Cooperative interpersonal communication and Relevant information*

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Abstract

This paper studies cooperation in multi-agent systems. In particular, we focus on the notion of relevance underlying cooperation. Given an agent who has some information need, we characterize pieces of information that are relevant to her. This characterization is done in a multi-modal logic. Finally, we give a formal definition for cooperation.

Keywords: cooperation, information relevance, multi-agent systems, information need

1 Introduction

Communication is the basis of social interactions. In this paper, we focus on cooperative interpersonal communication, i.e communication between two agents, the sender and the receiver, the sender being cooperative in its act of communicating. Cooperation implies that the piece of information which is sent to the receiver is easily understandable by her, i.e it is expressed in a language she understands and its interpretation does not require too long time nor effort. But more, this implies that the piece of information that is sent is, for the receiver, the very one which answers her information need. We call such pieces of information relevant to the receiver.

Relevance is a key concept in many areas and has already been given great attention in the literature. Thus, many definitions of relevance can be found. These definitions can be, according to Borlund [1], classified into two different groups : system-oriented relevance and agent-oriented relevance.

System-oriented approaches analyze relevance in terms of topicality, aboutness, matching degrees between a piece of information and a request, or in term of dependence. Most of the literature belonging to this approach can be found in: Information Retrieval where, given a request, the Information Retrieval system finds in its collection of documents the ones relevant for the request [2, 3];

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Artificial Intelligence where several notions of relevance have been introduced in order to speed up the inference in knowledge bases [4, 5]; Relevant Logics where alternatives to material implication have been defined so that antecedent and consequent are relevantly related [6].

On the other hand, *agent-oriented* approaches try to define a relation between some agent and a piece of information. Thus, relevance is analyzed in terms of agent's utility or informativeness for the agent. In those cases, relevant pieces of information are defined according the information need of the agent. The literature on this approach is quite informal but is of great interest. In Information Retrieval, Borlund [1] and Mizzaro [7] give a classification of different agent-oriented relevance depending the considered user level. They also point out the main concepts on which relevance is based on such as: the information need of the agent, her background knowledge, the context she is in, etc. In Linguistic, Grice [8] expounds his cooperation principle along with the corresponding maxims. One of the maxim is the relevance maxim and stipulates that one should be relevant in order to be cooperative. Many studies have followed Grice's [9, 10]. In particular, Sperber and Wilson reduce all the Grice's maxims to one and define a cognitive psychological theory, the Relevance Theory, based on the following informal definition: *An input (a sight, a sound, an utterance, a memory) is relevant to an individual when it connects with background information he has available to yield conclusions that matters to him.* Finally, in Philosophy, Floridi [11] has developed a subjectivist interpretation of epistemic relevance. In Floridi's theory, *the degree of relevance of a piece of information I towards an agent A is defined as a function of the accuracy of I understood by A as an answer to a query Q, given the probability that Q might be asked by A.*

In this present paper, our aim is to contribute to the study of agent-oriented relevance in cooperative communication. More precisely, we first give a logical definition of the concept of relevance. Then we give a logical definition of cooperative communicating agent.

This paper is organized as follows. Section 2 presents the multi-modal logic framework we base our model on. Section 3 deals with relevance defined according to an agent's information need. In section 4, we define a hierarchy that characterizes the most relevant pieces of information. In section 5, we propose a characterization for cooperation between agents. Finally, section 6 concludes this paper.

2 Formal framework

The formalism we use here to model agents and their mental attitudes is a propositional multi-modal logic. The mental attitudes we are interested in are belief and intention. This framework is very close to what has been suggested in [12].

The alphabet of our language is based on non logical symbols : a set $\mathcal{A}$ of agents, for every agent a of $\mathcal{A}$, we define two modalities B_a and I_a. We define also the set of logical symbols : a set $\mathcal{V}$ of variables symbols, $\neg$, $\vee$, (and), the constants $\top$ and $\bot$.

