Communication Between Humans: Towards an Interdisciplinary Model of Intercomprehension

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Marine Grandgeorge

Abstract Communication, to communicate… These are words daily used in common speech (e.g. media, science, business, advertising and so on). Although these words are familiar, the correct definition of communication remains complex. Here, our aim is to gather knowledge from different scientific disciplines to better understand what communication is. After some theoretical models of communication, we detailed what are verbal and nonverbal communications, how researchers try to classify them and which factors could influence them. We proposed, at last, an interdisciplinary model of intercomprehension between individuals that could be used to improve communication with robots.

Keywords Communication · Interaction · Relationships · Intercomprehension

1 Some Theoretical Models of Communication

Social life concerns associations of individuals belonging to the same species, e.g. humans. For example, communication ensures coordination between individuals. Thus, communication was initially defined as a social phenomenon of exchanges between two or more congeners. It uses specific signals, to survive (i.e. reproduction, protection, feeding) and maintain group cohesion [1].

First, communication was conceptualized as an information source (i.e. source's message and a transmitter) that transmits a signal to a receiver and a destination [2] (Fig. 1). Information is considered as a sequence of signals combined according to precise rules which modifies the receiver's state. Notice that the message could be modified by noise. Here, communication is a linear and mechanical system without social component. The design of this first model, so-called *telegraphic*, has since evolved, to better include the complexity of communication. Indeed, communication is not limited to verbal language. It is multichannel, including signals of various kinds

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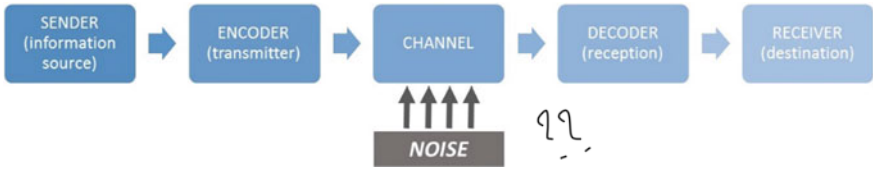

Fig. 1 Shannon and Weaver model of communication [2]

such as sounds, gestures, mimics, tactile or even electrical signals [3]. It takes into account not just "what is said […] but rather *how* it is said, and *who* says it" [4].

First models were simple, excluding contexts. Individuals were not considered as a whole of their environment. However, humans are social entities, an essential element that, later, was introduced in the model proposed by Riley & Riley [5]. They use the notions of affiliations to human groups (e.g. judging each other) as well as of a feedback loop between the sender and the receiver, highlighting the existence of reciprocity phenomenon. Conceptualization of communication moves from a linear view to a circular process.

In same time, as first models were too simple, some researchers developed a linguistic approach of communication. For example, Jakobson defines six functions of language or communication functions that are necessary for communication to occur: context, addresser or sender, addressee or receiver, contact, common code and message; all work together [6]. Here, the importance of the communicative context appears and is defined as "either verbal or capable of being verbalized".

Later, Barnlund [7] postulates that interpersonal communication is a dynamic process in which participants are both sender and receiver of the messages, a weakness finding in the models used until his works. Thus, in communication, coding and decoding are not alternative processes but are interdependent, that is each contributing to the communication meaning [8]. We could consider it as a co-construction. Today, some authors define the communication as *orchestral*, that is all participants are immersed themselves in communication. Each one plays her/his *score*, as a member of an *orchestra* [9]. In addition, all behaviors may be meaningful to others, whether they are intentional or not. This difference suggests that we don't necessarily communicate what we are trying to communicate and we communicate even if we don't try to do so [7]. This could be linked to one axiom of communication: "one cannot not communicate" [10]. That is "every behaviour is a kind of communication, people who are aware of each other are constantly communicating. Any perceivable behaviour, including the absence of action, has the potential to be interpreted by other people as having some meaning". The 4 other axioms—statement that is taken to be true, to serve as a premise or starting point for further reasoning and arguments—are:

1. every communication has a content and relationship aspect such that the latter classifies the former and is therefore a metacommunication. In other words, we always try to communicate something different of the exchange content. Here, the interest is on "how" is the communication act, i.e. non-verbal communication (e.g. gaze, intonation, gesture, mimicry …).

