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 (cognitivist and embodied cognition theories) 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.

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Methodology. Our field research involved a random sample of 102 adults. We submitted to 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 every message component works like a physical stimulus, eliciting readers' automatic (body level) reactions which precede 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 what expected, incoherence

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

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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 conscious knowledge, achieved through the attribution of meanings (semantic aspect) to the incoming signals and stimuli, which turns into the related building of concepts. The other animals can perform sophisticated reactions to the environmental inputs; however, they do not "understand" them. At the most, possibly, they can socially exchange some elementary learnings through imitation (about this, a classic study in Mainardi, 1988 and some recent example of research in 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 have 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 linguistics with biology and neurosciences (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 complexity in Deacon, 2012). Even though natural language has been traditionally approached under its profile of

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symbol-based system, the way it works cannot be reduced to a simple coding-decoding procedure. By one hand, a one-to-one correspondence among written signs (or spoken sounds) and words does exist; by 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 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. Our field research brings some contributions to such endeavour.

Research lines and ideas: a synthetic overview. The available scientific literature is so wide to make it impossible, 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; recently, even a "hard" natural science like physics has generated a "psychophysics" branch, specifically oriented to deepen the knowledge problem through the instruments of that discipline. Another trend, thanks to the extraordinary development of technology and informatics, is the enhancement of the studies that explore

[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 things and different words can be used to indicate the same thing.

[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.

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interpretation inside the neural processes of the brain cortex; the neuron-level research and the wide use of advanced imaging techniques (like fMRI) witness for this. All this considered, we can roughly outline a picture with two main scientific research lines:

- **Mind-centred approaches** – Understanding/interpretation is totally based on abstract (conceptual) knowledge. Information feeds are provided through the body (perception) but the "mind"[3] processes stimuli and incoming signals at symbolic level, transforming them in 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.
- **Body-centred approaches** – Understanding/interpretation is attained through a motor reaction of the body that can, at maximum, co-exist with conceptual knowledge. When an external stimulus/signal is perceived, it is firstly "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) in-

[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 subject: by one hand, the early survey of Sperry, 1952; by the other hand, the more recent works of Marcus, 2004; Rose, 2005; Zeki, 2010. In the context of this introduction, the "mind" is simply intended as a factor which, by following some theoretical positions, totally controls body through "superior functions" with respect to biological processes.

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formation 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 first group theories' main features 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). In addition to this, a browsing of the literature unveils a wide series of theories that, even if they differ in many details, 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 1, specially pages 20-22; for a synthesis of the cognitivism 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

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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[4], up until a new series of neurophysiological studies appeared, in the second part of XXth Century[5]. Such researches gathered evidence that the sequential processing theory and the supposed totally passive role of motor system are untenable. In addition, a leap ahead has probably been accomplished with the discovery of mirror neurons (di Pellegrino et al., 1992) and the following studies on them (for example Gallese, 2000; Rizzolatti & Craighero, 2004; Iacoboni et al., 2005; Rizzolatti & Sinigaglia, 2006). According to this theory, understanding would be firstly attained through a motor reaction of the body, "immediately and automatically"[6]. Cognition would be "embodied".

[4] 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 from the body experience).

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

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

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Embodiment of cognition, and its consequences on knowledge and interpretation process, are the object of a heated scientific dispute; 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 (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 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 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).

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, 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 ongoing dispute, a summary and a state-of-the-art outline can be found in Zipoli Caiani, 2013; apart from this, one of

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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).

In the end, it is worth dedicating a special mention to the sector of 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

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191 in the Artificial Intelligence (AI) studies[7]. Inside psychophysics, a specific sector
192 concentrates on what follows interpretation, that is confrontation among different
193 "apprehensions" (conscious perceptions); the result of such confrontation is a
194 "judgement", that is decision and conceptualization (Arecchi, 2010a; 2010b; 2010c;
195 2011a). New concepts are introduced to investigate semiosis: semantic and non-semantic
196 complexity (Arecchi, 2008), deterministic chaos (Guastello, 2002; Arecchi, 2011b),
197 inverse Bayesian inference (Arecchi, 2010d), creativity as NON-bayesian process
198 (Arecchi, 2010e), quantum dynamics (Arecchi & Kurths, 2009; Nathan et al., 2012) and
199 the reference to Gödel's incompleteness theorem as a limit to the possibility of
200 understanding cognition "from inside" (since that, while studying cognition, we become
201 a system that investigates itself)[8].

202 At the end of our overview, we got the impression that the two research lines not
203 only present evident differences, but also have something in common. Indeed, they both
204 refer to the brain cortex like to the venue of "representations"; these are intended as
205 models, schemes, codifications, in certain cases "maps" having a crucial role in the
206 process of understanding. For the mind-centred theories, such representations are of a
207 propositional kind and result from the symbolic processing of sensorial inputs (all in all,

50 [7] The origins of Artificial Intelligence (AI) studies can be traced back to the Thirties and the works of
51 Turing on a possible "intelligent machine". About the origins see Leavitt, 2007, chapters 6 and 7, and
52 Turing, 1950 (the original work of Alan Turing). About the "Turing test" (testing the ability of
53 distinguishing humans from computers through written messages exchanges) see a journalist's
54 account in Christian, 2012. Some materials about recent research threads, closer to our article's topics
55 (like machine learning and natural language or image interpretation), can be found in Mitchell, 1997;
56 Menchetti et al., 2005; Mitchell, 2009; Khosravi & Bina, 2010; Verbeke et al., 2012.

57 [8] See Goldstein, 2006 for a popular-scientific coverage about Gödel and his theorem; Leavitt, 2007,
58 chapters 2 and 3, for a particularly clear synthesis of the theorem and of its genesis (in connection with
59 the *Entscheidungsproblem*, i.e. the "decision problem").

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they *are* the conceptual knowledge); for the body-centred theories, they are motorial and provide immediate, automatic answers to the inputs (such answers possibly preceding a conscious processing of the incoming stimuli). The representations' biological (neuronal) foundations are not yet well understood; there are different opinions even on their deep nature (states or processes). However, representations seem to be universally accounted as a necessary condition for cognitive processes.

Method

One main reason why all this matter has not yet been cleared is that there are still structural obstacles of technical and ethical nature[9]. Another difficulty is the 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. The methodological aspect is crucial, and

[9] About the technical difficulties of data collecting: experimental techniques used on macaque monkeys (electrodes direct insertion inside single neurons) return very accurate measuring, but on small brain cortex surfaces. About ethic difficulties: these techniques are quite 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 Rizzolatti & Sinigaglia, 2006, chapters 2, 6, 7, and Rizzolatti & Vozza, 2008, *passim*. A recent thread 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 reliable correspondences.

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we delved a little further into it. Some of the mirror neurons discoverers and theorists have expressly tackled the question and highlighted that one strong point of the neurophysiological research that led to their discovery is the researchers' preference for a naturalistic-like approach: they let observed macaque monkeys freely interact with available objects, rather than stimulate them with selected artificial stimuli only (Rizzolatti & Sinigaglia, 2006, p. 3). About the reductionism question, and the distinction between methodological and ontological reductionism, see Gallese, 2000, p. 26, and Gallese, 2009b; Gallese, 2010. Opposite to these stances, 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, we had in our background two works about interactions inside online collaborative groups (Maffei, 2006; Maffei, Cavari & Ranieri, 2007) which let us appreciate the potential of scientific observation on real-world communication cases. Thus, for our research, we tried a naturalistic approach, designing observations in conditions the closest as possible to the natural ones. On these bases, we designed field research on a random 102 adult sample, 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-

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246 samples drawn from it for control purposes in SI Section 6 with Tables S3-S5; some
247 quantitative aspects of collected data in SI Section 7; quality check of the collected data,
248 their compliance with the research necessities and their suitability in SI Sections 8 and 9
249 with Tables S6, S7 and Fig. S1-S3.

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

261 Our work is not a clinical trial and no experimentations on the participants took
262 place. Our sample was not recruited in hospitals or any other institution; we gathered it
263 through the conductors' personal relationship network (details on sampling and survey
264 modalities in SI Section 3, particularly points 10.-13.). In addition, no personal data was
265 collected or anyhow involved in the survey. Through our questionnaire, we just
266 collected, in a strictly anonymous way (details here below and in SI Section 3), the
267 participants' opinions about an exchange of written messages, in order to investigate the

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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; we anyway requested, and obtained, the approval of the Ethics Committee for Scientific Research of the Association ARPA-Firenze. The Committee held a dedicated session to our research (in 2012, april 2d) 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 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

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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.

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. SI Section 4 for the messages' and the questions' texts.

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 that each questionnaire's

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question sent two inputs to the respondents: at first, they 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. 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.

Answers to the questions' first input: qualitative analysis. These answers have fully confirmed the expected wide 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[10]. Inside our research, the answers to Question #2 provide us a specific example. Firstly, we asked participants if, through comparing Message #3 to Message #1, they found the attitude of XX (the sender) toward YY (the receiver) being changed (SI Section 4 for the messages' and questions' texts). Then, to the 61 who answered "YES" (60% of the sample), we asked to specify how they would define the new XX's attitude. They provided 83 specifications: 64 stated XX's position as strengthened, 12 as weakened and 7 unchanged (although these seven, too, had answered "YES" to the first

[10] Specifically: 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 communication event).

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part of Question #2). In addition, we can find completely opposing statements in these specifications and we can see that scattering covers very different aspects of the XX-YY interaction (behaviours, emotions and so on, Table 1).

Such a phenomenon can be observed for all the messages and for any part of them, even if accurately selected: it is impossible to find parts of a message that are interpreted in the same way by all the participants. The observed interpretation scatter can be represented through a "megaphone-shape" picture (Fig. 1): receivers take the same information into account but their final interpretations diverge[11]. We named this phenomenon "classic interpretation scatter" and tried to delve further into it. We made a first attempt using a semantic approach: we considered the respondents' answer texts like semantic sets to be investigated through pre-defined categories of meaning. After several tries, we abandoned such approach realizing that, whatever category set we used, too many exceptions, not-decidable cases and ambivalences we found (what confirms the "equivocal nature" of human language, see Footnote 1).

Answers to the questions' second input: quali-quantitative analysis. These answers contain the "concrete elements" respondents have indicated as the basis of their interpretations. We found the following categories of concrete elements:

- Summaries of the message texts and syntheses of the information content, presented through respondent's own words.

[11] 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 cannot be under question (being the message typed and having a unique editing).

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- 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).
- Incidental strings, meaningless *per se*. Such strings were extracted from original full phrases and quoted isolated from the rest.
- Complement/accessory parts of the text: punctuation marks[12], personal or professional titles used in the opening, the salutes used in the closing etc.
- Items unrelated to the text semantics or to the message content; a tight selection is presented in Table 2. The list 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 2, final row).
- References to some overall effects produced by the message on the respondent (see SI Section 8.a, final part, for details). In fact, in this kind of answers respondents 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".

[12] 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*.

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371 In such analysis we have tackled the answers like something *physical*, rather than
372 symbolic, and have treated their texts independently of their content and meaning. Doing
373 so, we have seen that the meaning can spring from parts of the message bereft of any
374 intrinsic content, from aspects external to the text and even from the lack of content
375 itself. In short: whichever the message, the source of its meaning can lie anywhere; this
376 was unexpected. In truth, the idea that the interpretation of a message is a question far
377 overtaking its pure words is widely investigated with regards to spoken communications;
378 this is reasonable if we consider the possible added signals, like non-verbal language and
379 context stimuli, in such situation (see, for example, Horchak et al., 2014, specially the
380 concept of "situated cognition", and Gibson, Bergen & Piantadosi, 2013). It has been
381 quite surprising to discover it in written communications, that are totally bereft of such
382 added signals; there was something else, in this matter, and it did not seem a simple
383 question of added information. Indeed, our impression that the meaning attributed to a
384 message can lie "anywhere" should be taken into a literal account: it seems impossible to
385 previously write up a "complete" list of the items that could become sources of meaning,
386 given that any new reader can introduce new subjective criteria and detect new sources
387 totally unpredictable for the other readers. The question now is: how does all this work?
388 How can we describe, and model, the process of interpretation, subjected to such
389 uncertainty?

390 In order to answer these questions, we named "components" the items indicated
391 in the answers to the questions' second input and went back to the questionnaires in order
392 to tally the components present in our survey. We have tallied a total of 1,319

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components clearly indicated by participants and we have displayed in Table 3 their absolute and relative amounts. Indications that clearly focus on the information content constitute only a small minority (around 12%, see Table 3, "%" row, "Cont." column) while references to different text components reach, on the whole, about 65% (Table 3, "%" 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 relative amount can be estimated in at least 35% (holding together symbols, incidental passages, other components and grammatical notations).

In order to verify our statement, we firstly carried out a distribution analysis about the components. This analysis returns a picture without any significant imbalance: sample's indications are uniformly distributed with respect to the different questionnaire's questions (Fig. 2) and quite-normally distributed with respect to the types of the components (Fig. 3). Similar results are obtained analysing the sample distribution with respect to the amount of component types employed and to the total indications provided by each respondent (Fig. 4, 5). 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, we carefully re-examined the filled questionnaires about the information content component. We found (Table 4) that one half of the sample (51 people) expresses, among the others, at least 1

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415 reference to such component (no recordable similar hint by the other half). However,
416 only 7 respondents provide a balanced or prevalent amount of indications (50%, or more,
417 of the personal total) about information content. Among them, only one reaches 100%. In
418 fact, references to the information content confirm themselves as a definite minority in
419 participants' indications.