Definition 1 *The formulae of our language are defined recursively as follows:*

- *if p belongs to $\mathcal{V}$ then p is a formula of our language. $\bot$ and $\top$ are formulae of our language.*
- *if a is an agent of $\mathcal{A}$ and φ a formula of our language then $B_a\varphi$ and $I_a\varphi$ are formulae of our language. $B_a\varphi$ is read "agent a believes that φ is true". $I_a\varphi$ is read "agent a intends φ to be true".*
- *if φ_1 and φ_2 are formulae of our language, so are $\neg\varphi$ and $\varphi \vee \varphi_2$.*

If φ_1 and φ_2 are formulae of our language and a some agent of $\mathcal{A}$, we also define the following abbreviations: $\varphi_1 \wedge \varphi_2 \equiv \neg(\neg\varphi_1 \vee \neg\varphi_2)$, $\varphi_1 \rightarrow \varphi_2 \equiv \neg\varphi_1 \vee \varphi_2$, $\varphi_1 \leftrightarrow \varphi_2 \equiv (\varphi_1 \rightarrow \varphi_2) \wedge (\varphi_2 \rightarrow \varphi_1)$, $\varphi_1 \otimes \varphi_2 \equiv (\varphi_1 \wedge \neg\varphi_2) \vee (\neg\varphi_1 \wedge \varphi_2)$, $Bif_a\varphi \equiv B_a\varphi \vee B_a\neg\varphi$.

A formula of our language without any modality is said to be *objective*.

We now give an axiom system for belief and intention. This axiom system consists of following reasoning rules. Let a be an agent of $\mathcal{A}$.

- Propositional tautologies
- KD45 pour B,
  - (K) $B_a(\varphi \rightarrow \psi) \wedge B_a\varphi \rightarrow B\psi$
  - (D) $B_a\varphi \rightarrow \neg B_a\neg\varphi$
  - (4) $B_a\varphi \rightarrow B_aB_a\varphi$
  - (5) $\neg B_a\varphi \rightarrow B_a\neg B_a\varphi$
- (UE) Unit exclusion for I_a, $\neg I_a(\top)$
- BI Introspection as follows,
  - (BI1) $I_a\varphi \rightarrow B_aI_a\varphi$
  - (BI2) $\neg I_a\varphi \rightarrow B_a\neg I_a\varphi$
  - (BI3) $B_a(\varphi \leftrightarrow \psi) \rightarrow (I_a\varphi \leftrightarrow I_a\psi)$

Inference rules are Modus Ponens (MP) and Necessitation for B_a (Nec), i.e $\frac{\varphi}{B_a\varphi}$.

For belief modality, we suppose that agent do not have inconsistent beliefs (D) and that are conscious of what they believe (4) and what they do not believe (5).

For intention modality, we suppose that agents cannot intend a tautology to be true (UE).

Finally, we suppose some relation between belief and intention that we call belief intention introspection. First, we suppose that agents are conscious of what they intend (BI1) and what they do not intend (BI2). Then, we suppose that if an agent believes that two propositions are equivalent, then intending the first one to be true is equivalent to intending the second one to be true (BI3).

From this axiom system, we can derive that $I_a\varphi \rightarrow \neg B_a\varphi$. It means that if an agent intends a proposition to be true, then she does not believe that this proposition is true. In other words, agents cannot intend what they already believe to be true. Thus, the framework suggested here is very close to [13] where intention and belief are defined in order to study notions of cooperation and speech acts.

The semantics for intention is inspired by [12]. We consider frames that are the hybrid of neighborhood frames (for intention modality) and Kripke structure (for belief modality). We have shown that the axiom system defined previously is sound and complete in respect to serial, transitive, euclidean, introspective and unit-exclusive models.

3 Relevance

In this section, we first introduce a formal definition for agent-oriented relevance. Then, we study its properties.

3.1 Definition

We define relevance the following way:

Definition 2 *Let a be some agent of $\mathcal{A}$, φ a formula and Q a request. φ is said to be* relevant *for agent a concerning request Q iff the following formula is true*

$$I_aBif_aQ \wedge (B_a(\varphi \rightarrow Q) \otimes B_a(\varphi \rightarrow \neg Q)) \wedge \varphi$$

This formula is denoted $R_a^Q\varphi$.

This definition comprises three elements:

- **Agent's information need** I_aBif_aQ : We suppose that the agents that exchange pieces of information have some information needs. Moreover, we suppose that an information need is quite simple and can be modelled the following way: "agent a wants to know if Q or if $\neg Q$, Q being a request". [1] Formally, information need is written I_aBif_aQ, that means agent a wants to know if Q.

[1] In this paper, we do not pay attention to transitions from individual goals to information needs and from information need (as it is perceived by the agent) to a formalized request.