2. the nature of a relationship is dependent on the punctuation of the partners communication procedures, that is communication is an exchange between partners and what one does impact the others and reciprocally.
3. human communication involves both digital and analog modalities. If I want to communicate the information "the road turns" to someone who does not speak English, I can use my body, my arms, my hands… to make curved movements from left to right. My gestures are similar to what they mean. It's the analog language. If both partners speak the same language, it is possible to use it and therefore, "to not show anything". Only the common knowledge of language or of a common code makes it possible to understand each other. It's the digital language. Notice that both are needed to communicate.
4. inter-human communication procedures are either symmetric or complementary. A symmetrical relationship is an equal relationship that diminish differences between individuals. Otherwise, complementary relationship maximizes the differences, with two positions, one high and the other, low.

More recently, Blanchet [11] argues that the old models are not enough to understand the richness, flexibility and complexity of language (Fig. 2). For this, he suggests some changes. The first one is the circularity in which speech operates, forming a loop of exchanges that act on each other. Speaking as well as other cues such as gestures, mimicry, images, symbols and so on overlap simultaneously. An exchange therefore never has really a beginning or an end. Then, the contexts are temporal, spatial and socio-cultural. The same statement has different meanings according to

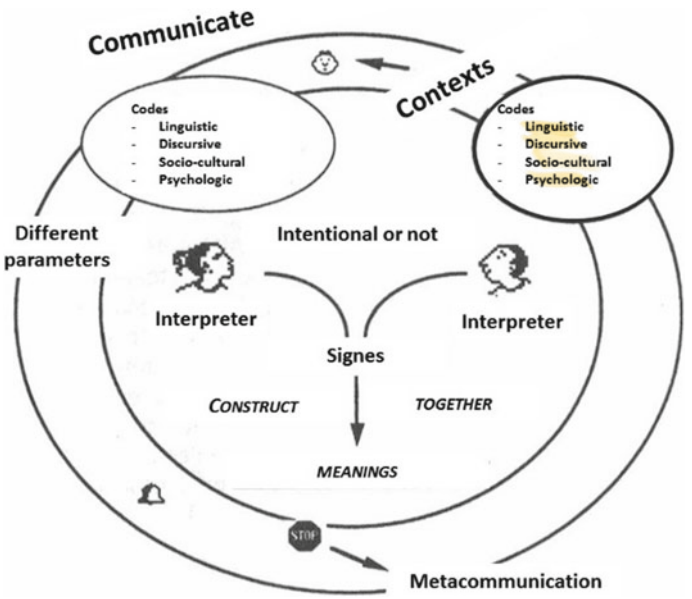

Fig. 2 Ethno-sociolinguistic conceptualization of communication adapted from Blanchet [11]

the participants, in different places or at different times, all elements are concerned. In addition, the contexts gathered also objects, noises, people present whose only presence influences the behaviors (i.e. audience effect, first time described [12]) and on what is communicated (i.e. emotions on face), the events around the exchanges, the ethno-socio-cultural setting in which the exchange takes place, and so on. With a different context, the implicit information and presuppositions are different, and hence have different meanings. Then each individual and group has their own codes, some are common, others not, even with a "same language" and "same culture".

Moreover, each individuals emits intentional signals (e.g. linguistic, gestural, symbolic, etc.) but also unintentional signals which are nevertheless perceived and interpreted by others because "one cannot not communicate". Intentionality includes the strategies of interaction, by which each one seeks to reach her/his goal (e.g. convince, inform, move and be recognized). Likewise, to exchange, each individual must engage in a form of collaboration with others, try to interpret the intentions of others, and reciprocally seek to produce valuable signals that could be interpreted by others. We can call it *cooperation* or *co-construction*. Therefore, the interpretation that partners construct during communication is done by inferences that integrate both the meanings and contextualization signals. The meaning is not reduced to the sense or the message. Metacommunication is the responsibility for the "success" or "failure" of the exchange that never falls to only one partner. As the possible meanings and modalities of the exchange are multiple, everything comes from interpretation.

When there is misunderstanding or apparently too large gap between intentions and results, we can then metacommunicate. To metacommunicate is *communicate about communication*. In short, it is to interrupt the circle of exchange, to explain strategies and interpretations. The discrepancies could be elucidated and then resolved. The exchange is reframed and may start again. This is a higher level of cooperation that requires more flexibility, openness and listening to others.