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

423 ▪ The interpretation process looks to be starting like a selective and subjective
424 picking up of (or focusing on) the most different components, rather than be-
425 ing a systematic, conscious scanning of the text's content. Such behaviour is
426 widely scattered: in the whole research, with regards to each specific message,
427 it is impossible to find two identical combinations of focused on components.
428 ▪ Readers seem to interpret a message indifferently picking up meaningful and
429 meaningless components and subjectively combining them. While reading and
430 text decoding go ahead sequentially, readers go on freely (randomly, from an
431 external observer's point of view) isolating "chunks" of the text (as well as
432 other components and even external context aspects) and selecting them as the
433 foundation of the message's meaning.
434 ▪ While the final meaning attributed to the message is justified through the se-
435 lected components, no reason (at all, in any cases) is provided for that selec-

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436 tion: in the respondents' accounts, the focused components suddenly appear;
437 they are presented just as "given", and without any doubt[13].

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

445 *A disassembling example in detail and a perceptual hypothesis*. Question #1
446 requests evaluations with regards to sender-receiver positions and to the relationship
447 between them, on the basis of Messages #1 and #2 (SI Section 4 for the messages' texts).
448 We found that 53 people (52% of the sample) had quoted an expression the sender (XX,
449 see SI Sections 2, 4) used in Message #1[14]: she premised her request of a technician
450 inspection with the words "we would be pleased if at least once…". This simple
451 expression, apparently trivial (also short, 8 words in a 67 word message, and in no way
452 highlighted in comparison to the rest of the text), has collected 68 quotations (15 people
453 expressed two, see Footnote 14). Then, respondents have given such specific passage at
454 least 22 divergent interpretations, summarized in Table 5.

111 [13] Just 1 participant (out of 102) declares uncertainties in his final choice. He writes that the final effect
112 could be obtained with both the messages under choice. This is the unique doubt expressed in the
113 whole research. In addition, it must be noted that, while answering the other questions, also this
114 special participant expresses himself in a totally doubt-free way, like the rest of the participants.

115 [14] The 53 people have expressed their interpretations answering Question #1-a (23), #1-b (15) or both
116 the questions (15). See SI Section 4 for the questions' full texts.

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455 This means that focusing on the same component does not imply convergent
456 interpretations. As much as to say that the interpretation scatter manifests at both levels:
457 the disassembling (scattering of focusing on components) and the successive attribution
458 of meaning (each sub-group, focused on a same component, provides scattered conscious
459 interpretations). This means also that the "funnel-shape" picture, too, must be revised:
460 what we observed could be better expressed through an "hourglass-shape" picture (Fig.
461 7). In fact, disassembling and classic interpretation scatter would co-exist and manifest
462 themselves **in sequence**. We notice that the expression we are discussing appears to be a
463 minor element in Message #1 text, something incidentally expressed; it is composed
464 using common words and bears no inherent information content (once the passage gets
465 isolated from the rest of the message, it is impossible to attribute it a definite meaning).
466 In short: it is a mere form component. So, how could respondents select such incidental
467 passage? And what did they, exactly, grasp in it? What is more, given that the following
468 interpretations are scattered, what did respondents, exactly, interpret, having started from
469 an identical, spontaneous selection?

470 Now, the message we have used in our research was always the same, invariable
471 with regards to written form as well as to information content. Thus, if the interpretations
472 of the readers are so scattered, this cannot depend on the message itself, it must depend
473 on the readers: they evidently give an active contribution in attributing meanings, they
474 are not passive symbol decoders. Nothing new, so far: our observations confirm old
475 ideas, for example the ones that the constructivist hypothesis proposed many years ago
476 (Watzlawick, 1984). The question is: how can this happen? By one hand, respondents

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477 explain through the outcomes of "disassembling" the conscious attribution of meaning
478 that follows; by the other hand, no accounts report about the source of disassembling.
479 The selective focusing manifests "immediately and automatically", apparently preceding
480 and feeding the conscious processing that follows, and that is all.

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

488 ▪ Considering interpretation as a process, decoding of written signs must be its
489 first step, for turning them into words. Decoding is the "technical" aspect of
490 reading, not directly linked to meanings and just feeding the following steps.
491 ▪ Along with the sequential decoding, words and the other message components
492 would immediately act like stimuli, triggering a receiver's automatic reaction
493 off ("body" level). This would be the second step, i.e. disassembling. Its res-
494 ults would be different from a person to another given that the capacity of a
495 component to act like a stimulus depends on the subjective reactivity of each
496 receiver.
497 ▪ Then, the conscious processing of the collected inputs would start. Being the
498 steps set in a cascade, the "input" on which this third step would be carried out

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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 is what oriented the following conscious process. One more question remains: 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 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 6). This clarifies what of the incidental passage ("we would be pleased if at least once…") has triggered the participants' reaction off: the fact that XX had (redundantly) placed it in a certain point of the message[15].

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).

[15] 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".

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519

520 **The second part of the research: checking the hypothesis**

521 Our research's second part represents a first check about our hypothesis. We
522 started submitting to participants two alternative versions (Messages #4/H and #4/S) of a
523 possible reply to Message #3. Then we asked them to, firstly, interpret (independently)
524 the two versions (Questions #3 and #4) in terms of their effects on XX; secondly, to
525 choose between them (Final question) the one suitable, in their opinion, to origin the final
526 XX's answer (Message #5, that seals the positive ending of the case; see SI Section 4 for
527 messages' and questions' full texts; Section 5 and Tables S1, S2 for details about the
528 reasons of the alternative). Our check's rationale was the following: the participant's
529 choice could come as a result of the text information's conscious processing (cognitivism
530 stance) or as an automatic reaction preceding every conscious processing (embodied
531 cognition stance). In the first case (our "Hypothesis 0"), the final choices should be
532 outcomes of the interpretations given to the messages; thus, they should result somehow
533 correlated with them. In the second case, no correlation, or a different kind of correlation,
534 should be found (our "Hypothesis 1"). The problem emerged of measuring such
535 correlation.

536 *The coherence between interpretation and choice*. Firstly, we displayed (Table 7)
537 the choices indicated by the sample members(SI Section 6 and Tables S3-S5 for the sub-
538 samples description) and found out a strong imbalance between "S" and "H" indications.
539 Secondly, we compared the interpretations of Message #4/H with those of Message #4/S
540 (SI Section 4 for messages' full texts). Source data (opened answers) was purely

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qualitative. However, answers were easily classifiable into two main categories: predictions for the message inducing a solution of the case (easing or 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: "+" 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-). The combination of the two symbols indicates the combined predictions each participant expressed about the effects: H+/S+ (both the messages 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 8). There is a clear convergence on combination "H-/S+"; the chi-squared test highlights, at this first stage, that some correlations between "H" and "S" interpretations could exist ($p = 0.001988$, total sample; $p = 0.015600$, sub-sample "AGE"; $p = 0.003861$, 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 factor drives both of them.

Then, we cross-checked the combinations with the final choices (Table 9). The most frequent combination (H-/S+) appears to be strongly associated to "S" choice; indeed, the significance tests (chi-squared) show that some further relations do exist between combined interpretations and choice ($p = 0.000017$, total sample; $p = 0.001174$, sub-sample "AGE"; $p = 0.000383$, sub-sample "EMPLOYMENT"). Such results led us

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facing the core-question related to our hypothesis: given the existence of some correlation between choice and combined interpretations, what is its direction? We mean: do the interpretations drive the choice (cognitivism stance) or, oppositely, does the choice precede and someway 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):

- The final Message #5 clearly indicates XX's satisfaction; therefore, the conflict has come to its end.
- Now, let us figure a respondent whose answers to Questions #3 and #4, for example, return a combination H+/S- (Message #4/H solving the conflict, 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.
- If another respondent provides the same combination but indicates Message #4/S in his final choice, this would represent the minimum coherence level.
- 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 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).

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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 10. In this way, it has been possible to study the final choice with respect to the coherence levels (Table 11). The percent distribution histogram of the whole sample (Figure 9, data from Table 11) shows that the distribution is the expected one 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 the lowest frequency of all. On the contrary, we found L values higher than the LM ones and representing 11% of the sample.

At this point, we refined our analysis through separately analysing 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 in the total sample). Data is displayed in Table 12, 13, 14, which show a surprising asymmetry. Graphic representations render even better such asymmetry: the total sample histograms (Fig. 10, percent distributions from Table 12) show that the percent frequency of "S" choosers (white bins) increases regularly from L category to G, reminding (as expected) of certain power, or exponential, curves. At the opposite, the percent frequency of "H" choosers (grey bins) is arranged in an irregular, almost bimodal shape. We checked these distribution shapes by using many different sub-samples (selection displayed in Fig. 11-16), included the already mentioned "Age" (Fig. 15, data from Table 13) and "Employment" (Fig. 16, data from Table 14) sub-samples. We always obtained the same imbalance. At this point, we have expressed the coherence levels through integer

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numbers (L=1; LM=2; MG=3; G=4), we have applied the ANOVA test to all of the groups represented in Fig. 11-16 and always obtained significant results (Table 15).

Such asymmetry, along with its permanence on different sub-samples, contrasts our "hypothesis 0": if the participants' final choice would depend on the interpretations of the two alternative messages, then the behaviours of "H" choosers and "S" choosers subsamples would be similar, and we would find the same shape (some kind of regular increasing from Low to Great coherence levels) in both the distributions. On the contrary, the observed difference indicates group behaviours correlated with the expressed choice, rather than with interpretations. Such conclusion is upheld by a control analysis: we have further applied the ANOVA test studying the variance of the coherence level in the different sub-samples of Table 15, separately for "H" and "S" choosers. The results ("H" choosers = 0.247; "S" choosers = 0.016) show no significance. As much as to say: no significance "within" the choices; high significance "between" the choices.

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 indicator, its employment and relative analysis in SI, Section 10 with Tables S8-S11. No contradiction has been found 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 the scientific research; finally, we will discuss

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626 some possible consequences of our results and indicate the possible directions in which
627 this study could be developed.

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

631 ➢ In all circumstances, the interpretation of natural language is a complex,
632 global experience not reducible to the interpretation of isolated spoken or
633 written words. *Experimental reference to our qualitative analysis of the*
634 *participants' answers to the first input of the questionnaire's first part*
635 *questions (specifically: description of the message non-word and meta-*
636 *information components, that prevail over verbal components and firstly*
637 *orient the reader's interpretation)*.

638 ➢ After decoding, a random, selective focusing on the most various and
639 unpredictable components of the message ("disassembling") starts, preceding
640 and preparing the following conscious processing of the information content.
641 *Experimental reference to our qualitative analysis of the participants'*
642 *answers to the first input of the questionnaire's first part questions*
643 *(specifically: observations about the sudden appearance, extreme subjectivity*
644 *and unexplained origin of the widely divergent and unpredictable selective*
645 *focusing).*

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- "Disassembling" looks like a stimulus-reaction mechanism, rather than an information treating process. *Experimental 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's first part 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. *Experimental reference to our quantitative statistical analysis of the participants' answers to the questionnaire's second part 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[16]. C*onsequence of the "in a cascade" setting of our model's three steps*

[16] 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

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(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.

Situating our work in the current research scenario. Scientific research of the 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

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 stdying it from a different point of view and through a different approach. The final result is the expert's solution of the case.

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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 problem which can be considered common to the two research lines: the use, during the experiments, of 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). The methodological issue elicits a further consideration: there is a cross-concept widely (if not fully) and implicitly shared by cognitivism and embodied theories, namely the idea that the meaning is something embedded inside words. These would work someway 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 (as 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 merely conceptual and resulting from a unidirectional 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

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706 would be embodied[17]. Now, how could our work be positioned in such picture? In a third
707 position, we would say. In fact, it is to be observed that both the approaches we have
708 argued about are based on the implicit idea that human communication is a continuous,
709 uniform process. On the contrary, we hypothesize discontinuity, with the interpretation
710 process made-up of three discrete, in-a-cascade steps; this could easily encompass both
711 the current ideas.

712 Actually, in our opinion, the embodied concept's features are clearly akin to our
713 second step ("disassembling", see Fig. 8): an immediate and automatic reaction that
714 precedes conscious processing of information. This last (our third step, Fig. 8) is clearly
715 akin to the cognitivist hypothesis, that refers to a conscious processing of the inputs with
716 subsequent conceptual output. We must add that such overlapping is just one aspect of
717 the question; our proposal entails at least one important difference with respect to the
718 current theories: the discrete, in-a-cascade structure of the process implies a feeding
719 chain, with the first step (decoding) that feeds the second (disassembling) which, in turn,
720 feeds the final one. This results, after "disassembling", in the loss of the contact with the
721 source message and in the conscious processing performed on the body-reaction signals
722 (presumably received through proprioception). The real object of our (first level, see
723 Footnote 16) knowledge would not directly be the outer world; rather, it would be our
724 instinctive reactions to it (the outer inputs combined with our inner world). This is a

157 [17] Such embodiment, inside the same embodied cognition field, can be conceived in different ways: it can
158 stand alone, *per se* resolving the problem of knowledge ("sensorimotor processing underlies and constitutes
159 cognition", Guan, 2013), or can be a "motor representation" that accompanies conscious knowledge
160 processes (the two kinds of knowledge proposed by Gallese, for example in Gallese et al., 2011; see also
161 Gallese, 2014).

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725 relevant point, and we have selectively examined the available literature for a first check
726 of it.