- **Agent's beliefs** $B_a(\varphi \to Q) \otimes B_a(\varphi \to \neg Q)$: Using her beliefs and the piece of information φ, the agent must be able to answer her request Q, that means she can deduce either Q or $\neg Q$. In order to represent this deduction, we choose logical implication.
  If some agent, from a piece of information φ can deduce both Q and $\neg Q$, then φ does not really answer the information need. Using $\otimes$ prevents this case to happen [2].

- **The piece of information truth value** φ: We consider that a false piece of information cannot be relevant. A false piece of information, even it has a meaning, is false. If we analyse the epistemical relevance in terms of cognitive efforts, misinformation is deleterious. For example, let us consider some agent who wants to take the train to Paris. This train leaves at 1.05 pm. In this context, telling the agent that the train leaves at 1.15 pm is damaging (as she can miss her train). Then, we cannot consider that the piece of information "The train leaves at 1.15 pm" is relevant to the agent. [3]

The following example illustrates the definition of relevance.

Example 1 *Let us consider a world where two agents a and b have to take a train. Unfortunately, some incidents in train stations can block train and make them be late (modelled by late). Let us consider that the piece of information "There are some incidents", modelled by inc, is true.*
Agent a needs to know if her train is late or not. Thus, she has the information need $I_a Bif_a Q$. *Agent a believes that if there are some incidents, then her train is late. This is modelled by* $B_a(inc \to late)$. *Thus, in this world, we have :*

- $I_a Bif_a(late)$
- $B_a(inc \to late)$
- inc
- *Then, we can deduce* $R_a^{late}(inc)$

That means that information inc is relevant to agent a concerning her request late.
Agent b also needs to know if her train is late or not. Her beliefs are different from a's ones. Indeed, agent b believes that if there are no incidents, then her train is not late. This can be modelled by $B_b(\neg inc \to \neg late)$ [4]. *Thus, in this world, we have :*

- $I_b Bif_b late$
- $B_b(\neg inc \to \neg late)$

[2] Using $\otimes$ prevents the case where the agent already believes $\neg\varphi$ to happen. Indeed, in this particular case, from $\neg\varphi$, the agent would be able to deduce anything.

[3] In some particular cases, misinformation can be relevant. For example, it is relevant for a teacher to learn that one of his pupils is wrong about some lessons. However, in this case, this is not the wrong lesson itself that is relevant to the teacher but the fact that the pupil is wrong.

[4] We also suppose that agent b does not have any other belief about *inc* or *late*

- *inc*

This time, the piece of information inc is not relevant for agent b as she cannot deduce neither late or ¬late.
The information ¬inc, which is false in the context, cannot be relevant for agent b as it would allow her to make wrong conclusions about her information need.

3.2 Properties

In this part, we study some properties of the relevance operator. For that, let us take an agent a of $\mathcal{A}$, Q, Q_1 and Q_2 some requests, φ, φ_1, φ_2 some formulas. The following propositions are theorems of our logic [5].

Proposition 1 $R_a^Q\varphi \to \neg B_a\varphi \wedge \neg B_a\neg\varphi$

If some piece of information φ is relevant for some agent a, then agent a does not believe neither φ (otherwise she would be already able to answer her information need), or $\neg\varphi$ (in contradiction with the use of $\otimes$ in definition of relevance).

Proposition 2
- $I_aBif_aQ \to R_a^QQ \otimes R_a^Q\neg Q$: *one of the pieces of information Q or $\neg Q$ is relevant to agent a concerning her request Q.*
- $R_a^Q\varphi \leftrightarrow R_a^{\neg Q}\varphi$: *some piece of information that is relevant concerning a request Q is relevant too concerning the request $\neg Q$.*
- $\neg(\varphi_1 \wedge \varphi_2) \to \neg(R_a^{Q_1}\varphi_1 \wedge R_a^{Q_2}\varphi_2)$: *two conflicting pieces of information cannot both be relevant.*

Proposition 3 $R_a^Q\varphi \to \neg B_aR_a^Q\varphi$

If some information φ is relevant to some agent a, then a does know it. This is due to the truth value of the piece of information contained in the relevance definition. If the agent believes that the piece of information is relevant to her, then she believes this piece of information. If she believes this piece of information, then she can deduce from her set of beliefs the answer to her information need. This is in contradiction with the fact the agent has the information need (relation of strong realism between belief and intention).