The proposed models focus often on the only verbal communication. It is therefore important to open up such models to a larger communication view if we want, at the end, to include both animals and humans, and by extension, robots.

2 Verbal and Nonverbal Communication

As previously stated, communication models give prominence to verbal communication. However, we can't omit nonverbal or para verbal communication when we are interested in human communication.

2.1 Verbal Communication

We consider that verbal communication corresponds to language in humans. Numerous definitions exist and this area of research is still evolving; here, we don't want

to review all theoretical and experimental approaches but seek to just give a general overview.

Directly in the dictionary of the CNRS (i.e. National Center for Scientific Research in France), it is defined as the ability of humans to express their thought and to communicate with each other throughout a system of vocal and/or graphic signs constituting a language. There are two main types of language. On the one hand, there is the articulated language that is language with different, identifiable and meaningful sounds. It is possible to analyze it in significant and minimum units (i.e. monemes), themselves could be analyzed in distinctive and minimum units (i.e. phonemes). This is a common characteristic of all languages. On the other hand, there is also an inner language, a form of internalized and self-directed dialogue that is not expressed. Thus, in a general way, language can be defined as a system of communication by speaking, writing, or making signs in a way that can be understood, that allows the mention of present but also past and future situations.

Here, we mention only an old but interesting work of Hockett [13]. He established that 13 characteristics are common to all languages:

1. The first characteristic is the vocal-auditory channel that leaves the body free for other simultaneous activities. Notice that other communication systems use other channels, e.g. sign language.
2. Multi-directional transmission and directional reception characteristic that is the source of emission is localizable. It is based also on the physical aspect of sounds.
3. Quick disappearance of the signal is one of the advantageous features of sound communication, compared to other which are persistent (e.g. chemical or visual communication).
4. Interchangeability means that human can, in general, produce any linguistic message that she/he understands.
5. Feedback allows to hear what is relevant in the message, and especially to internalize the message.
6. Specialization means that the sound produced has no other function: it is specialized to ensure communication.
7. In humans, words have meaning regardless of the context of transmission. For example, the word “table” evokes the object “table”, even if it is absent. It corresponds to semantics, the study of meaning.
8. Link between the message elements (i.e. sounds) and the referent can be arbitrary or not. Words don’t need to be similar to the object they designate. We could have a long word for a small thing (e.g. microorganism) or short for a big beast (e.g. lion). The link between words and referents is arbitrary.
9. Next characteristic is discrete units. Human vocal abilities are very extensive, but they use only a small number of sounds to speak. For example, in French, there are 37 basic sound units or phonemes. The language is produced from these basic discrete sound units, easily identifiable.
10. Movement that refers to the fact that humans would apparently be the only species able—using language—to refer to objects and events removed from

time or place where the speaker is. This property makes it possible to evoke distant objects in time or space, but also to verbally evoke things that have no spatial location or that never occur. Humans are disconnected from the object to which they relate and that it has a meaning regardless of a given context.

11. Productivity can be defined as the ability to utter new messages, i.e. to say things that have never been said and heard before, but that can be understood by someone who speaks the same language. Language is really an open system, as we could say "she has naturally green hair".
12. Cultural transmission means that all humans are *genetically* able to acquire language. If everyone has structures for the language production and processing, learning and education remain essential for acquisition.
13. Double articulation is defined as the combination of basic sound units, these basic sound units have no specific meaning. Morphemes result from the combination of a small number of distinct and meaningless sounds, i.e. the phonemes. For example, the words "team" and "meat" are two words that have a very different meaning, but result from the combination of the same basic sound units, the same phonemes, but not associated in the same order.

The ethologist Thorpe [14] added three new characteristics to this list: the ability to lie, the metalinguistic ability (i.e. ability to speak about the system itself) and the learning of derived systems (e.g. learn other language).

To date, there is significant debate about this question: does the language belong only to humans? The linguist Chomsky [15] states that "human language appears to be a unique phenomenon, without significant analogue in the animal world". However, this previous classification [13] may be used to compare verbal language with other animal communication systems, even if the choice of the items used for comparison is still in debate. For example, should we try to take into account the complexity or on the contrary, is it better to agree on a minimum and essential core? Indeed, recent data showed that we need to rethink the limits between humans and animals (as well as robots [16]) according several parameters [17, 18]. For example, learning, attachment, culture, laugh, identity and so on are now rethinking and still not belong to only humans. But remain that animal vocal communication, as human language, is—before all—a social act. And language, as verbal communication, is associated to nonverbal communication.