727 Conscious thinking following (rather than preceding) "body" reaction can be
728 traced back up to the hypotheses of Nineteenth Century philosopher and psychologist
729 William James. In one of his examples (the "James's bear", see James, 1890, Chapter
730 XXV), James explains his theory of emotions suggesting that, for example (our
731 synthesis), we do not run away from a bear because we have seen it, we were scared of it
732 and, consequently, we consciously decided to run (as common sense would sustain).
733 Conversely, we feel like we are afraid because we find ourselves (consciously and
734 successively) having started a desperate run. In other words: what we call "emotion" is
735 usually intended as a body reaction consequent to the rational processing of consciously
736 perceived environmental stimuli; James suggests that the body reaction follows
737 perception immediately and what we call "emotion" is the consciousness of the new
738 body state (a form of self-consciousness). We are aware that James's theory (exactly:
739 James-Lange theory) has been criticized and opposed through several alternative theories
740 (for example Cannon, 1927; Schachter & Singer, 1962); nevertheless, we do refer to it
741 because recent scientific research and reviews seem to suggest some re-consideration of
742 the matter (for example, Friedman, 2010). We will not deepen the question here;
743 however, we feel that James-Lange's intuitions could deserve another chance.

744 In Twentieth Century, we can find the Gregory Bateson's approach to human
745 communication as a system and to the question of the receiver's active role; he uses a
746 strictly formal presentation (see Bateson, 1972, in particular Chapter 4.8 on the logical

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747 categories of communication, founded on Russel and Whitehead's theory of logical
748 types). In addition, we remind of a group of theories and models (which repeatedly refer
749 to Bateson's studies) that tackle the question mainly from a pragmatic slant: the so called
750 "pragmatic models" (Berne, 1961; Watzlawick, Beavin Bavelas & Jackson, 1967;
751 Bandler & Grinder, 1975). Conceived inside a psychoanalytic context, they all put
752 perception and stimuli at the centre of their attention and reverse the relationship between
753 action and thought using action (rather than thought) to induce training and therapeutic
754 effects[18]. We find no important contradictions among our hypotheses and such models;
755 rather, we find complementarity: they show how physical stimuli can act like messages;
756 our results tell that words (even if only written) can act like physical stimuli. What is
757 more, we can suggest an explication of an unsolved point related to them: the biological
758 foundations of the "aspect of relation" in human communication (Watzlawick, Beavin
759 Bavelas & Jackson, 1967). On the basis of our results, this aspect could be exactly the
760 body-level automatic reaction which precedes the conscious information processing.

761 About the relevance of unconscious processes in human behaviour, some
762 fundamental clarification is provided by Custers & Aarts, 2010 through a review of
763 experimental works that re-examines the disputed question of the passage from

166 [18] By one hand, it is worth mentioning a special work coming from NLP founders (Grinder & Bandler,
167 1979): it appears quite different from the work that founded this theory (Bandler & Grinder, 1975) and
168 that has successively been developed by NLP specialists (for example Dilts, 1998). As a matter of
169 fact, that work gives a central role to perception and to physical stimuli (not mediated by language) as
170 a possible communication and therapeutic instrument (see, in particular, the concept of "sensorial
171 anchors" in Grinder & Bandler, 1979). By the other hand, we should remind a Watzlawick's work on
172 the modern evolution of psychotherapy (Watzlawick, 1987) that represents a severe critic to the
173 classic approach and reverses the relation between action and thought (an Italian translation is
174 retrievable in Nardone & Watzlawick, 1990, Chapter 1). In the same Nardone & Watzlawick, 1990,
175 see also chapter 2 on perception as one main source of psychopathology.

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764 perception to action. The authors compare the traditional positions of Sensory-motor
765 Principle (SMP, for example Massaro & Cowan, 1993; and, for a presentation and
766 discussion about the sequential processing of stimuli conceived as the foundation of
767 human/environment interactions see also Rizzolatti & Sinigaglia, 2006, chapters 1, 2)
768 and Ideomotor Principle (IMP, Stöcker & Hoffmann, 2004; Pezzulo et al., 2006; Melcher
769 et al., 2008; and, for a synthesis, Iacoboni, 2008, Chapter 2, pp. 56-57 of Italian edition).
770 In so doing, they show how certain stimuli (images, solid objects or even written words),
771 intentionally added to an experimental setting, can alter the sample behaviours, even if
772 such stimuli are not consciously detected: "under certain conditions, actions are initiated
773 even though we are unconscious of the goals to attain… [and] goal pursuit can… operate
774 unconsciously" (Custers & Aarts, 2010). They also sustain that arguments frequently
775 presented as rational motivations for action are, actually, *ex-post* justifications of
776 unconsciously performed behaviours.

777 The role of physical stimuli in swaying communication through natural language
778 is confirmed by a series of recent works (for example Zhong, Bohns & Gino, 2010; Tsay,
779 2013; and, for a popular-scientific coverage, Lobel, 2014). Further, quite unpredictable,
780 factors that can sway message interpretation can be the specific national languages used
781 (for example Marian & Kaushanskaya, 2005; Costa et al., 2014) or the metaphors used to
782 express concepts (Thibodeau & Boroditsky, 2011; Thibodeau & Boroditsky, 2013). Our
783 data is consistent with all this in that it confirms precedence of perception-reaction with
784 regards to conscious processing.

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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*).

In our opinion, embodied cognition hypothesis looks at the act of pouring in its **purely motor** 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. 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 dynamic status of the bottle content. 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.

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807 *Some possible consequences*. One main consequence of our results, once they
808 will be confirmed, would concern the nature of words. We are used to consider words
809 quite exclusively in their symbolic nature; however, our research shows that they could
810 have a double nature: they could work like symbols as well as physical stimuli. In a
811 specific circumstance, which of the two natures will be active depends on the subjective
812 "disassembling" performed by the receiver, rather than on the sender's intentions. This
813 implies that which nature is in action will become observable only at the moment of the
814 receiver's interaction with the message. This is very similar to what happens in certain
815 physics phenomena, for example the double nature of light (waves/particles) or the
816 uncertainty about some features of many atomic particles: the ambivalence is solved just
817 in the process of measuring the phenomena (Zeilinger, 2010, for a discussion about the
818 case of photons and von Baeyer, 2013 for a recent point of view about such
819 ambivalence). All this entails what follows:

820 ➢ There is a structural uncertainty in the human communication general process:
821 when a sender sends a message, he/she has the intention to produce some
822 effects on the receiver (his/her communication has a goal, this is the
823 pragmatic aspect); however, the actual effects the message will produce will
824 depend on a sub-process (interpretation) that is under control by the receiver,
825 not by the sender. Uncertainty is linked to the irreducible subjectivity of the
826 receiver's "disassembling"[19].

182 [19] Another way to express such concept is considering the sender-receiver couple as a complex system,
183 and the meaning like an emergent phenomenon which characterizes it (about this specific matter see,
184 for example, Guastello, 2002).

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- Such subjectivity is not just a question of interpretation scatter, with regards to 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 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. 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. Such feature could heavily affect the possibility to reproduce human interpretation process on digital computers, regardless of their calculation power and data storage capacity; the two systems could result not only different, rather incompatible. We are not the first to propose such observation (for example Arecchi, 2008; Arecchi, 2010b;

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849 Arecchi, 2010c on the non-algorithmic nature of knowledge and intelligence). In the end,
850 all this could lead to an operative definition of "meaning" (expressing the meaning of
851 "meaning"), beyond the possible abstract ones: *The meaning attributed to a message is*
852 *the receiver's synthetic conscious report on the final state of his/her organism after*
853 *experiencing the interaction with the message*.

854 Other possible consequences of our results are the following:

855 ➢ The distinction between content and form of a message would lose its sense,
856 given that the apparently most insignificant (from the sender's point of view)
857 variation of the form can completely change the message's meaning (from the
858 receiver's point of view). Given a message, we simply could not distinguish
859 what is "content" and what is "form", before the receiver interacts with it.
860 ➢ Human beings do not interpret data or single signals/stimuli; rather they
861 interpret *situations*. Again, the human approach to a message, as well as to the
862 surrounding environment (natural or social), would work analogically, through
863 the organism's resounding to a recognizable situation, rather than digitally,
864 through a rational scanning of the available incoming information.

865 *Opened questions*. We have provided some data upholding our hypothesis and
866 our discussion; at the same time, we are conscious that our results and our conclusions
867 need to be confirmed. Among the undoubtedly several points to be checked, we highlight
868 two main questions. The first one is linked to the matter of analogical vs. digital nature of
869 the processes that contribute to meaning and knowledge building. Following our
870 hypothesis, both the natures would be playing a role, each in a specific step of the

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871 interpretation process: “disassembling” has an analogical nature while the conscious
872 processing has a digital one. The main question is the timing of these two steps: if
873 conscious processing precedes, then the current models would be confirmed; if
874 disassembling precedes, then our hypothesis would be confirmed. The problem is just to
875 find a way in order to definitely answer such question, and it does not seem something
876 easy. Some clues upholding the second hypothesis can be found in Guan et al., 2013.

877 The second point to be checked regards the reasons of the observed radical
878 difference between the “H” choosers and “S” choosers group behaviours in terms of
879 interpretation/choice coherence; about this, we think there are two possible hypotheses:
880 (1) The two subsamples follow different paths in interpreting natural language messages
881 (“S” choosers would base their choices on rational information processing, which would
882 precede action, while “H” choosers would react instinctively and choose before analysing
883 the available information); (2) The two subsamples actually follow the same path
884 (automatic reaction preceding conscious information processing, in our opinion) and the
885 difference they show is linked to the differences in their automatic reaction schemes (“S”
886 choosers’ reaction would privilege the attention to the relational aspects while “H”
887 choosers’ reaction would privilege the content aspects). We consider relevant such matter
888 and we will not engage ourselves in extemporaneous considerations about it; rather, we
889 have already begun to think to a dedicated specific research.

890

891 **Conclusion**

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892 Human behaviour (communication through natural language and "understanding"
893 included) must be rooted into biology. Such position can be considered established, even
894 though many details still need to be cleared and it is not yet universally accepted. We
895 share this idea; for this, our results will have to pass the crucial test: valid compliance
896 with the evolution theory. Specifically, we must ask ourselves if a conscious organism
897 that reacts before rationally thinking (what our work seems to confirm) could be a valid
898 outcome of the evolution process.

899 At present times, human beings live inside sophisticated societies; however, their
900 biology is the result of natural selection and represents the best fitting in a **natural**
901 **hostile environment**. Biologically, we are "still the ones of the stone and of the sling"[20]
902 even though, from a cultural slant, we can describe ourselves in a very different way.
903 Rational thinking is, undoubtedly, much slower, in comparison to intuitive reactions; at
904 the same time, in a natural environment, fast reaction capacities are a critical surviving
905 factor; thus, reaction preceding reflection appears to be consistent with the evolution
906 theory. Human communication and culture could have begun by employing the new
907 feature of language through such general rule: at first, perception would not start
908 complex (and slow) information treatment; rather, the entire organism automatically
909 would change and, "resounding" similar situations, would be primed for immediate
910 action. Then, rational thinking would follow. Another possible example of the
911 "exaptation" process (Gould & Vrba, 1982).

193 [20] From the poem *Uomo del mio tempo* (Man of my age), of Italian poet (1959 Nobel Prize) Salvatore
194 Quasimodo, 1947: *Sei ancora quello della pietra e della fionda, / uomo del mio tempo…* [You are still
195 the one of the stone and of the sling, / Man of my Age…]. A complete text of the poem (original
196 language) is *available at http://www.incontroallapoesia.it/poesie%20salvatore_quasimodo.htm*
197 (accessed 1 Sept 2014).

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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, if human semantic approach to the surrounding environment could ever be represented through a computational model, then the "computer" should be the whole human organism, not the sole brain cortex. As a consequence, what really could prevent present times computers from imitating human thought would not be insufficient data processing power or data storage capacity; rather, it could be the lack of a special peripheral unit: a human body.

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Figures

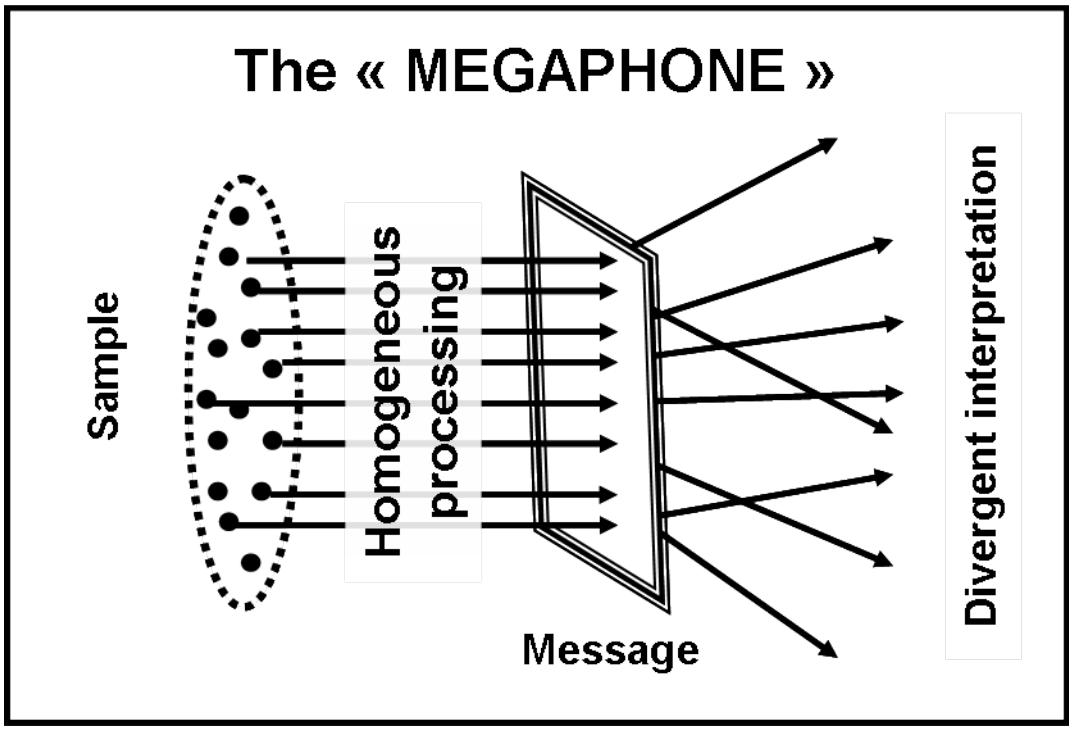

Figure 1: The "megaphone-shape" model.