Proposition 4 *Let $*$ be some belief revision operator satisfying AGM postulates [14]. Bel_a represents the set of beliefs of agent a and $Bel_a * \varphi$ the set of beliefs of agent a after being revised by φ using revision operator $*$. Then, we have* $(R_a^Q\varphi \to (Bel_a * \varphi) \to Q) \otimes (R_a^Q\varphi \to (Bel_a * \varphi) \to \neg Q)$

This proposition shows that the deduction operator that we have chosen, logical implication, corresponds to some "basic" belief revision operator. Indeed, if she revises her beliefs with the relevant piece of information, the agent has in her new beliefs set the answer to her information need.

[5]To lighten, we will not write the symbol $\vdash$ in front of theorems.

Notation. In what follows, we will write $B_a(\varphi_1, \varphi_2/Q)$ instead of $\neg(B_a(\varphi_1 \to Q) \wedge B_a(\varphi_2 \to \neg Q)) \wedge \neg(B_a(\varphi_1 \to \neg Q) \wedge B_a(\varphi_2 \to Q))$. This formula means that agent a believes that φ_1 and φ_2 do not allow to deduce a contradiction concerning Q.

Proposition 5 $B_a(\varphi_1, \varphi_2/Q) \to (\varphi_2 \wedge R_a^Q\varphi_1 \to R_a^Q(\varphi_1 \wedge \varphi_2))$

Proposition 6 $B_a(\varphi_1, \varphi_2/Q) \to (R_a^Q\varphi_1 \wedge R_a^Q\varphi_2 \to R_a^Q(\varphi_1 \vee \varphi_2))$

Those two propositions show that the relevance operator characterizes too many relevant pieces of information. this is illustrated in the following example.

Example 2 *Let us take the example of the train that can be late because of incidents. Agent a needs to know if her train is late or not and we suppose that inc is relevant to her.*
Let us suppose that the piece of information "it rains", modelled by rain is true in this context. Then, the piece of information $inc \wedge rain$ *is relevant to a. Indeed, it contains all necessary elements so that agent a is able to answer her information need. Nevertheless, intuitively, the piece of information inc is more relevant to a than* $inc \wedge rain$ *because this last one contains the element rain that is not necessary to answer a's information need.*

All the pieces of information characterized relevant are "sufficiently" relevant. Indeed, each of them gives an answer to the information need. On the other side, one could consider pieces of information that are "necessarily" relevant, that means the ones without which the agent cannot answer her information need. If we combine the two concepts, we can find, among the "sufficiently relevant" pieces of information, the ones that are the most "necessary". Thus, those most necessary pieces of information are the very ones that are the most relevant.

4 A hierarchy for relevance

4.1 Minimal explanation

In this section, we characterize the "necessary relevance" notion described below. For that, we first introduce the notion of minimal explanation. This notion has been used in Lakemeyer [4] to define relevance. However, the definition of minimal explanation he uses is quite syntactical [6]. In order to have a more semantic definition, we update the definition by using notions of semantic independence defined in [5].

Definition 3 *Let* φ *be an objective formula.* φ *is said to be in Negation Normal Form (NNF) if and only if only propositional symbols are in the scope of an occurrence of* $\neg$ *in* φ.
$Lit(\varphi)$ *denotes the the set of literals occurring in the NNF of* φ.

[6] Indeed, he uses CNF form of a formula. But for a given formula, the CNF form is not unique

For example, the NNF form of $\varphi = \neg((\neg a \wedge b) \vee c)$ is $(a \vee \neg b) \wedge \neg c$. Then, $Lit(\varphi) = \{a, \neg b, \neg c\}$.

Definition 4 *Let φ be an objective formula, l a literal.*
φ is said to be syntactically Lit-dependent on l (resp. syntactically Lit-independent from l) if and only if $l \in Lit(\varphi)$ (resp. $l \notin Lit(\varphi)$).

Definition 5 *Let φ be an objective formula, l a literal.*
φ is said to be Lit-independent from l, denoted $l \not\mapsto \varphi$, if and only if there exists a formula Σ such that $\Sigma \equiv \varphi$ and Σ is syntactically Lit-independent from l. Otherwise, φ is said to be Lit-dependent on l, denoted $l \mapsto \varphi$. Given a language, the set of all literals of this language such that $l \mapsto \varphi$ is denoted by $DepLit(\varphi)$.