2.2 Nonverbal Communication

One of the first researchers to work on this topic was Charles Darwin who described the biological and innate origins of nonverbal communication and especially emotions [19]. He proposed the existence of universal emotions. Nonverbal communication can be defined as construction and sharing of meanings that happen without speech use [20]. Para-verbal communication is then a component of the nonverbal communication that is relative to the voice, while excluding a semantic component.

Other authors use a different dichotomy, proposing a session between speech-based communication and non-speech communication [21]. Other definitions propose that nonverbal communication be called "bodily communication" because most nonverbal items are expressed through the gestures and movements of some body parts [22]. Para-verbal communication concerns intonations, rhythm, latency between words, volume whereas nonverbal communication concerns gestures, gaze, mimicry and posture. There is neither single theory about nonverbal communication, nor single discipline that deals with the study of nonverbal communication characteristics and functions [20].

2.3 How to Classify Nonverbal Communication?

Here, we propose a non-exhaustive list of classifications of nonverbal items that researchers propose to better understand nonverbal communication. First, Bonaiuto & Maricchiolo [23] proposed a scale where the items of nonverbal communication are graduated (Fig. 3), from the most obvious items (i.e. external appearance and spatial behavior) to the least obvious items (i.e. vocal cues).

Specifically, we proposed to gather 5 classification propositions of para-verbal communication items (see Table 1 for details). Literature seems to agree with para-verbal communication as sub-component of nonverbal communication that corresponds to "verbal vocal signs with para-verbal meaning, non-verbal vocal cues, and silences" [20].

Some authors focused on particular human body elements to classify items constituting nonverbal communication. For example, Bonaiuto et al. [30] proposed a classification of hand gestures, whether or not related to speech. More precisely, Rozik [31] illustrated the role of the hands in the theatrical play situation with a specific classification. Some other authors focused on the whole body parts. Gestures could be analyzed as we analyze linguistic [32]. The term kineme was created by comparison to phoneme. The kineme itself is meaningless. Its repertoire is based on human body division into 8 parts: head, face, neck, trunk, arms, hands, legs and feet. Then, each part is subdivided. This method of formal classification is extremely fine, but is unusable in direct observation, unless you record the interaction and view frame by frame, which involves significant effort.

Another classification, not based on structure but on function, proposed to separate communicative gestures from so-called extra-communicative gestures [3] as previously suggested by Morris [27]. Among communicative gestures, 3 broad categories are distinguished: (1) quasi-linguistic gestures that is conventional form and use of gestures according to the culture that can be used independently of the speech, although they often have an equivalent verbal expression, (2) syllinguistic gestures that is gestures necessarily associated with speech and at last (3) synchronizers which are centered on the interaction and ensure good exchange run. Among extra-communicative gestures, the author distinguishes also 3 broad categories:

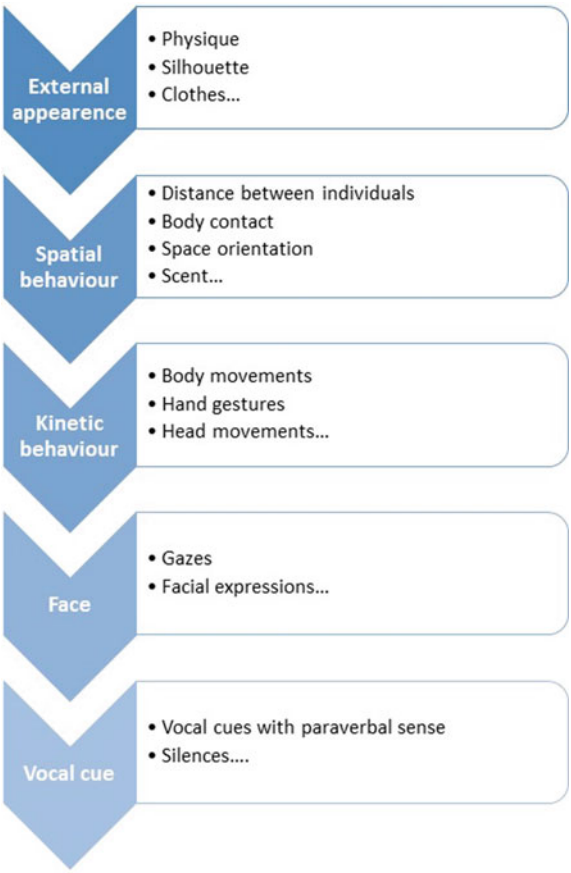

Fig. 3 Classifications of nonverbal items with the most obvious at the top and the least obvious at the bottom [23]

(1) comfort gestures that is change of position, (2) self-centered gestures or self-body manipulation and at last (3) playful gestures equivalent to the previous ones, but centered on the object.

Notice that when a gesture is accompanied by language, gesture becomes a support whereas when a gesture is not accompanied by language, it becomes language per se (e.g. sign language; deaf children have difficulty to learn conventions and implicit rules governing the language use).

As we mentioned above, nonverbal communication also contains silences. Our daily experience reveals that all silences are not the same (e.g. silence following an embarrassing question, silence due to reflection, silence to ignore others). Silence—depending on context and partners involved—may have a positive or negative valence that could impact relationships (e.g. dominance). For example, silence becomes positive when it is used in cases of emotions so strong that they can't be expressed verbally (e.g. love at first sight) or to express approval. If the silence is accompanied by gaze avoidance, it may indicate that the partner is embarrassed or wishes to close

Table 1 Summary of five classifications of paraverbal items

Authors	Classification of para-verbal *items*	
Trager [24]	1. Voice quality	
	2. Vocalisations	• Vocal characteristics
		• Vocal qualifications
		• Sounds
Harrow [25]	1. Reflex movements 2. Fundamental movements 3. Perceptual skills 4. Physical skills 5. Motor skills 6. Gestural communication	
Argyle [26]	According the type of speech (*e.g.* friendly)	
Morris [27]	1. Intentional gestures 2. Non intentional gestures	
Laver & Trudgill [28]	1. Extralinguistic characteristics of the voice	
	2. Paralinguistic characteristics of the voice tone	
	3. Characteristics of the phonetics	
Anolli *et al.* [29]	1. Vocal and verbal cues	
	2. Vocal but non verbal cues	• Tone • Intensity • Velocity

the conversation for example. Sachs et al. [33] developed a classification of silence in conversation in 3 parts: gap, lapse and pause. A silence of gap-type corresponds to the moment when you take your turn in speech. A silence of lapse-type defines situations where none of the interlocutors speak, causing the interruption of the conversation. At last, silence of pause-type corresponds to delay of the partner observed following a request, a question, a greeting. The latter can be considered, at least in our culture, as a violation of the informal rules of the conversation.

2.4 Factors That Modulate Communication

Communication may be influenced by several factors. For example, Anolli et al. [29] proposed four main types of factors: biological factors (e.g. gender, age), social factors (e.g. culture, social norms, environmental context, the degree of knowledge about each other), personality factors and emotional factors.

2.4.1 Degree of Knowledge About Each Other: Interaction or Relationships

Many definitions coexist [34, 35]. Here, we privileged the one proposed by Hinde [36], which is used in several disciplines such as psychology and ethology: "By an interaction, we usually mean a sequence in which individual A shows behavior X to individual B, or A shows X to B and B responds with T". This sequence of interaction can be repeated, identically or not. The description of an interaction is based on what individuals do together (content) and how they do it (quality). Hinde [37] argued that "in human interactions, such qualities can be as or more important than what the interactants actually did together". When two individuals encounter them for the first time, their level of uncertainty is strong, in the sense that there is indecision about the beliefs and behaviors that the other is likely to display [38]. Getting to know each other corresponds to reducing this uncertainty, so that the other appears predictable, a decision can be made about the desirability of future interactions and the level of intimacy that is desirable [39]. That is how, from an interaction, we move to a relationship.