If the interpretation of a message should be linked only to the processing of its information content, then we would expect a uniform interpretation, given that the source information is absolutely identical for all the participants. On the contrary, a wide scatter is always observed and its process can be represented with a "megaphone-shape" model: information would be homogeneously processed but differently interpreted.

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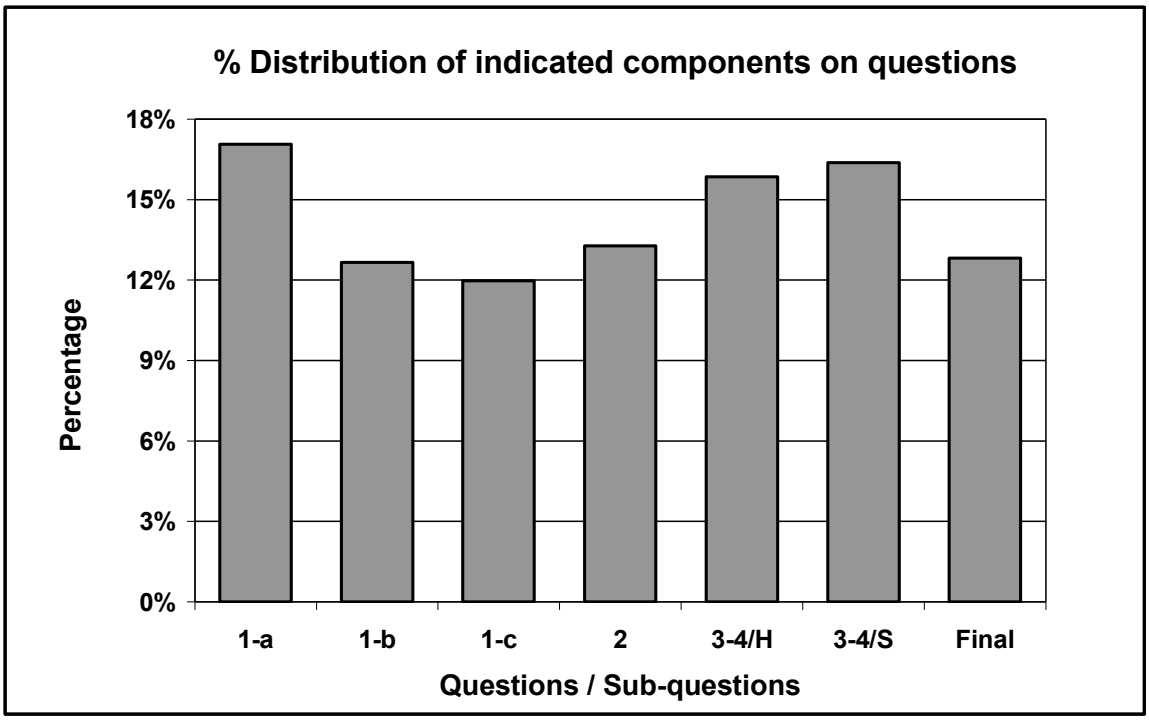

1333

1334 **Figure 2: Percent distribution of total indications with respect to questions/sub-**

1335 **questions.**

1336 With respect to questions, the respondents' total indications about the focused

1337 components present a flat-like percent distribution (differences in a range around 5%,

1338 from 12% to 17% about, source data from Table 3, "%" column). The range reduces to

1339 around 3.6% (from 12.8% to 16.4% about) if we group together the three sub-questions

1340 of Question #1 and consider their mean (the reason is that the answers to Questions #1-b

1341 and #1-c are often given in short, indicating reference to the already provided answer to

1342 Question #1-a). The indications are distributed without any significant imbalance among

1343 the different questions of the questionnaire. The approach through subjective selective

1344 focusing does not definitely advantage any question or item.

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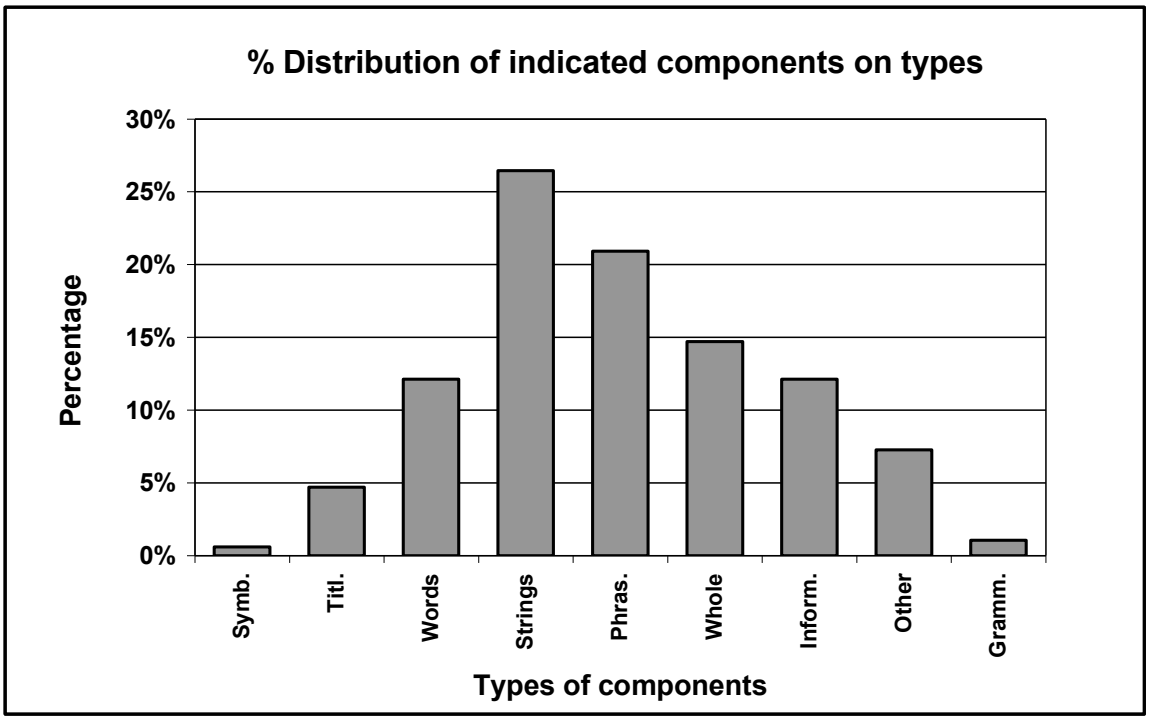

1347

1348 **Figure 3: Percent distribution of total indications with respect to types of**

1349 **components.**

1350 [Legend: Symb. = Punctuation marks; Titl. = Title/salutes (opening and closing
1351 expressions); Phras. = Complete phrases/periods; Whole = References to the message as
1352 a whole; Inform. = Information content; Gramm. = Grammar notations (verb tense etc.)]

1353

1354 The respondents' indications have been grouped in bins by type. The presented percent
1355 distribution (source data from Table 3, "%" row) has been built through the ranking of
1356 the first six types (from "Symbols" to "Whole") by increasing size of the text "chunks"
1357 considered. The remaining three types (Information content, Other components and
1358 Grammar notations) have been added ranking them by decreasing values. The highest
1359 frequencies correspond to middle-sized "chunks" of the messages.

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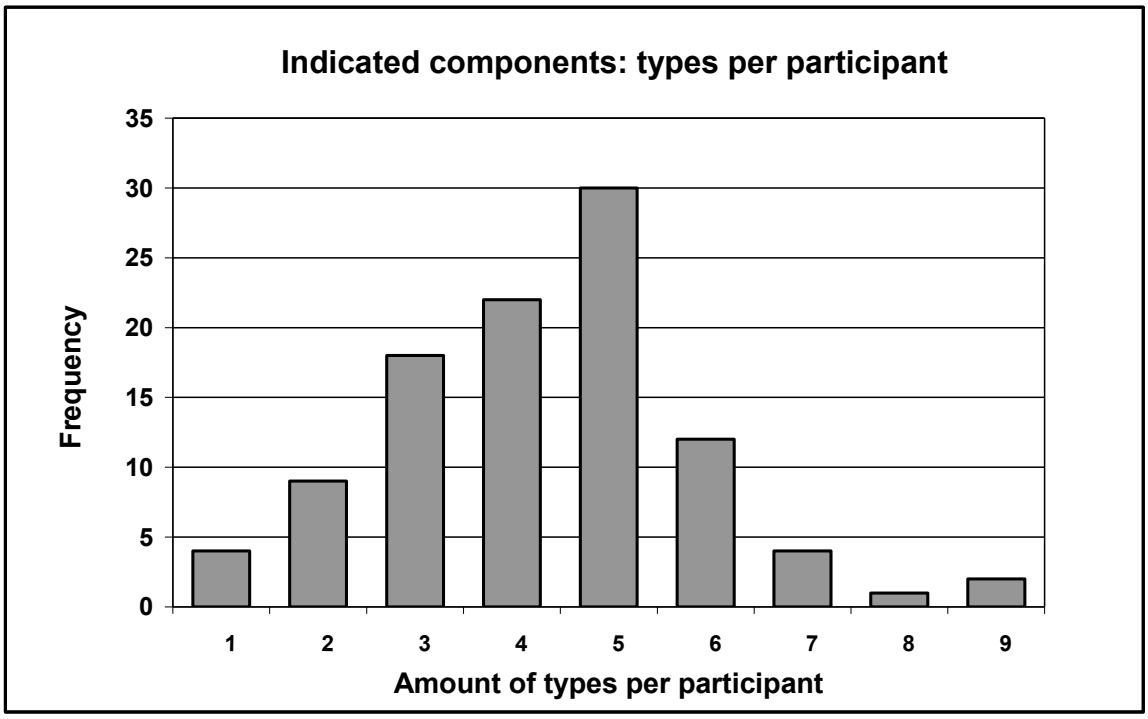

Figure 4: Sample distribution with respect to the amount of component types indicated by participants.

Respondents have been grouped in bins by the amount of types they indicated. The histogram shows the sample's distribution; it presents the highest frequencies on the 3-4-5 types-per-participant bins and has an almost "bell curve" shape. The main statistical indexes of the distribution are the following:

Mean = 4.3; SD = 1.6; Skewness = 0.25; Kurtosis = 0,49.

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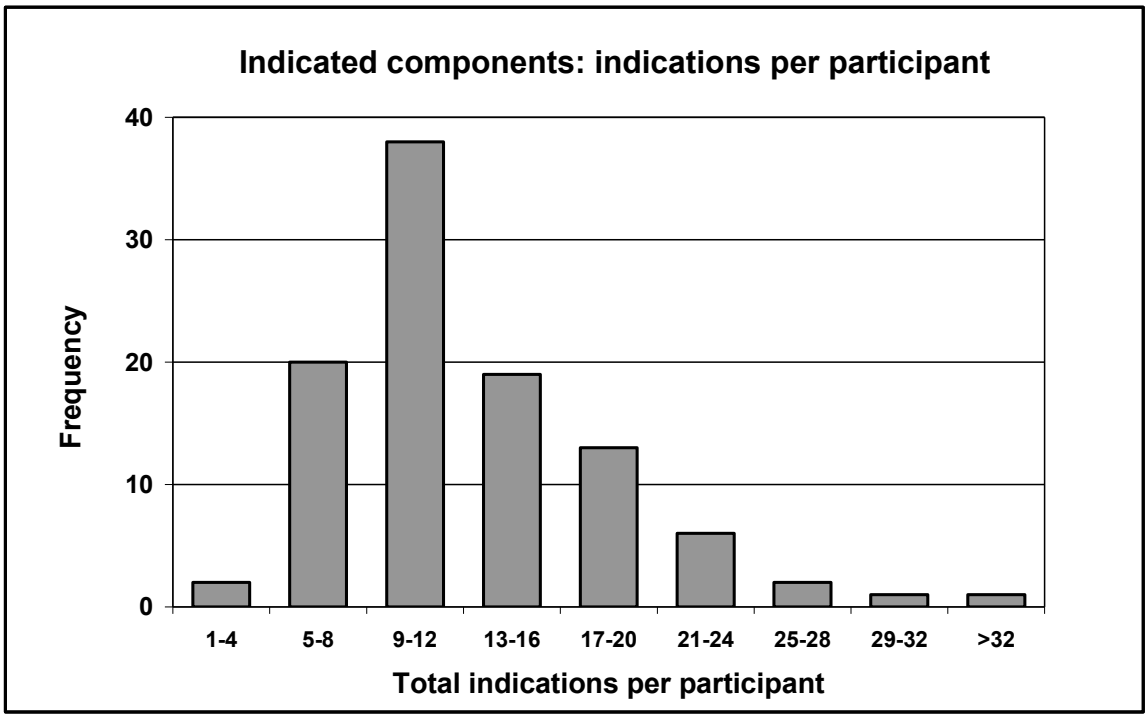

Figure 5: Sample distribution with respect to the total indications provided by participants.

