synthesis, Iacoboni, 2008, Chapter 2, pp. 56-57 of Italian edition). In so Doing so, they show how certain stimuli (images, solid objects or even written words), intentionally added to an experimental setting, can alter the sample behaviours, even if such stimuli are not consciously detected: "under certain conditions, actions are initiated even though we are unconscious of the goals to attain… [and] goal pursuit can… operate unconsciously" (Custers & Aarts, 2010). They also sustain that arguments

frequently presented as rational motivations for action are, actually, *ex-post* justifications of unconsciously performed behaviours.

The role of physical stimuli in swaying communication through natural language is confirmed by a series of recent works (for example Zhong, Bohns & Gino, 2010; Tsay, 2013; and, for a popular-scientific coverage, Lobel, 2014). Further, quite unpredictable factors that can sway message interpretation can be the specific national languages used (for example Marian & Kaushanskaya, 2005; Costa et al., 2014) or the metaphors used to express concepts (Thibodeau & Boroditsky, 2011; Thibodeau & Boroditsky, 2013). Our data is consistent with all this the outlined scenario in that it confirms precedence the effects of perception-reaction with regards to on conscious processing.

In the end of this rapid survey, we think it is worth re-examining the example (Hickok, 2009, for the opposing point of view see Gallese et al., 2011) presented in our Introduction in order to check our proposal in a concrete case. About the capacity of an observer to understand the action of pouring performed by someone, the author highlights that the "embodied cognition" hypothesis cannot explain the fact that the observer can interpret such action "as *pouring, filling, emptying, tipping, rotating, inverting, spilling* (if the liquid missed its mark) or *defying/ignoring/rebelling* (if the pourer was instructed not to pour)…" (see Hickcok, 2009, page 1240, italic by the author). The author also anticipates the counter-argument of a supposed mirror neuron theorist, i.e. that mirror neurons codify the goals, or intentions, of the actor: "But a goal, say to fill a glass with water, can be accomplished with any number of individual actions

or sequence of actions: pouring from a pitcher, turning a spigot, dipping a glass in a lake, setting the glass in the rain…" (*ibidem*).

Some possible consequences. Naturally, our results need to be confirmed; once they would be, we can see four main possible consequences. The first one regards the discontinuous nature of the interpretation process and, specifically, the role of the second step of our model (disassembling) in human communication through natural language: some traditional empirical knowledge would find theoretical bases (for example in advertising and marketing fields) and a revision of human communication current models would be needed (for example with regards to mass media and education). Simply, the fact should be taken into account that human communication through natural language could work in a slightly different way than expected and thought up until now.

One main consequence of our results, once they will be confirmed, would concern the nature of words. We are used to consider words almost exclusively in their symbolic nature; however, our research shows that they could have a double nature: they could work like symbols as well as physical stimuli. In a specific circumstance, which of the two natures will be active depends on the subjective "disassembling" performed by the receiver, rather than on the sender's intentions. This implies that which nature is in action will become observable only at the moment of the receiver's interaction with the message. This is very similar to what happens in certain physics phenomena, for example the double nature of light (waves/particles) or the uncertainty about some features of many atomic particles: the ambivalence is solved just in the process of measuring the

phenomena (Zeilinger, 2010, for a discussion about the case of photons, and von Baeyer, 2013 for a recent point of view about such ambivalence). All this entails what follows:

- There is a structural uncertainty in the human communication process: when a sender prepares a message (message production sub-process), he/she has the intention to produce some effects on the receiver (his/her communication has a goal, this is the pragmatic aspect); however, the actual effects the message will produce will depend on another sub-process (interpretation) that is under control by the receiver, not by the sender. Uncertainty is linked to the irreducible subjectivity of the receiver's "disassembling"[24].
- Such subjectivity is not just a question of statistical scatter, with regards to presumed pre-definable message components; the question is that it is impossible to foresee what components, exactly, will trigger the receiver's automatic reaction off (receiver's reactivity is an absolutely individual feature).
- What is more, the selective focusing, by the receiver, on specific message components, seems to be a creative act, rather than a simple recognition of something contained inside the message. So, it would be impossible to previously detect and list, in a laboratory condition, "all" the components of a message. In fact, whatever the message, the concept of an inherent message's

[24] Another way to express such concept is considering the sender-receiver couple as a complex system, and the meaning like an emergent phenomenon which characterizes it (about this specific matter see, for example, Guastello, 2002).

measurable information content fades. Human communication seems to be a process having a different nature from computer communication.

In the end, communication and knowledge processes would be firstly analogical, rather than digital. The second consequence would be the analogical, rather than digital, basis of interpretation. Meaning would be established starting from the body automatic reaction in the "disassembling step", analogically triggered through individual reaction schemes probably based on similar, previous personal experiences. The final meaning, expressed through natural language, would be the result of the following step, i.e. conscious taking into account of the outcomes of such analogical process. This final meaning would not be directly based on the source message; rather, it will be based on the body reaction. Indeed, all This could lead us to approach consider natural language expertise like as a system of acquired reflexes, what would mean that human beings would "communicate through their body" in a wider and deeper sense than conceived at present (something quite different from mere non-verbal language performances). and Such feature could heavily affect the possibility to reproduce human interpretation process on digital computers, regardless of their processing power and data storage capacity. The two systems could result not only different, rather incompatible. We are not the first to who propose such observation (for example Arecchi, 2008; Arecchi, 2010b; Arecchi, 2010c on the non-algorithmic nature of knowledge and intelligence).