A relationship involves a series of interactions in time: partners have, on the basis of the past experiences, expectations on the other individual's responses [36]. Depending on the interaction perceptions (i.e. positive or negative valence), relationships could range from trust and comfort to fear and stress. Once the relationship is established, it is not static: each interaction may influence the relationship or may persist despite a long separation [40]. Relationships expressed by (1) strong attraction between individuals, (2) proximity seeking, (3) preferences, (4) psychophysiological imbalance after isolation, (5) co-operation, (6) activity coordination, (7) affiliations and (8) predisposition to social facilitation (according to Laurence Henry, lecturer in University of Rennes 1). Henry and her collaborators [41] reports a general trend, through the animal kingdom including humans: vocal communication is important to establish a relationship between two individuals. Vocal communication is often used during first interactions but tends to decrease across time (e.g. number of occurrences), when a stable relationship is established.

Throughout the works of several authors from different disciplines [42–44], we propose a synthetic view of the word "relationship". The relationship between two individuals comes from the first encounter. It is instantiated from a very general model of the partner (e.g. man or woman, age range). Interaction after interaction, the "model" of the partner would be refined (e.g. from interaction valence, identity of each partner) to become an individual model. When the individual model is established, the relationship corresponds to the one defined by Hinde [36]. During interactions, continuous process allows to get individual model into conformity with what this model really is, the identity of each partner is dynamic and progressive.

2.4.2 Socio-Cultural Factors

While it seems common-sense that verbal communication is subject to socio-cultural factors, nonverbal communication is also submitted to such factors, even at a young age and ubiquitous way. For example, Efron [45] compared gestures of Italian immigrants to Jewish ones from Eastern Europe in the United States. He shows that gestures used are different in the first generation of both groups. These differences diminish in the second generations to finally become typically American for both populations. Differences are also observed on common gestures. For example, the gesture using hand to mean "come here" depends on the culture of people who use it. While, in France, the movement of the hand and fingers is palm up, in many Mediterranean countries, the gesture is palm down. Differences exist also in facial expressions as shown by cross-cultural studies. Facial expression of emotions corresponds to universal patterns but society would provide use rules: emotional expressions are not equally accepted according to cultures. For example, word numbers using to qualify emotions varies among cultures. In France, a hundred are identified while in Chewong, ethnologists found only 7 words [46].

2.4.3 Emotions

Defining "emotion" is very complex. Literature offers more than a hundred definitions [47] and more than 150 theories [48], showing that currently no consensus is reached. At the interpersonal level, function of emotions is to coordinate immediate social interactions, particularly through emotional expressions that help people to know the partner's emotions as well as beliefs and intentions [49, 50]. It has long been considered that *Arousal* (i.e. strength of the emotional stimulus) and *Valence* (i.e. emotionally positive or negative characteristics of stimulus) were only relevant components of emotion [51]. However, Scherer [52] identified a greater number of specific dimensions: *Intensity*, *Dominance* and *Impact* of emotion.

Finally, Tcherkassof [49] argues that emotion may have importance in communication as well as other components: affective state (i.e. sensation of pleasure or displeasure), sense (i.e. affective states of moral origin, emotionally charged attitudes), mood (i.e. chronic phenomenon compared to the emotion characteristic, i.e. acute phenomenon, that affects behavior), temperament (i.e. stable affective dispositions) and affect (i.e. experience of pleasure and displeasure).

2.4.4 Multimodal and Multichannel Communication

While it is true that verbal language, through the voice channel, is the preferred way to communicate, it is far from being the only channel used by humans. Observing a situation of communication of everyday life allow us to realize the importance of multimodal and multichannel communication in our interactions [53]. Human communication can, therefore, use different channels to transmit the signal: (1) the

auditory (e.g. sound) channel, linked to verbality and vocalizations, (2) the visual channel linked to gestures and (3) the olfactory, thermal and tactile channels unfortunately often neglected in adults of Western cultures. These channel uses are subject to strong socio-cultural factors. For example, the regulation of interactions between human adults (e.g. to ensure the attention of the partner) is mainly displayed by glances and gazes and not by direct physical contact, especially if the partners don't know them. In the context of robots, both the robot and the human multimodality must also be considered [54]. But researchers encounter several difficulties related to this question, in particular on the integration of several modalities in human-robot communication (e.g. synchronization of different modalities, gesture recognition).