Respondents have been grouped in bins by the amount of total provided indications. The histogram shows the sample's distribution; it presents the highest frequencies on the second, third and fourth bins and has an almost "bell curve" shape (even if it is clearly shifted towards the left side). The main statistical indexes of the distribution are the following:

Mean = 12.9; SD = 6.2; Skewness = 1.93; Kurtosis = 7.18.

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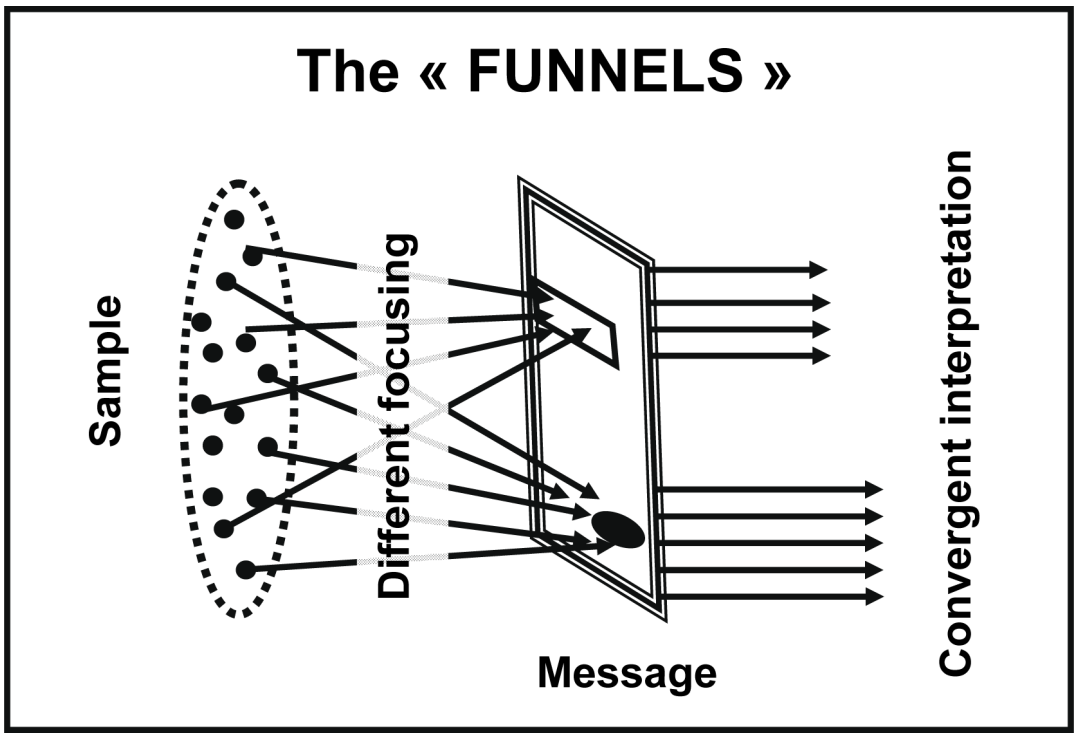

Figure 6: The "funnel-shape" model.

If the always observed "classic" interpretation scatter should be based on the scattering detected in "disassembling" operation, we could expect that the focusing on one same component would be followed by a convergent interpretation of it, as shown in this figure. This kind of process would prove itself as the opposite of the "megaphone-shape" model shown in Fig. 1.

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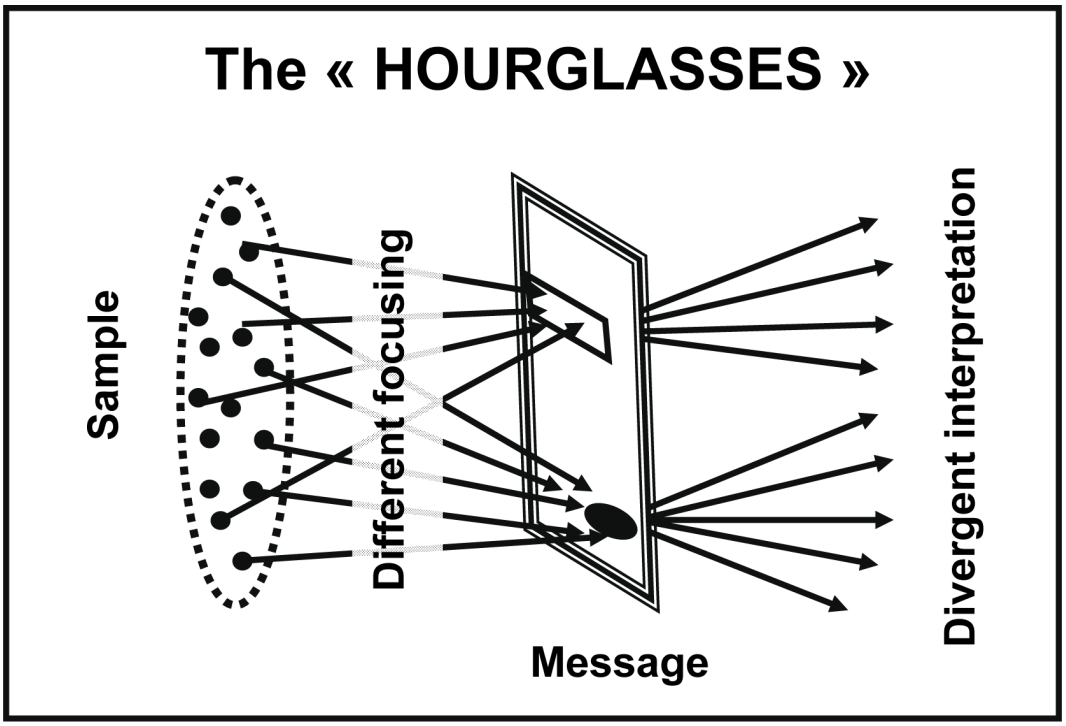

Figure 7: The "hourglass-shape" model.

This figure is a possible representation of the observed process of message interpretation. Two kinds of scatter co-exist, manifesting themselves in sequence: the first one regards dispersion during the focusing on the components ("disassembling" operation) and the second one regards the interpretation of the focused components ("classic" interpretation scatter).

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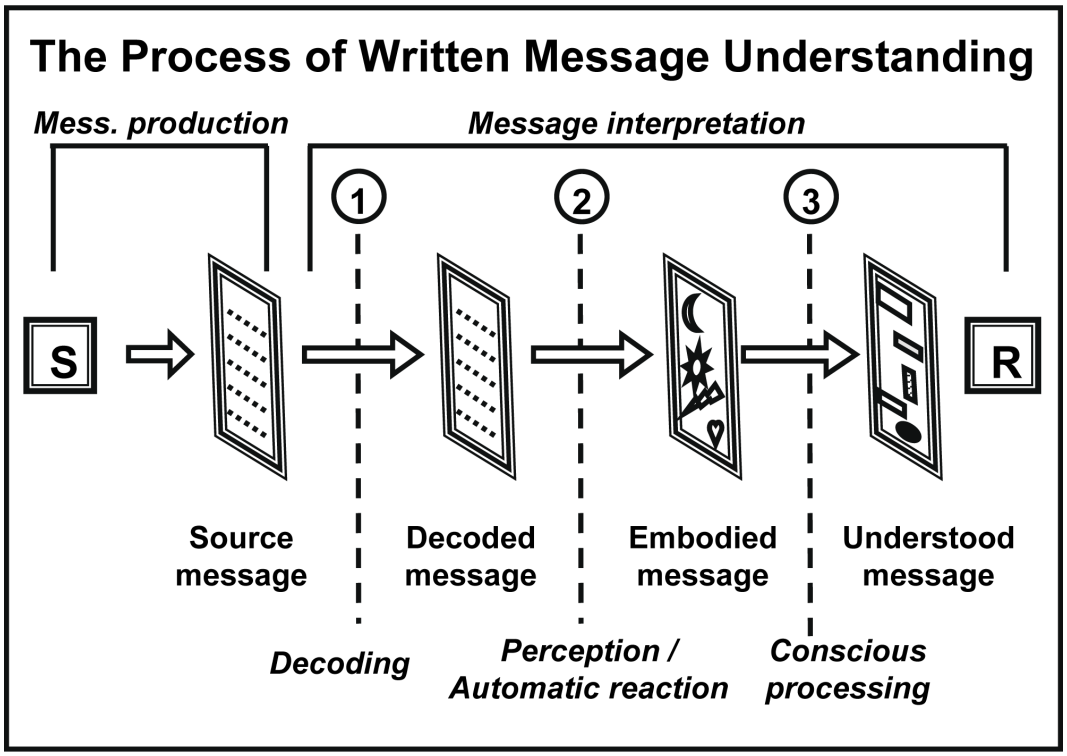

Figure 8: Scheme of the process of written message interpretation (how messages are understood).

[Legend: S = Sender; R = Receiver; 1-2-3 = Progressive steps of the process]

This figure presents our hypothesis to answer the question: "How is a written message understood by the receiver?". Message production (performed by the sender) is not deepened. The process of interpretation is made up by three sub-processes, in a cascade. The automatic reaction on perceptual basis (step #2) precedes the conscious information processing (step #3). The step #1 is decoding, given that the words must be recognized, at first, in order to be interpreted.

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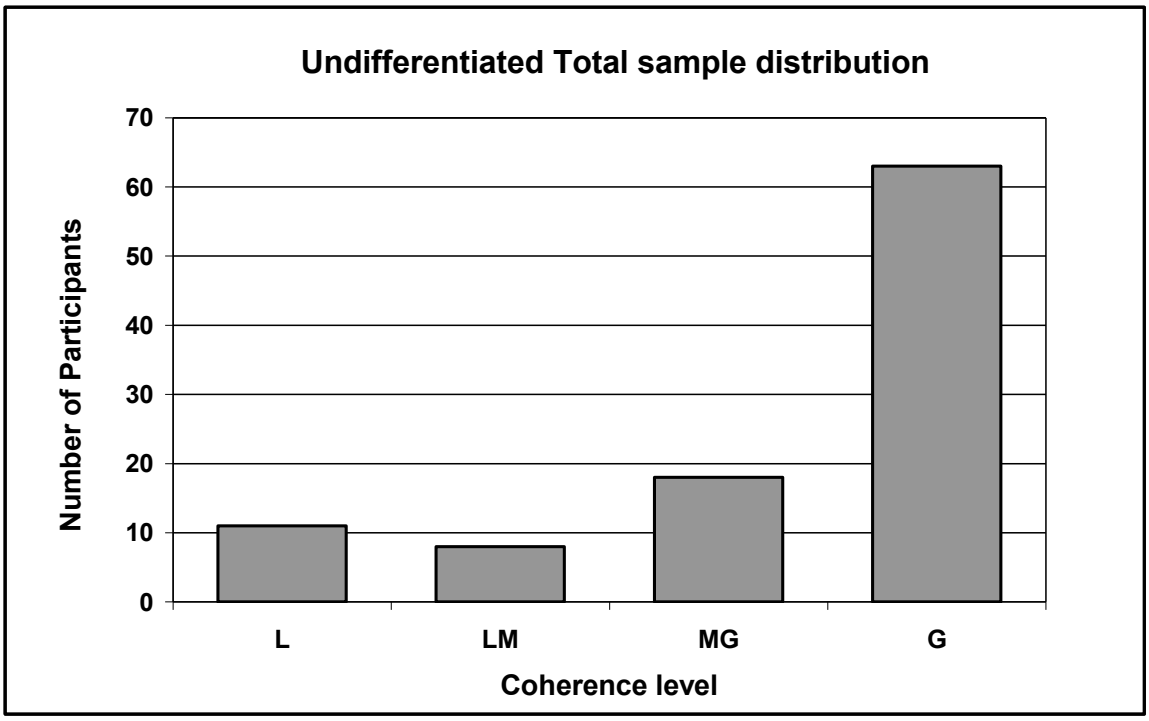

1478

1479

1480 **Figure 9: Sample distribution with respect to coherence levels / Undifferentiated**

1481 **Total Sample**

1482 [Legend / Coherence indicator:

1483 L = Low; LM = Low-Medium; MG = Medium-Great; G = Great level of coherence]

1484

1485 This histogram shows the distribution of ALL respondents according to the coherence

1486 (expressed through the coherence indicator) between, by one hand, their interpretation of

1487 Messages #4/H and #4/S; by the other hand, their final choice. Data is shown for the

1488 undifferentiated total sample. The L level results over-represented with respect to what

1489 expected.

