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QUESTIONS, INFERENCES, AND DIALOGUES

1. Internal Question Processing

Logical theories of questions supply formalisms for questions as well as characteristics of the question-answer relation.¹ As long as question asking and question answering are concerned, they usually adopt a simple dyadic perspective. It is assumed that there are two parties: a questioner and an answerer. The former asks a question, whereas the role of the latter is to provide an answer to the question. Even eliciting information from Nature is modeled that way.² When cooperative questioning is analyzed, an agent can play both roles, depending on the stage. This dyadic perspective, however, seems to obscure some important phenomenon, which may be called *internal question processing*.

What we mean here by internal question processing (hereafter: **IQP**) is not tantamount to question answering. When a question is internally processed, the immediate outcome need not be an answer to this question: an ‘inference’ performed on a question can lead to another question, which may be ‘sent’ by a cognitive agent either to itself or to a certain external source of information and then answered, but can also be processed further in an analogous way. Usually, this results in a problem decomposition: a (difficult) problem represented by a certain question is decomposed into sub-problems represented by other questions. However, the decomposition is dynamic and comes in stages: the consecutive questions (which constitute the sub-goals of the next stage) depend on how the previous requests for information have been fulfilled. In other cases a (difficult) problem represented by a certain

question is restated by formulating a new question. The relevant transformations of questions usually facilitate question answering and problem-solving. But there are cases in which they result in a plausible answer/solution to a question/problem.

In brief, our main objective will be to present some logical tools which are useful in a formal modeling of **IQP**.

2. Erotetic Inferences

In order to provide a formal account of **IQP** we need a logic which analyzes inferences performed on questions and proposes criteria of their validity. At first sight this claim may seem a contradiction, since questions are neither true nor false. But a moment’s reflection shows that there are inferential thought processes which result in questions. They are called *erotetic inferences* (from Greek ‘erotema’, which means ‘question’).

Sometimes we pass from proposition(s) to a question, as in:

- (1) *Andrew always comes in time, but now he is late. So what has happened to him?*

We also pass from a question to a question on the basis of some proposition(s), e.g.:

- (2) *Where did Andrew leave for? If Andrew took his famous umbrella, then he left for London; otherwise he left for Paris or Rome. So did Andrew take his famous umbrella?*

Moreover, it happens that we pass from a question directly to a question, as in:

- (3) *Is 112657853 a prime? So is there a natural number divisor of 112657853 different from it and from 1?*

In the second and third cases inferences are performed on questions: they play the roles of ‘premises’ and ‘conclusions’.

Inferential Erotetic Logic (**IEL** for short) puts erotetic inferences in the centre of

¹ For an overview see: Harrah, D., ‘The Logic of Questions’, in: D. Gabbay, T. Guenther (eds.) *Handbook of Philosophical Logic, Second Edition*, Volume 8, Kluwer, Dordrecht/ Boston/ London 2002, pp. 1-60.

² Cf. Hintikka, J., *Inquiry as Inquiry: A Logic of Scientific Discovery*, Kluwer, Dordrecht/ Boston/ London 1999.

its interest.³ **IEL** gives an account of the phenomenon of question raising and defines validity of erotetic inferences.

As for question raising, we have two different types of cases here, corresponding to two types of erotetic inferences. A question can arise out of a set of propositions, and a question can arise from a question on the basis of a (possibly empty) set of propositions. The relevant concepts of question raising are explicated in **IEL** by defining the semantic concepts of *evocation* of a question by a set of propositions, and *erotetic implication* of a question by a question and a set of propositions. A semantic approach is then mirrored by a syntactic one, and question-evoking and question-implicating rules are formulated. *Validity* of erotetic inferences is defined in terms of evocation and erotetic implication, respectively. Erotetic implication, as characterized in **IEL**, has a 'teleological' feature: an implied question Q^* is not only semantically grounded in the implying question Q , but Q^* is also cognitively useful with respect to Q in an 'open-mined' way: *i.e.* each direct answer to Q^* potentially contributes to finding, at least partial, answer to Q . Let us stress that the latter condition is explicated in semantic terms.

We will concentrate upon erotetic inferences which have questions as premises and conclusions, and thus on erotetic implication. This relation will be defined in terms of the so-called Minimal Erotetic Semantics.

3. Distributed IQP and E-Scenarios

One can distinguish two types of **IQP**: *ultimate* and *distributed*.

As long as ultimate **IQP** is concerned, no information requests are sent and the processing itself may lead to a plausible answer to a question. In the case of distributed **IQP** requests for additional information are sent, and questions are transformed into further questions depending on how previous information requests have been fulfilled. These requests for information may be sent by a cognitive agent

to itself (for instance, in order to activate his/her memory), or to a certain external source of stored information, or to other cognitive agent (*e.g.* in an information-seeking dialogue).

The concept of *erotetic search scenario* (e-scenario for short) can be useful in the formal modeling of **IQP**.⁴

An e-scenario is an abstract structure defined by means of tools taken from **IEL**. However, an e-scenario function is to show how a principal question may be answered by asking and answering auxiliary questions. An e-scenario has a tree-like structure with the principal question as the root and possible answers to this question as leaves. Other questions enter e-scenarios on the condition they are erotetically implied (in the sense of **IEL**). Moreover, an auxiliary question either: (a) has another question as the immediate successor, or (b) all the direct answers to the auxiliary question follow the question as its immediate successors. In the latter case an auxiliary question is a *query* and the immediate successors represent the possible ways in which the relevant request for information can be satisfied. The structure of an e-scenario shows what kind of further information requests (if any) are to be satisfied in order to arrive at an answer to the principal question.

Distributed **IQP** can be modeled in terms of e-scenarios in various ways. One of the possible lines of thought is the following. We attribute to a cognitive agent an initial e-scenario for his/her principal question just processed. The topmost query of this e-scenario determines the first request for information to be sent. Now, when the query is answered in a given way, the e-scenario *contracts*: consecutive queries which would follow the alternative answers to the query become inessential, and one arrives at a new e-scenario (again, for the principal question) with a new 'topmost' query, which is processed analogously. But suppose that one arrives at a query such that no answer to it is available by existing means. So, a *revision* of the current e-scenario is needed. One possible move is a revision by *embedding*: an e-scenario for the

³ Cf. Wiśniewski, A., *The Posing of Questions: Logical Foundations of Erotetic Inferences*, Kluwer, Dordrecht/ Boston/ London 1995, or: Wiśniewski, A., 'The logic of questions as a theory of erotetic arguments', *Synthese* 109, No. 2, 1996, pp.1-25; Wiśniewski, A., 'Questions and inferences', *Logique et Analyse* 173-175, 2001, pp. 5-43.

⁴ Cf. Wiśniewski, A., 'Erotetic search scenarios', *Synthese* 134, No. 3, 2003, pp. 389-427; see also: Wiśniewski, A., 'Erotetic search scenarios, problem-solving, and deduction' *Logique et Analyse* 185-188, 2004, pp. 139-166.

troublemaking query is embedded into the e-scenario just considered. Another possible move is a revision by *conditionalisation*: an answer to the query is added (with an appropriate comment) to the initial premises and the current e-scenario contracts accordingly. There are also other moves possible. Note that it is the initial e-scenario that is being transformed. As a consequence, the following desirable property is retained: each path of an intermediate scenario leads to an answer to the principal question. The process as a whole is goal-directed, comes in stages, and the sub-goals are processed/ created in a dynamic way.

The concept of e-scenario will be introduced, some operations of e-scenarios will be characterized, and the issue of applicability of the concepts of erotetic implication and e-scenario in the analysis of dialogues will be discussed.