3 A Proposed Intercomprehension Model

To communicate well, intercomprehension between individuals is prerequisite. However, this word is rarely defined, such as in dictionary. Nevertheless, it seems consistent that for intercomprehension, reciprocity is necessary. Jamet [55] proposes that intercomprehension could be defined as the ability to understand and be understood in an unknown language through different communication channels, both verbal and non-verbal. It cannot be limited to the verbal language and must include all components of the communication including, for example, smelling, touching or visual modality. For our model, we propose that intercomprehension is the ability to understand and be understood through different modalities of communication. This model was proposed by a consortium of interdisciplinary researchers working together in 2010–2011 in a project named MIAC ("*Modélisation interdisciplinaire de l'acceptabilité et de l'intercompréhension dans les interactions*" that is "Interdisciplinary Model of Acceptability and Intercomprehension in Interactions" between humans, animals and robots) [56]. In this model, we were first interested in the concept of identity. Identity is complex and dynamic, changing across time and according to the individual which whom you interact as well as the context you are in [57]. Each individual has her/his own identity with several sides (e.g. biology, personality, skills, knowledge, uses, emotions, and so on) [58, 59].

During an interaction, each individual activates one of "her/his identity", according to the partner's identity as well as to the context, i.e. moment, place, social environment and interactive situation/co-activity [11]. This is called *proposed identity* (e.g. A/A; Fig. 4). Likewise, each individual has her/his own identity perceived by others, that we called *perceived identity* (e.g. B/A) that could be influenced by past interactions. In this model, everyone conceives of what the others may represent about her/him: we called that the *represented identity* (e.g. (A/B)/A). Notice that "/" means "for". Based on the dynamic described above, we proposed a model of intercomprehension that could be common to humans, animals and machines including robots (Fig. 5). Thus, if the identity proposed by the individual A (e.g. status, aim… in the interaction) is consistent with the represented identity of A, and conversely for these two identities of the individual B, we can then talk about intercomprehension.

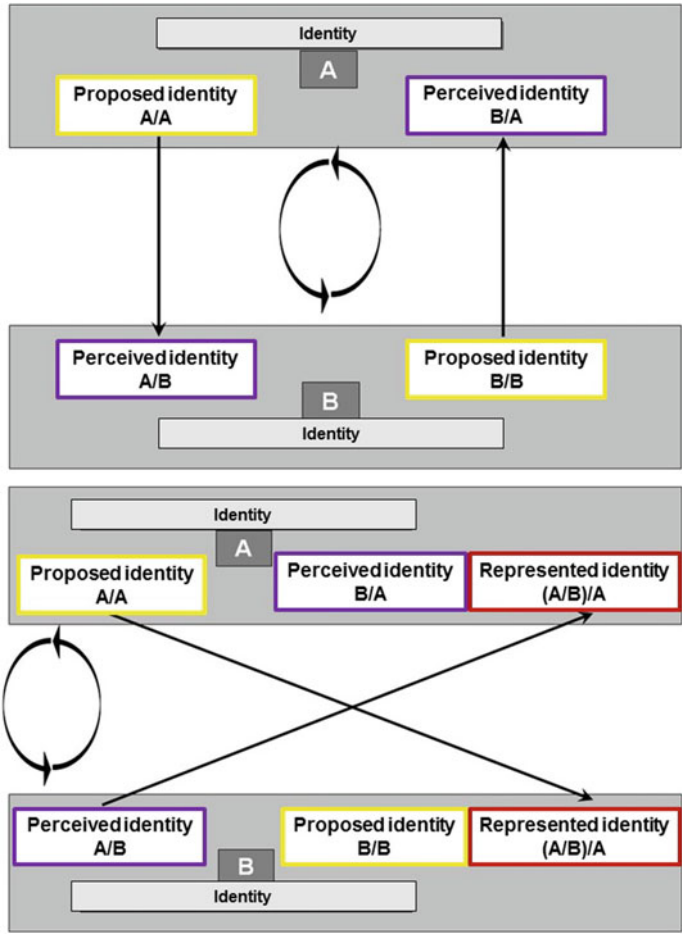

Fig. 4 Dynamics at the identity level. A and B are 2 different individuals (e.g. human, animal, robot). The arrows indicate the direction of the action (e.g. the proposed identity of A activate in B the perceived identity of A). Circle arrow indicate that the phenomena is always in process. Notice that "/" means "for"