1490

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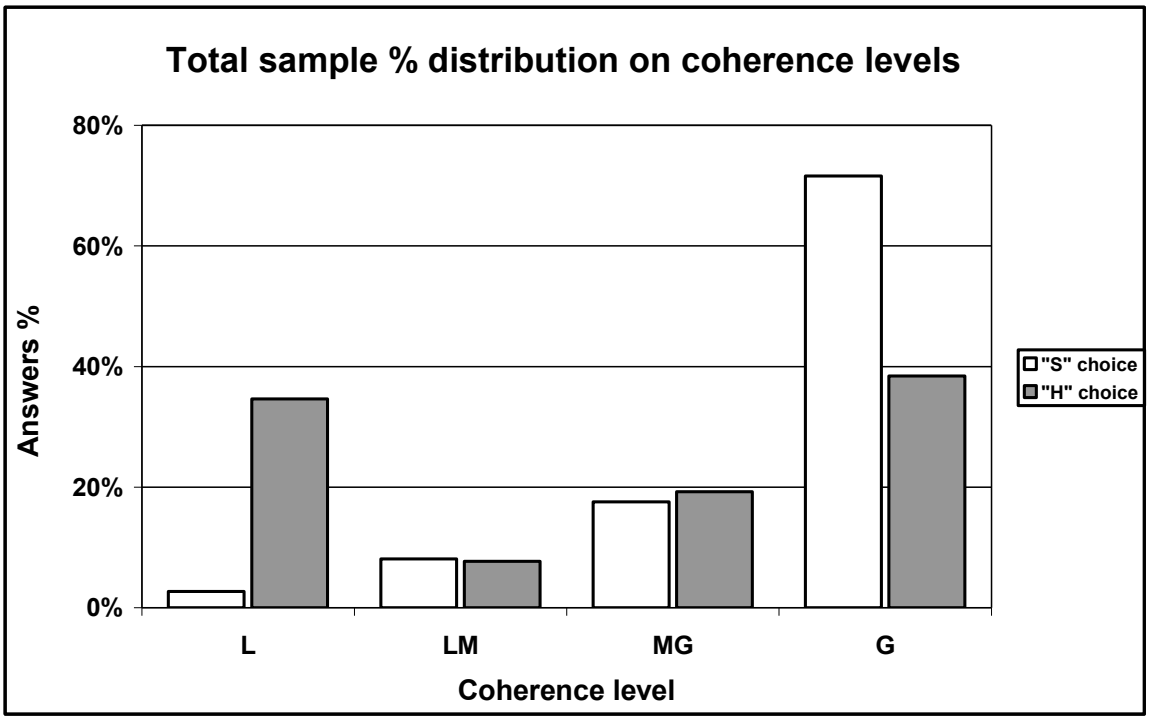

1493

1494 **Figure 10: Sample percent distribution with respect to coherence levels / Comparing**

1495 **"H"/"S" choosers - Total Sample**

1496 [Legend / Coherence indicator:

1497 L = Low; LM = Low-Medium; MG = Medium-Great; G = Great level of coherence]

1498

1499 This histogram shows the percent distribution of ALL respondents according to the

1500 coherence (expressed through the coherence indicator) between, by one hand, their

1501 interpretation of Messages #4/H and #4/S; by the other hand, their final choice. Data is

1502 shown distinctively for "H" and "S" choosers. Distributions result significantly different

1503 (chi-squared test: p=0.000095).

1504

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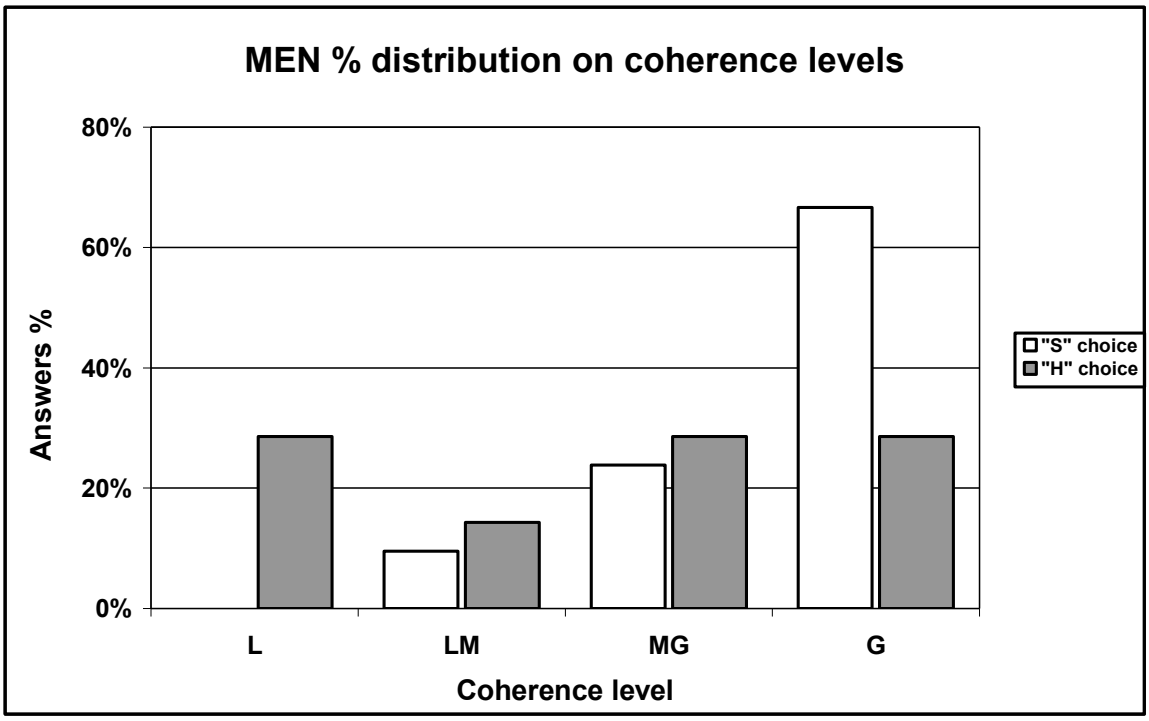

1507

1508 **Figure 11: Sample percent distribution with respect to coherence levels / Comparing**

1509 **"H"/"S" choosers - Subsample MEN**

1510 [Legend / Coherence indicator:

1511 L = Low; LM = Low-Medium; MG = Medium-Great; G = Great level of coherence]

1512

1513 This histogram shows the percent distributions of MALE respondents according to the

1514 coherence (expressed through the coherence indicator) between, by one hand, their

1515 interpretation of Messages #4/H and #4/S; by the other hand, their final choice. Data is

1516 shown distinctively for "H" and "S" choosers. Chi-squared test unsuitable for the

1517 presence of a zero value.

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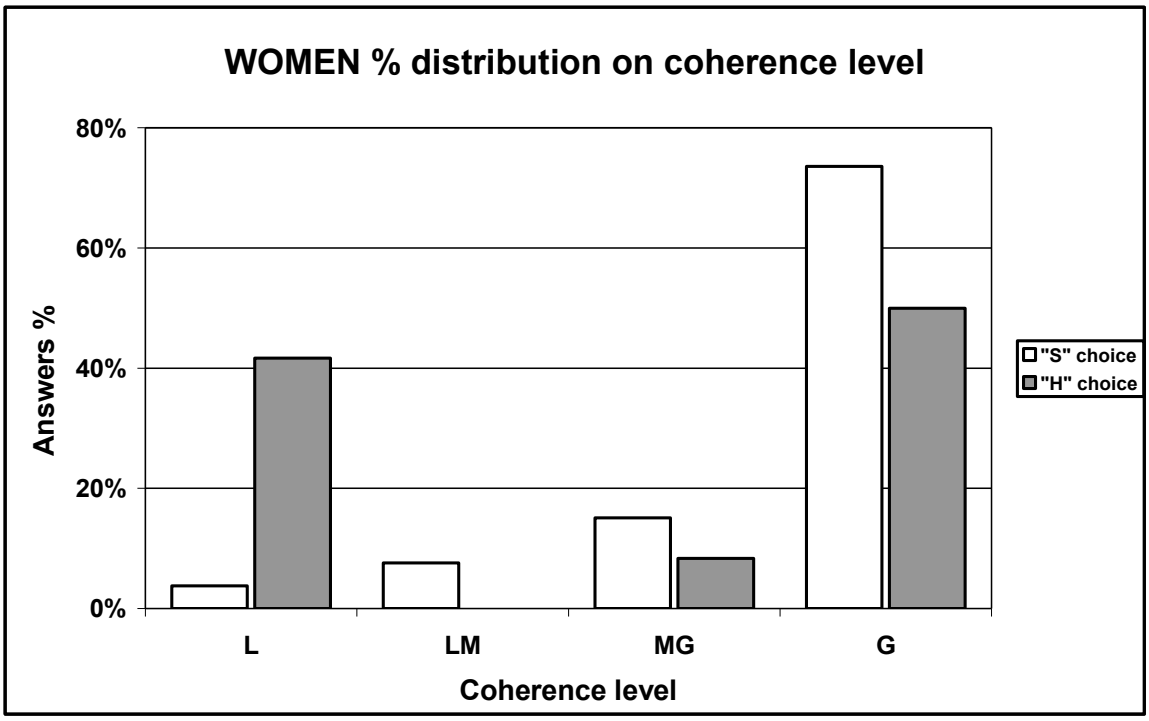

1520

1521 **Figure 12: Sample percent distribution with respect to coherence levels / Comparing**

1522 **"H"/"S" choosers - Subsample WOMEN**

1523 [Legend / Coherence indicator:

1524 L = Low; LM = Low-Medium; MG = Medium-Great; G = Great level of coherence]

1525

1526 This histogram shows the percent distributions of FEMALE respondents according to the

1527 coherence (expressed through the coherence indicator) between, by one hand, their

1528 interpretation of Messages #4/H and #4/S; by the other hand, their final choice. Data is

1529 shown distinctively for "H" and "S" choosers. Chi-squared test unsuitable for the

1530 presence of a zero value.

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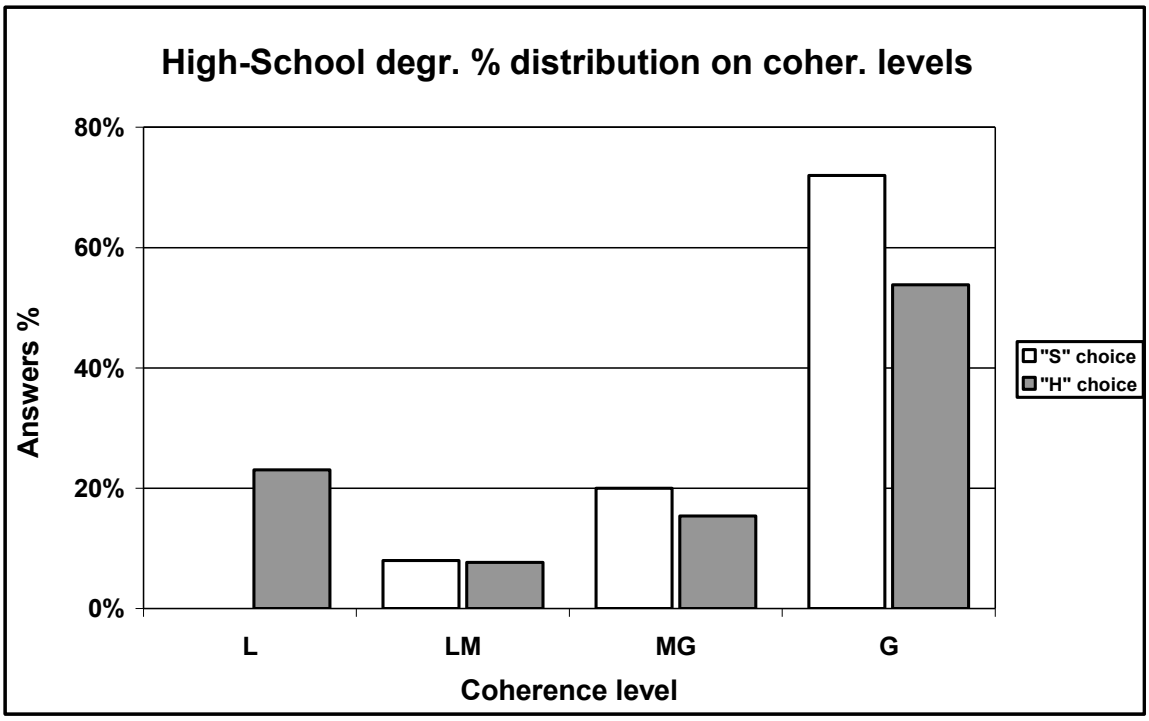

1533

1534 **Figure 13: Sample percent distribution with respect to coherence levels / Comparing**

1535 **"H"/"S" choosers - Subsample High School**

1536 [Legend / Coherence indicator:

1537 L = Low; LM = Low-Medium; MG = Medium-Great; G = Great level of coherence]

1538

1539 This histogram shows the percent distributions of HIGH-SCHOOL degree granted

1540 respondents according to the coherence (expressed through the coherence indicator)

1541 between, by one hand, their interpretation of Messages #4/H and #4/S; by the other hand,

1542 their final choice. Data is shown distinctively for "H" and "S" choosers. Chi-squared test

1543 unsuitable for the presence of a zero value.