Example 3 *Let $\varphi = (a \wedge \neg b \wedge (a \vee b))$. We have $DepLit(\varphi) = \{a, \neg b\}$. Note that φ is Lit-independent from b because it is equivalent to $\Sigma = (a \wedge \neg b)$, in which b does not appear positively.*

Now, let us give the definition of minimal explanation.

Definition 6 *Let Δ be a finite set of objective formulae, and α and β be two objective formulae.*
β is an explanation of α if and only if $\vdash B\Delta \rightarrow B(\beta \rightarrow \alpha)$ and $\nvdash B\Delta \rightarrow B(\neg\beta)$.
β is a minimal explanation of α if and only if β is an explanation of α and there is no explanation β' of α such that $DepLit(\beta') \subseteq DepLit(\beta)$.

4.2 Most relevant information

From this minimal explanation, we can define what are the most relevant formulae.

Let $\mathcal{R}_a^Q$ be the set of relevant formulae. For all φ in $\mathcal{R}_a^Q$, we have $B_a(\varphi \rightarrow Q)$ or $B_a(\varphi \rightarrow \neg Q)$ and $\neg B_a(\neg\varphi)$, that means that for all φ in $\mathcal{R}_a^Q$, φ is an explanation of Q or $\neg Q$.

Definition 7 *Let $\mathcal{R}m_a^Q$ be the subset of $\mathcal{R}_a^Q$ that contains the minimal explanations of Q and $\neg Q$. We will write $Rm_a^Q\varphi$ to express that the formula φ belongs to $\mathcal{R}m_a^Q$.*

Example 4 *Let us consider the following set of relevant pieces of information to agent a concerning her request Q:$\mathcal{R}_a^Q = \{inc \wedge rain, inc \vee strike, strike\}$. Then $\mathcal{R}m_a^Q = \{strike, inc \wedge rain\}$.*

Thus, necessary (in respect to minimal explanation) and sufficient relevant pieces of information can be characterized. Of course, according to a different definition of "necessary" for a piece of information, we could have a different set of most relevant pieces of information.

5 Cooperation

Let us come back to the notion of cooperation in communication. Now that we have given a formal definition for relevance, we can formally define the notion of cooperation. For that, we extend our logical framework and consider for every couple (a, b) of agents in $\mathcal{A}$ the operator $Inf_{a,b}$ defined by Demolombe [15] [7]. $Inf_{a,b}\varphi$ is read "agent a informs b about φ". This operator is a non-normal operator for which we only have the substitutivity of equivalent formulae.

$$\frac{\varphi \leftrightarrow \psi}{Inf_{a,b}\varphi \leftrightarrow Inf_{a,b}\psi}$$

Intuitively, cooperation expresses the fact that only relevant information are exchanged. This is formalized the following way :

Definition 8 *Let a and b be two agents of $\mathcal{A}$. The agent b is* cooperative *with regard to a iff forall formula φ, b informs a about φ if and only if there is a request Q such that b believes that φ is maximal relevant for a concerning Q. This is represented [8] by :*

$$Coop(b, a) \equiv \forall\varphi, Inf_{b,a}\varphi \leftrightarrow \exists Q, B_b(Rm_a^Q\varphi)$$

Thus, an agent is cooperative with regard to another if she informs the other agent about pieces of information that she thinks maximal relevant for her and only those pieces of information. In other words, the set of exchanged pieces of information from b to a is exactly the set of pieces of information that b believes to be maximal relevant for a concerning any of her needs.

Thus, with this definition for cooperation, an agent b is *non-cooperative* in regard to another agent a if 1. b informs a about something for which b believes a has no need for or if 2. b believes that a piece of information is maximal relevant for a and does not inform her about it.

As we have seen, many pieces of information are relevant (inc, $rain \wedge inc$ for example). This is why b should only inform a about she thinks to be maximal relevant for a.

Many definitions of cooperation do exist in the literature [8, 16, 15]. In what follows, we compare the definition proposed here with two notions of cooperation: Sadek's [16] and Demolombe's [15].

Sadek [16] took a particular interest in studying the human-machine interaction. For him, being cooperative means giving back cooperative answers, i.e. answers that relevantly extend the question that was explicitly asked. Thus, a system can give back different types of cooperative answers to some user:

- completing answers: additional pieces of information that the user did not explicitly ask.
- correcting answers: pieces of information that invalidate some user's presuppositions.