This definition is useable for interactions between individuals from same species. But, for individuals from different species or individuals of same species with particular way of communication (e.g. autism, blind people), it is required to add a condition to talk about intercomprehension: the functional communication between the individual A and the individual B (upper part of the Fig. 5). This notion is based on Von Uexküll's concept [60] of Umwelt, i.e. an environment-world of each organism. They perceived the experience of living in terms of species-specific, spatio-temporal and 'self-in-world' subjective reference frames. Each individual's Umwelt has a meaning and imposes determinations. In order to communicate, two individuals must have functional concordances between their own perceptive devices, i.e. their senses allow

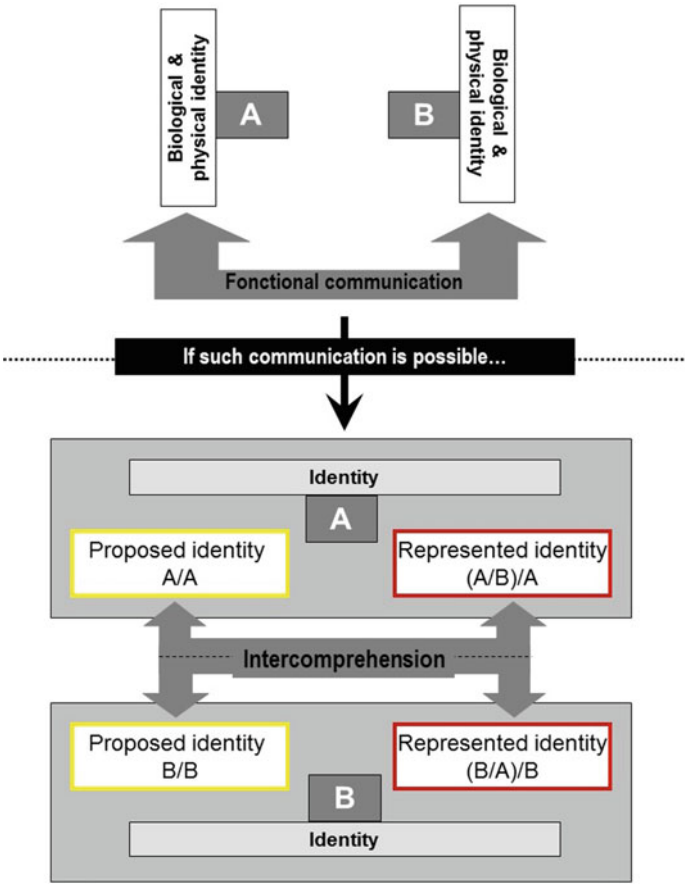

Fig. 5 Model of intercomprehension common to humans, animals and machines

to perceive each other, and therefore the signals emitted can be interpreted at a minimum level. Thus, among all the signals that a species uses, some are selected as having a meaning for other species [60]. In addition, these signals could become significant by learning. Therefore, communication between individuals from different species is limited by reception and recognition of signals used. These are a required but not sufficient condition for intercomprehension. Taking into account functional communication appears essential, for example, in human-robot interactions. Indeed, if we are interested in blind children, the visual modality may not be preferred in the design of the robot; likewise for elderly people with hearing problems, etc. Thus, if these conditions are fulfilled, individuals from different species can communicate and thus activate their different identities allowing intercomprehension between them.

4 Conclusions

Throughout this manuscript, we show that communication is dynamic, circular, complex and flexible. It is both intentional and unintentional signals that are used throughout multichannel and multimodal way. All communication has a purpose. At last, communication consists of cooperation and co-construction.

We proposed here a model of intercomprehension, taken into account several scientific disciplines. Real need appears in terms of research in order to improve human-robot communication. We hope that this model may help in such way. Indeed, as stated previously [61], "it is highly probable that the way humans "view" their robots has an important influence on the way they use them. Daily human-robot interactions are very varied and include both positive (e.g. services) and negative (e.g. breakdown) events, leading to more or less balanced relationships." Now, with such model and adaptations that could be involved, "further research is needed in order to assess how to maximize robot acceptance in the human environment - at least in some societies, what type of robot (e.g. size, functions) may help develop a positive relationship, what influence human involvement has on the relationship and so on". These constitute now major challenges for following researches.

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