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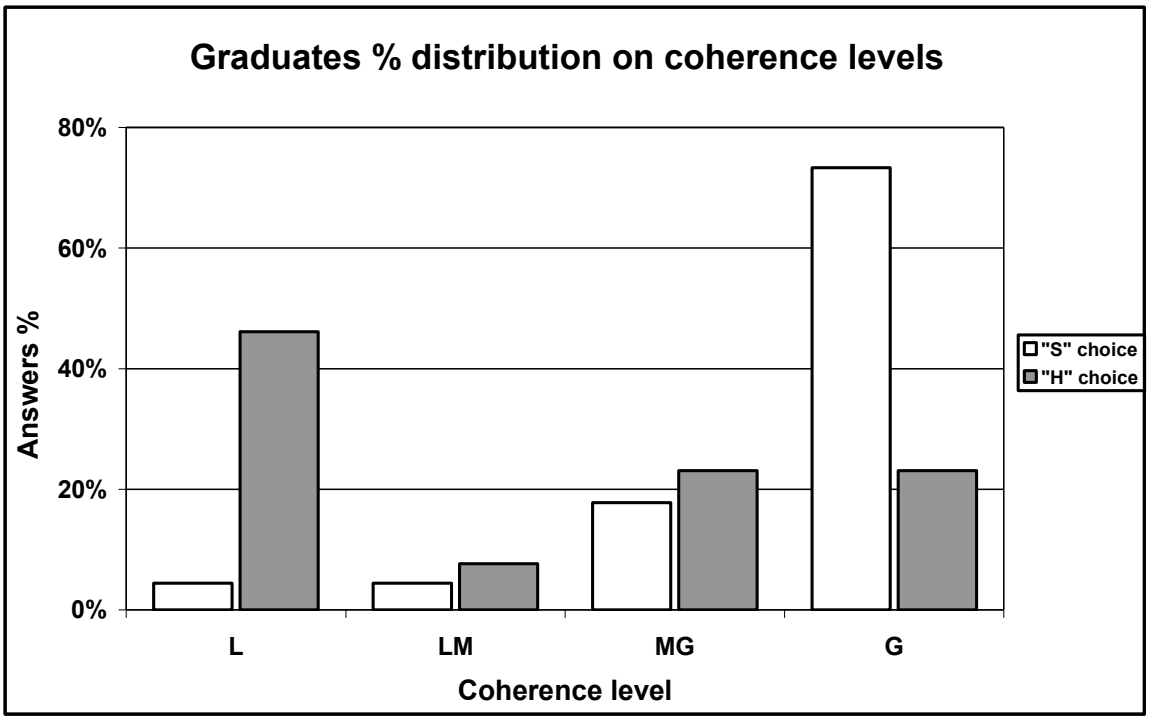

1546

1547 **Figure 14: Sample percent distribution with respect to coherence levels / Comparing**

1548 **"H"/"S" choosers - Subsample Graduates**

1549 [Legend / Coherence indicator:

1550 L = Low; LM = Low-Medium; MG = Medium-Great; G = Great level of coherence]

1551

1552 This histogram shows the percent distribution of GRADUATED respondents according

1553 to the coherence (expressed through the coherence indicator) between, by one hand, their

1554 interpretation of Messages #4/H and #4/S; by the other hand, their final choice. Data is

1555 shown distinctively for "H" and "S" choosers. Distributions result significantly different

1556 (chi-squared test: p=0.000649).

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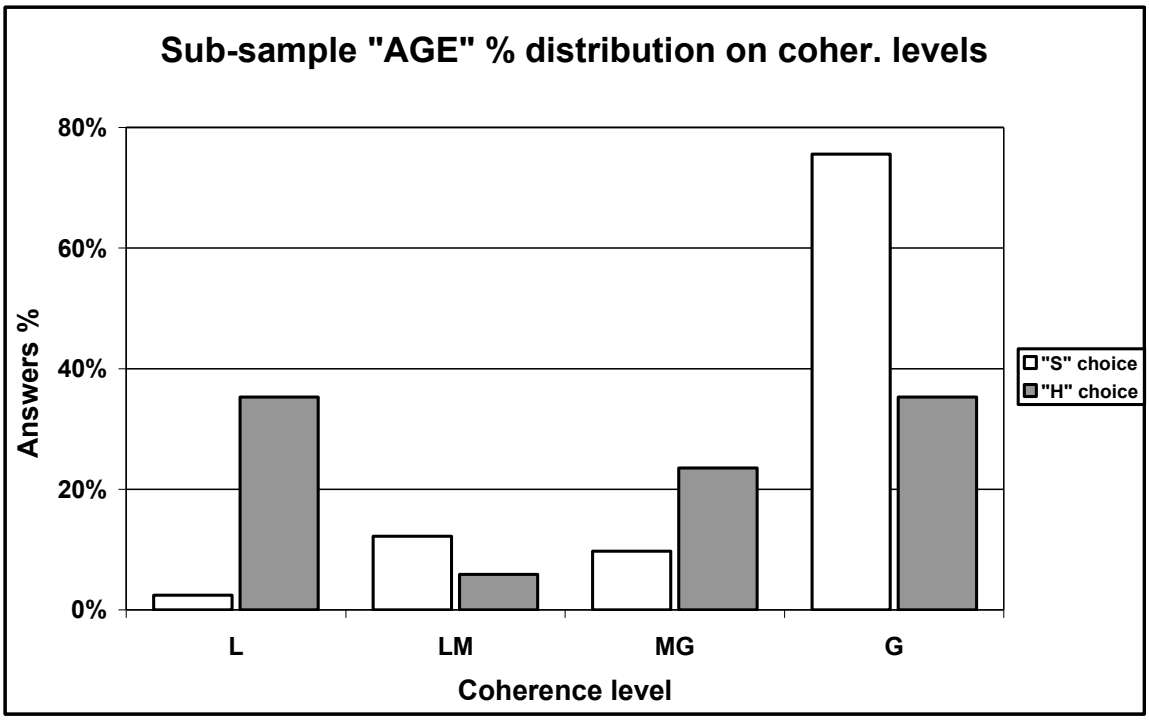

1559

1560 **Figure 15: Sample percent distribution with respect to coherence levels / Comparing**

1561 **"H"/"S" choosers - Subsample "AGE"**

1562 [Legend / Coherence indicator:

1563 L = Low; LM = Low-Medium; MG = Medium-Great; G = Great level of coherence]

1564

1565 This histogram shows the percent distribution of respondents belonging to subsample

1566 "AGE" (30 years, and over, old persons) according to the coherence (expressed through

1567 the coherence indicator) between, by one hand, their interpretation of Messages #4/H and

1568 #4/S; by the other hand, their final choice. Data is shown distinctively for "H" and "S"

1569 choosers. Distributions result significantly different (chi-squared test: p=0.001174).

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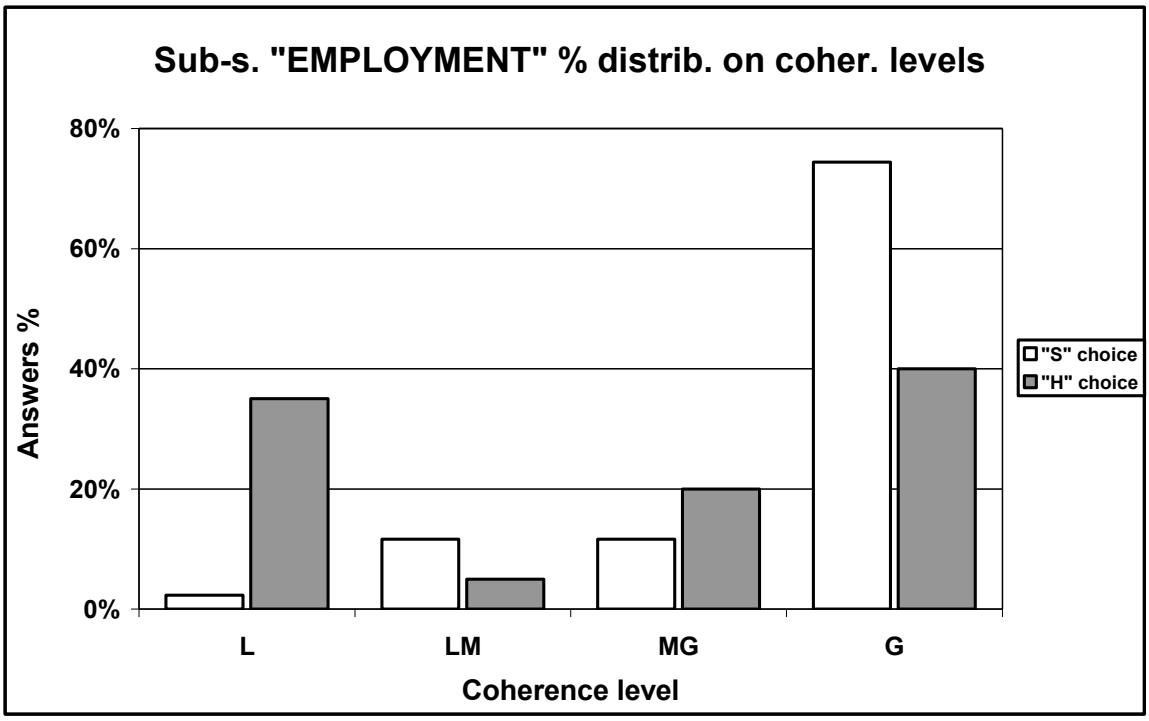

1572

1573 **Figure 16: Sample percent distribution with respect to coherence levels / Comparing**

1574 **"H"/"S" choosers - Subsample "EMPLOYMENT"**

1575 [Legend / Coherence indicator:

1576 L = Low; LM = Low-Medium; MG = Medium-Great; G = Great level of coherence]

1577

1578 This histogram shows the percent distribution of respondents belonging to sub-sample

1579 "EMPLOYMENT" (workers only, students and unemployed excluded) according to the

1580 coherence (expressed through the coherence indicator) between, by one hand, their

1581 interpretation of Messages #4/H and #4/S; by the other hand, their final choice. Data is

1582 shown distinctively for "H" and "S" choosers. Distributions result significantly different

1583 (chi-squared test: p=0.001560).

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1584 **Tables**

1585

1586

Category	Sub-category	Examples of participants' interpretations
Behaviours [7 answers]	---	XX requests for an intervention
		She reports flaws
		She is just sending a duty communication
Emotions [16 answers]	XX is:	Angry, Disturbed, Worried, Aggressive, Discouraged
		Brave, Impatient, Afraid
Relations XX-YY [41 answers]	XX expresses:	Assertiveness, Aggressiveness, Superiority, Subordination
	XX takes a position:	Tough, Technical, Neutral
	XX:	Demands a solution
		Recalls YY to his duty
		Thwarts YY's plans
Message form [19 answers]	Msg #3 is more:	Concrete, Correct, Detailed
		Direct, Effective

1587

1588 **Table 1: An example of interpretation scatter from our research.**

1589 Sixty-one individuals (60% of the sample), after having compared XX's Messages #1 and

1590 #3, answered "YES" to Question #2 and provided 83 specifications for the changes they

1591 had detected in XX's position toward YY. The table classifies the specifications into 4

1592 main categories and provides some examples for each one of them.

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Components	Examples
The POSITION of a statement	*XX explains her absence **at the beginning** of Msg #3 to forestall possible criticism.* *YY scoffs at XX, expressing a little courtesy **just at the end** of Msg #4/H.*
The LENGTH of a text	*Msg #4/H **being long** / Msg #5 **being short** have an underlying meaning.*
Dotted lists	***The use of it** in Msg #4/H has a meaning.*
Type of lexicon	*The use of **technical words / expressions** imply precision, but also suggest the intention to keep one's distance.* ***Thanking and reassuring expressions** have détente effects.*
The relational or social roles of characters	*Some interpreted Msg #4/H as an attack to XX **being a woman**.*
The professional roles of characters	*XX not being an Account, **she would not cheat**.*
Grammatical observations	*The **verbs' tense is noted** as having an underlying meaning.*
LACK of content	*YY **does NOT wonder** why XX requests a control.* *YY announces a solution **NOT clarifying** what it will be.*

1597

1598 **Table 2: A selection of messages' "other components" that readers may focus on.**

1599 The table displays a tight selection of the messages' "other components" focused by
1600 respondents. These components are independent of the information content and, in most
1601 cases, of the message text. They are extremely various, indeed unpredictable, and return
1602 the impression that the receivers' preferences could be totally rule less.

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Quest.	Sym.	Titl.	Words	Incid.	Phras.	Whole	Cont.	Other	Gram.	TOT	%
1-a	1	7	46	55	53	16	29	14	4	225	17.1%
1-b	1	7	26	53	27	18	20	12	3	167	12.7%
1-c	0	6	22	58	34	13	11	12	2	158	12.0%
2	4	5	22	52	32	17	34	7	2	175	13.3%
3-4/H	0	1	13	49	54	35	31	24	2	209	15.9%
3-4/S	0	22	14	52	48	45	29	5	1	216	16.4%
Final	2	14	17	30	28	50	6	22	0	169	12.8%
TOT	8	62	160	349	276	194	160	96	14	*1,319*	100%
%	0.6%	4.7%	12.1%	26.4%	20.9%	14.7%	12.1%	7.3%	1.1%	100%	

1606

1607 **Table 3: Statistics on indicated components.**

LEGEND	
Sym. = Symbols (punctuation marks)	Whole = General tone of the message / Blocks of text
Titl. = Titles – Salutes (starting/closing expressions)	Cont. = Information content of the message
Words = Meaningful isolated words/expressions	Other = Other components of the message
Incid. = Incidental passages, meaningless *per se*	Gram. = Grammar notations, like verbs tense and similar
Phras. = Complete phrases/periods	TOT = Totals; % = Percentage on totals

1608

1609 The table displays a descriptive statistical analysis of what the respondents look at inside the messages. The information
1610 content is focused by 12.1% of respondents only (“Cont.” column, “%” row). Even if we suppose that reference to complete
1611 phrases/periods could actually mean reference to their content, the sum of “Cont.” and “Phras.” column % totals would amount
1612 just to 33% of respondents, again a clear minority.