[7] This operator was denoted $I_{a,b}$ in [15]

[8] The following formula cannot be represented in our framework. It is just a notation

- suggestive, conditional answers, ...

Sadek's approach contains some notions that are central in the characterisation of relevance and of cooperation put forward in this paper. Indeed, even if Sadek does not insist on this point, he considers that there is an implicit need of the user underlying his cooperation. This can be a need for additional pieces of information, or a need for correcting pieces of information and the type of the need will induce the type of the answer. Moreover, the fact that the system gives back a piece of information he possesses in its database is in accordance with our hypothesis. To conclude, it seems that our modelling framework is compatible with Sadek's approach about completing answers.

The cooperation defined in [15] is the closest one to the cooperation we define. This is why we compare the two notions. In [15], Demolombe defines the notion of cooperation from one agent in regard to another about a piece of information. We will represent agent b is cooperative in regard to agent a for piece of information p by $C_p(b,a)$. Following [15],

$$C_p(b,a) \equiv B_b p \leftrightarrow \mathit{Inf}_{b,a} p$$

That means that agent b is cooperative in regard to agent a for p iff if b believes p then b informs a about it.

The biggest difference between the Demolombe's definition and the one we propose is the presence of the information need. In [15], Demolombe does not take into account the information need of the receiver. Thus, this last one can receive pieces of information for which he has no interest or no need but that are true in some others agent belief base and for which this agent will be cooperative for.

In the definition we propose for cooperation, information exchanged from b to a should not only be believed by b but must also be believed by b as most relevant for a.

Let us illustrate the two cooperation definitions on an example.

Example 5 *Let a and b be two agents of $\mathcal{A}$. Agent a needs to take a train;*

Agent b works in the train station. He believes that agents such a that have to take a train need to know if their train are on time. She also believes that the persons that have a train to take are often pessimistic and will expect their train to be late if they learn that there are some incidents. We suppose that she does not believe anything else about other agents beliefs or intentions.

Agent b believes that there is an incident. She also believes that it rains.

Thus, we have:

- $B_b(I_a Bif_a late)$
- $B_b(inc) \wedge B_b(rain)$
- $B_b(B_a(inc \rightarrow late))$
- *Then,* $B_b Rm_a^{late} inc$

Let us consider the situation where b informs a only that there is an incident, i.e $\mathit{Inf}_{b,a} inc$. In that case, agent b is cooperative in respect to agent a, i.e

$Coop(b, a)$ because agent b believes that inc is relevant for agent a and this is the only information exchanged. Agent b is also cooperative in respect to agent a in regard with inc i.e $C_{inc}(b, a)$. However, she is not cooperative in respect to agent a in regard with rain i.e $\neg C_{rain}(b, a)$ because this information is believed to be true and is not exchanged.

Now, let us suppose that b informs a that there is an incident, i.e $Inf_{b,a} inc$ and that it rains $Inf_{b,a} rain$. In this case, agent b is cooperative in respect to agent a in regard with inc and in regard with rain i.e $C_{inc}(b, a)$ and $C_{rain}(b, a)$. However, agent b is not cooperative in respect to agent a, i.e $\neg Coop(b, a)$ because there is an information that is exchanged and that is not believed by b to be relevant for a. a has no need about rain so he should not be informed about it.

Thus, the definition of cooperation expresses what information should be exchanged whereas Demolombe's one does not consider this point.

6 Conclusion

In this paper, we formally characterized the notion of relevance. Given an agent that has some information need, we expressed in a multi-modal framework, what are relevant pieces of information for her concerning her information need. As too many pieces of information are relevant, we proposed a hierarchy for relevant pieces of information. This hierarchy can be seen as a compromise between "being precise" and "being concise".

From this characterization of relevance, we defined the notion of cooperation between agents that communicate. Thus, an agent is cooperative to another one if and only if she informs the other about and only about what she thinks maximal relevant for the other.

This work can be extended in many ways.

First, in the same way that we have define a relevance concerning an information need, we could define a relevance concerning a verification need. In that case, any piece of information in accordance or in contradiction with the agent's believes (in a given domain) would be relevant. Thus, it would be possible to define a new cooperation according to this relevance. This cooperation would correspond to Sadek's notion of correcting answers.

Then, we could extend this present work by considering the notion of time. Indeed, information need, truth value of a piece of information or beliefs are concepts that change with time. Then, the issue of time should be considered in relevance and cooperation definitions.

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