The third consequence could derive from our observations about the taking into account of the message components by the reader, that seems to be performed like a subjective operation, quite arbitrary and unpredictable. If this will be confirmed, the

concept of "content of a message" should probably be revised, given that it would result impossible to *ex-ante* define all the contents a reader could detect in a specific message. What is more, as a fourth possible consequence, if mere "form" (aesthetic) components are indifferently taken into account as sources of meaning with respect to the content components, then the difference between form and content fades, leading to a concept of "message" as a unit made up only by *components*, all of them having the same importance (the same *ex-ante* probability of being chosen).

In the end of a so long arguing about the attribution of meaning, it is worth briefly considering the problem of "what is meaning" (what is the meaning of "meaning"). Beyond the strictly phylosophical, abstract definitions, nowadays we can record attempts to provide operative definitions; for example Guastello, 2002, who considers the sender-receiver couple as a complex system and the meaning like an emergent phenomenon which characterizes it. In the end, all this could Our research can lead to an hypothesize another operative definition of "meaning" (expressing the meaning of "meaning"), beyond the possible abstract ones: *The meaning attributed to a message is the receiver's synthetic conscious report (through natural language) on the final state of his/her organism after experiencing the interaction with the message*.

Other possible consequences of our results are the following:

- The distinction between content and form of a message would lose its sense, given that the apparently most insignificant (from the sender's point of view) variation of the form can completely change the message's meaning (from the

receiver's point of view). Given a message, we simply could not distinguish what is "content" and what is "form", before the receiver interacts with it.

- Human beings do not interpret data or single signals/stimuli; rather they interpret *situations*. Again, the human approach to a message, as well as to the surrounding environment (natural or social), would work analogically, through the organism's resounding to a recognizable situation, rather than digitally, through a rational scanning of the available incoming information.

Opened questions. We have provided some data upholding our hypothesis and our discussion; at the same time, we are conscious that our results and our conclusions need to be confirmed. Among the undoubtedly several points to be checked, we highlight two main questions. The first one is linked to the matter of analogical vs. digital nature of the processes that contribute to meaning and knowledge building. Following our hypothesis, both the natures would be playing a role, each in a specific step of the interpretation process: "disassembling" has an analogical nature while the conscious processing has a digital one. The main question is the timing of these two steps: if conscious processing precedes, then some current models would be confirmed; if disassembling precedes, then our hypothesis would be confirmed. The problem is just to find a way in order to definitely answer such question, what does not seem easy.

The second point to be checked regards the reasons of the observed radical difference between the "H" choosers and "S" choosers group behaviours in terms of interpretation/choice coherence; about this, we think there are two possible hypotheses: (1) The two subsamples follow different paths in interpreting natural language messages

("S" choosers would base their choices on rational information processing, which would precede action, while "H" choosers would react instinctively and choose before analysing the available information); (2) The two subsamples actually follow the same path (automatic reaction preceding conscious information processing, in our opinion) and the difference they show is linked to the differences in their automatic reaction schemes ("S" choosers' reaction would privilege the attention to the relational aspects while "H" choosers' reaction would privilege the content aspects). We consider relevant such matter and we will not engage ourselves in extemporaneous considerations about it; rather, we have already begun to think to a dedicated specific research.

Conclusion

Human behaviour (communication through natural language and "understanding" included) must be rooted into biology. We consider established and thoroughly share this such idea; for this, our results have to pass the crucial test: valid compliance with the evolution theory. Specifically, we must ask asked ourselves if a conscious organism that reacts before rationally thinking (what our work seems to confirm) could be a valid outcome of the evolution process.

At present times, human beings live inside sophisticated societies; however, their biology is the result of natural selection and represents the best fitting in a **natural hostile environment**. Biologically, we are still "the ones of the stone and of the sling"[25]

[25] From the poem *Uomo del mio tempo* (Man of my age), of Italian poet (1959 Nobel Prize) Salvatore Quasimodo, 1947: *Sei ancora quello della pietra e della fionda, / uomo del mio tempo…* [You are still the one of the stone and of the sling, / Man of my Age…]. A complete text of the poem (original

even though, from a cultural slant, we can account for ourselves in different ways. Rational thinking is, undoubtedly, much slower in comparison to with intuitive automatic reactions; at the same time, in a natural environment, fast reaction capacities are a critical surviving factor. Thus, reaction preceding reflection appears to be consistent with the evolution theory. Human communication and culture could have begun by employing the new feature of language through such general rule: at first, perception would not start complex (and slow) information treatment; rather, the entire organism automatically would change its state and, "resounding" similar situations, would be primed for immediate action. Then, rational thinking would follow. Another possible example of the "exaptation" process (Gould & Vrba, 1982).

Summing up all the data, literature and considerations we have presented, two things remain to be said. The first is that, now, we have at least a hypothesis to describe how human beings understand or do not understand one another and their environment: it depends on the way they firstly react (biological level) to the inputs and then can manage (cultural level) their own reactions. The second is that, in such perspective, if there is any possibility to represent the human semantic approach to relationship with the surrounding environment through a computational device, then its model should be the whole human being, not the sole brain cortex. As a consequence Consequently, what really can prevent present times computers from imitating human thought is not insufficient data processing power or data storage capacity; rather, it is the lack of a special peripheral unit: a human body.

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language) is *available at* *http://www.incontroallapoesia.it/poesie%20salvatore_quasimodo.htm* (accessed 1 June 2015).

Acknowledgements

We thank Laura Baglietto, Andrea Baldini, Marco Calabrò, Leonardo Cavari, Hasna El-Hachimi, Alessandro Farini, Alessandra Gasperini, Maddalena Morandi, Claudia Santovito, Arabella Tanyel-Kung for their comments.

A special thanks to Fortunato Tito Arecchi for his suggestions; to Andrea Fiaschi and Christina Tsirmpa for their text revision; to Letizia Scrobogna for her contribution to data revision; to Irene Maffei for her final text survey and impact assessment.

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