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Bins (% on personal total)	N. of respondents	%
0%	51	50,0%
1%-24%	31	30,4%
25%-49%	13	12,7%
50%-99%	6	5,9%
100%	1	1,0%
TOTAL	102	100,0%

Table 4: Sample distribution with regards to the indicated components referred to information content.

Answering to the second part of the questionnaire's questions (requesting to indicate the "concrete elements" on which the interpretation was based), just the exact half of the sample indicated, at least once, information content components. In this table, the sample is distributed in bins defined through the percentage that the components referred to information content represent on the personal total of the provided indications. Just for 7 people out of 102 the indications pointing at information content balance the others or prevail (50% or more); just 1 people among them indicates information content components only.

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Category	Examples of participants' interpretations
"… we'd be pleased…" [32 quotations]	Aggressiveness; Office duty expression; Informality; Irony
	Just a request; Sarcasm; Highlighting XX's subordinate role
	Expression of alternative visions
"… if at least once…" [17 quotations]	Conflict; Doubt on YY's reliability; Expression of courtesy
	Taunting; Request for attention; Request for information
	A reminder; Stimulus to organization top management
"… we'd be pleased… … if at least once…" [19 quotations]	Expression of XX's fear, because she doesn't feel safe
	Insignificant (just a normal office communication)
	Complaint/claim
	Reprimand/reproach, by XX to YY
	XX's clarification request
	Information exchange

Table 5: Interpretation scatter referred to one component (the incidental passage of Message #1).

The table displays the result of classifying the interpretations given by a subset of 53 individuals (52% of the sample) to one component of Message #1. These respondents, even though focusing on that same component (the incidental passage "…we would be pleased if at least once…"), have nonetheless dispersed their interpretations. This means that not even the "funnel-shape" model (Fig. 6) could result acceptable.

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Factors	**Examples**
Form of address	*Using or not titles indicates formality level*
Use of idiomatic expressions	*Sign of familiarity, informality*
Regards / greetings form	*Length and presence/absence of thanks are taken into account and interpreted as sign of attention, carelessness, respect, defiance…*
Reply quickness	*Courtesy / promptness sign*
Use of technical terms	*Sign of intention to keep a distant role*
Amount / level of details provided	*Sign of major / minor accuracy or interest*
Quantifying information	*Sign of quibbling, coldness*
Referring to rules / laws	*Taken as sign of escalation in formality*

1640

1641 **Table 6: Examples of possible stimulus-factors.**

1642 The table displays examples, drawn from the filled questionnaires, of one category of
1643 possible stimulus-factors inside the messages. The capability of these factors to work as
1644 stimuli is not linked to the information they might contain, but to "the fact that" they are
1645 present within the message, in a certain form and/or at a certain point.

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Variable	Total Sample		Sub-sample AGE		Sub-sample EMPLOYMENT	
	Answers	%	Answers	%	Answers	%
"H" choice	26	*25.7%*	17	*28.8%*	20	*31.2%*
"S" choice	75	*74.3%*	42	*71.2%*	44	*68.8%*
Total	**101**	*100%*	**59**	*100%*	**64**	*100%*

1649

1650 **Table 7: Statistical distribution of the answers to the Final question (H/S choice).**

1651 The table displays (for the total sample and the two control sub-samples) the frequencies

1652 of the answers to the Final question (the choice between Message “H” and Message “S”

1653 as the solution of the case). A strong imbalance is shown, as indications of Message #4/S

1654 overwhelm the Message #4/H ones in all cases.

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	Total sample						Sub-sample "AGE"						Sub-sample "EMPLOYMENT"					
	S+		**S-**		***TOTALS***		**S+**		**S-**		***TOTALS***		**S+**		**S-**		***TOTALS***	
H+	18	*22.5%*	12	*57.1%*	30	*29.7%*	8	*17.8%*	7	*50.0%*	15	*25.4%*	9	*18.8%*	9	*56.3%*	18	*28.1%*
H-	62	*77.5%*	9	*42.9%*	71	*70.3%*	37	*82.2%*	7	*50.0%*	44	*74.6%*	39	*81.3%*	7	*43.8%*	46	*71.9%*
Totals	***80***	*100.0%*	***21***	*100.0%*	***101***	*100.0%*	***45***	*100.0%*	***14***	*100.0%*	***59***	*100.0%*	***48***	*100.0%*	***16***	*100.0%*	***64***	*100.0%*
Gen. Total	***101***						***59***						***64***					

Table 8: Distribution of predictions about Message #4/H and Message #4/S effects.

Predictions about Message #4/H and Message #4/S effects are independently expressed, by each member of the sample, through answering to Questions #3 and #4. Answers are classified through the dummy variable "Expected effects" (possible values "+", if respondents point out that the message will solve the XX-YY contrast, or "-", in the opposite case). The table shows that all the possible combinations of predictions (for the total sample and the two control sub-samples) are present. Distribution is clearly imbalanced (definite preference on "H-/S+" combination). Significance is checked through chi-squared test: p=0.001988, total sample; p=0.015600, sub-sample "AGE"; p=0.003861, sub-sample "EMPLOYMENT".

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	Total sample						Sub-sample "AGE"						Sub-sample "EMPLOYMENT"					
	"H" Choice		"S" Choice		Totals		"H" Choice		"S" Choice		Totals		"H" Choice		"S" Choice		Totals	
H+ / S+	5	*19.2%*	13	*17.6%*	18	*18.0%*	4	*23.5%*	4	*9.8%*	8	*13.8%*	4	*20.0%*	5	*11.6%*	9	*14,3%*
H+ / S-	10	*38.5%*	2	*2.7%*	12	*12.0%*	6	*35.3%*	1	*2.4%*	7	*12.1%*	8	*40.0%*	1	*2.3%*	9	*14,3%*
H- / S+	9	*34.6%*	53	*71.6%*	62	*62.0%*	6	*35.3%*	31	*75.6%*	37	*63.8%*	7	*35.0%*	32	*74.4%*	39	*61,9%*
H- / S-	2	*7.7%*	6	*8.1%*	8	*8.0%*	1	*5.9%*	5	*12.2%*	6	*10.3%*	1	*5.0%*	5	*11.6%*	6	*9,5%*
Totals	***26***	*100.0%*	***74***	*100.0%*	***100***	*100.0%*	***17***	*100.0%*	***41***	*100.0%*	***58***	*100.0%*	***20***	*100.0%*	***43***	*100.0%*	***63***	*100,0%*
Gen. Total	***100***						***58***						***63***					

Table 9: Cross-table of combined predictions and final choices between Message #4H and Message #4S.

In this table the combined predictions of Message #4/H and Message #4/S effects (see Table 8) are crossed with the final choices of the respondents (all the variables are independent). Data shows the association (for the total sample and the two control sub-samples) between the most frequent combination "H-/S+" and "S" as final choice. In addition, some correlations between the two choices is underlined by chi-squared test: p=0.000017 (total sample); p=0.001174 (sub-sample "AGE"); p=0.000383 (sub-sample "EMPLOYMENT").

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	L (*low coherence*)	LM (*low-medium c.*)	MG (*med.-great c.*)	G (*great coherence*)
"H" choice	**H- / S+**	**H- / S-**	**H+ / S+**	**H+ / S-**
"S" choice	**H+ / S-**	**H- / S-**	**H+ / S+**	**H- / S+**

Table 10: Plot of the coherence level scale.

The table shows the scale of the coherence levels expressed through the coherence indicator; four levels of coherence are defined and ranked. The indicator rates the degree of coherence among the predictions one respondent expressed about the "H" and "S" versions effects (answers to Questions #3 and #4) and the final choice he/she made ("H" or "S", answer to the Final question). All the questions were independent. The predictions are represented through the dummy variable "Expected effects" and labelled "+" if they indicate that the message will ease or solve the contrast between XX and YY, "-" in the opposite case.

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Coherence level	Total sample		Sub-sample "AGE"		Sub-sample "Employm."	
	Values	*%*	*Values*	*%*	*Values*	*%*
L	11	*11.0*	7	*12.1*	8	*12.7*
LM	8	*8.0*	6	*10.3*	6	*9.5*
MG	18	*18.0*	8	*13.8*	9	*14.3*
G	63	*63.0*	37	*63.8*	40	*63.5*
Total	**100**	***100.0***	**58**	***100.0***	**63**	***100.0***

Table 11: Sample distribution with respect to coherence levels.

[Legend: L = Low; LM = Low-medium, MG = Medium-great, G = Great level of coherence between predictions and choice; H/S = Versions of Message #4; +/- = type of predicted effect (resolution or escalation of the conflict) of the messages on XX.]

The table displays, for the total sample and the two subsamples "Age" and "Employment", the distribution of participants with respect to the different levels of coherence (see Table 10). The L level results over-represented with respect to what expected.

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"H" Choosers			**"S" Choosers**			**Total**	
Coherence level	***Values***	***%***	***Coherence level***	***Values***	***%***	***Values***	***%***
L (H-/S+)	9	*34.6*	**L** (H+/S-)	2	*2.7*	11	*11.0*
LM (H-/S-)	2	*7.7*	**LM** (H-/S-)	6	*8.1*	8	*8.0*
MG (H+/S+)	5	*19.2*	**MG** (H+/S+)	13	*17.6*	18	*18.0*
G (H+/S-)	10	*38.5*	**G** (H-/S+)	53	*71.6*	63	*63.0*
Total	**26**	***100.0***	***Total***	**74**	***100.0***	**100**	***100.0***

1705

1706 **Table 12: Sample distribution with respect to coherence levels and expressed choice**

1707 **(total sample).**

1708 [Legend: L = Low; LM = Low-medium, MG = Medium-great, G = Great level of

1709 coherence between predictions and choice; H/S = Versions of Message #4; +/- = type of

1710 predicted effect (resolution or escalation of the conflict) of the messages on XX.]

1711

1712 The table displays (for the total sample) the distribution of participants with respect to the

1713 different levels of coherence and the expressed choice. Data highlight some correlations

1714 between the two variables coherence and choice: Chi-squared test returns high

1715 significance (p<0.01).

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"H" Choosers			"S" Choosers			Total	
Coherence level	*Values*	*%*	*Coherence level*	*Values*	*%*	*Values*	*%*
L (H-/S+)	6	*35.3*	**L** (H+/S-)	1	*2.4*	7	*12.1*
LM (H-/S-)	1	*5.9*	**LM** (H-/S-)	5	*12.2*	6	*10.3*
MG (H+/S+)	4	*23.5*	**MG** (H+/S+)	4	*9.8*	8	*13.8*
G (H+/S-)	6	*35.3*	**G** (H-/S+)	31	*75.6*	37	*63.8*
Total	**17**	***100.0***	***Total***	**41**	***100.0***	**58**	***100.0***

1717

1718 **Table 13: Sample distribution with respect to coherence levels and expressed choice**

1719 **(Sub-sample "Age").**

1720 [Legend: L = Low; LM = Low-medium, MG = Medium-great, G = Great level of

1721 coherence between predictions and choice; H/S = Versions of Message #4; +/- = type of

1722 predicted effect (resolution or escalation of the conflict) of the messages on XX.]

1723

1724 The table displays (for the sub-sample "Age", >29yy-old people only) the distribution of

1725 participants with respect to the different levels of coherence and the expressed choice.

1726 Data highlight some correlations between the two variables coherence and choice: Chi-

1727 squared test returns high significance (p<0.01).

1728

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"H" Choosers			**"S" Choosers**			**Total**	
Coherence level	***Values***	***%***	***Coherence level***	***Values***	***%***	***Values***	***%***
L (H-/S+)	7	*35.0*	**L** (H+/S-)	1	*2.3*	8	*12.7*
LM (H-/S-)	1	*5.0*	**LM** (H-/S-)	5	*11.6*	6	*9.5*
MG (H+/S+)	4	*20.0*	**MG** (H+/S+)	5	*11.6*	9	*14.3*
G (H+/S-)	8	*40.0*	**G** (H-/S+)	32	*74.4*	40	*63.5*
Total	**20**	***100.0***	***Total***	**43**	***100.0***	**63**	***100.0***

1730

1731 **Table 14: Sample distribution with respect to coherence levels and expressed choice**

1732 **(Sub-sample "Employment").**

1733 [Legend: L = Low; LM = Low-medium, MG = Medium-great, G = Great level of

1734 coherence between predictions and choice; H/S = Versions of Message #4; +/- = type of

1735 predicted effect (resolution or escalation of the conflict) of the messages on XX.]

1736

1737 The table displays (for the sub-sample "Employment", people with a regular employment

1738 only) the distribution of participants with respect to the different levels of coherence and

1739 the expressed choice. Data highlight some correlations between the two variables

1740 coherence and choice: Chi-squared test returns high significance (p<0.01).

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Sub-samples	ANOVA test results
Total sample	21.36
Men	10.36
Women	09.47
Degrees	04.53
Graduated	23.56
"AGE"	13.32
"EMPLOYMENT"	12.31

1745

1746 **Table 15: Results of the ANOVA test applied to the variables "choice" and**

1747 **"coherence" in the selected sub-samples.**

1748 The Table shows the results of the ANOVA test applied to the variables "choice" and

1749 "coherence level". The test has been applied on the total sample and on all the selected

1750 sub-samples cited in the manuscript; all the results indicate significant relations between

1751 the two variables.

1752

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