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Questions, Answers, and Presuppositions

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Abstract. The paper deals with empirical questions that come attached with a presupposition. In case that the presupposition is not true, there is no unambiguous direct answer. In such a case an adequate complete answer is a negated presupposition. Yet these simple ideas are connected with a bunch of problems. First, we must distinguish between a pragmatic and semantic presupposition, and thus also between a presupposition and mere entailment. Second, we show that the common definition of a presupposition of a question as such a proposition that is entailed by every possible answer to the question is not precise. We follow Frege and Strawson in treating survival under negation as the most important test for presupposition. But a negative answer to a question is often ambiguous. The ambiguity consists in not distinguishing between two kinds of negative answers, to wit the answers applying narrow-scope or wide-scope negation. While the former preserves presupposition, the latter seems to be presupposition denying. We show that in order the negative answer to be unambiguous, instead of the wide-scope negation presumably denying presupposition, an adequate and unambiguous answer is just the negated presupposition. Having defined presupposition of a question more precisely, we then examine Yes-No questions, Wh-questions, and exclusive-or questions with respect to several kinds of presupposition triggers. These include inter alia topic-focus articulation, verbs expressing termination of an activity, factive verbs, the „whys and how comes", and past or future tense with reference time interval. Our background theory is Transparent Intensional Logic (TIL) with its *procedural* semantics. TIL is an expressive logic apt for analysis of questions and presuppositions, because within TIL we work with *partial* functions, in particular, with propositions with truth-value gaps. These features enabled us to define a *general analytic schema* of sentences associated with a presupposition. Our results are applicable in linguistics and artificial intelligence, in particular, in the systems the behavior of which is controlled by communication and reasoning of intelligent social agents.

Keywords. Question, answer, presupposition, entailment, wide-scope vs. narrow-scope negation, Transparent Intensional Logic, TIL.

1 Introduction

Questioning and answering plays an important role in our communication, and has many logically relevant features. Thus, a formal analysis of interrogative sentences and appropriate answers should not be missing in any formal system dealing with natural language semantics. To this end, many systems of *erotetic logics* have been developed.[1] In general, these logics specify axioms and rules that are special for questioning and answering. However, many important features of questions are based on their *presuppositions*. Everybody who is at least partially acquainted with the methods applied in social sciences has heard of the importance to consider the presuppositions of a question in *questionnaires*. Yet, to our best knowledge, none of the systems of erotetic logics deals with presuppositions of questions in a satisfactory way. This situation is due to the fact that in order to properly analyze presuppositions, we need to work with *partial functions* that may lack a value at some of their arguments. The goal of this paper is to fill this gap and propose an analysis of questions that come attached with presuppositions. And since answering is no less important then raising questions, we are also going

[1] See, for instance, [8, 18, 19, 20, 27].

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to propose a method of adequate unambiguous answering to such questions with presuppositions.

Our background theory is Transparent Intensional Logic (TIL) with its *procedural* semantics that assigns abstract procedures to terms of natural language as their context-invariant meanings. These procedures are rigorously defined as TIL constructions that produce lower-order objects as their products or in well-defined cases fail to produce an object by being improper. In case of *empirical* expressions the produced entity is a *possible-world intension* viewed as a *partial* function with the domain in possible worlds and times. In this paper we concentrate on the analysis of empirical interrogative sentences and define an empirical question as an α-intension denoted by the respective declarative counterpart of the interrogative sentence, whose α-value an inquirer would like to know. Hence in TIL, questions and answers are not formal expressions that would be only implicitly defined by means of axioms and rules controlling the dialog consisting of a sequence of queries and answers, as it is often so in formal systems of erotetic logic.[2] Rather, TIL belongs to the category of systems that Harrah in [8] characterizes as objectual, similarly as, e.g., Higginbotham in [9].

We analyze direct and complete answers to empirical questions with presuppositions. We are going to show that in case that a presupposition of a question is not true, then there is no unambiguous direct answer to the question. In such a case an adequate answer should convey just information that the presupposition is not satisfied, hence an adequate complete answer will provide negated presupposition so that the inquirer can appropriately adjust the question, which is one of the contributions of this paper. However, we will not deal with the issue of answering a query with a query, that is, with query clarification request, except of the case of the negated presupposition answer that can be considered as a clarification request.[3] Another novel contribution of this paper is a rigorous definition of a presupposition of a question. To this end, we distinguish two kinds of negation, to wit a wide-scope and narrow-scope negation. Since the direct answer applying a wide-scope negation is not unambiguous, the adequate negative answer is the one applying narrow-scope, or presupposition preserving negation.

Our results are applicable in particular in the area of artificial intelligence, because by an explicit rendering of the structural character of questions and answers we can specify an intelligent behavior of agents in a multi-agent system consisting of social agents who communicate with their fellow-agents by messaging. Such a system has no central dispatcher and its behavior is controlled just by messaging of agents who communicate in order to meet their individual as well as collective goals. They are able to enrich their ontology and knowledge base, and make decisions based on the derived consequences from the explicit knowledge base. To this end, it is desirable that they communicate and answer questions unambiguously, by conveying as much information as possible, so that the system be not prone to inconsistencies.

The rest of the paper is organized as follows. In Section 2 we classify questions into three sorts that we are going to deal with, into wit Yes-No questions, Wh-questions, and exclusive-or questions. Section 3 deals with presuppositions of a question. First, by distinguishing two kinds of negation and direct vs. complete answers we rigorously define presupposition of a question as such a proposition that is entailed by every unambiguous (including negative) answer to the question. Thus, we are also able to distinguish between a presupposition and a mere entailment. Then we deal with particular presupposition triggers. Section 4 provides examples of question and answer analysis that takes into account presuppositions of a question. To this end we apply a general TIL analytic schema that makes use of the *If-then-else* function. Finally, concluding remarks are contained in Section 5.

2 Classification of Questions

Interrogative empirical sentences can be classified according to many criteria, and various

[2] For TIL analysis of questions, see [24], and for the general characterization of erotetic logic, see, for instance, [10].

[3] For the analysis of query-to-query relations see, for instance, [15, 16].

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categorizations of questions have been proposed.[4] Questions can be open-ended or close-ended. The former gives the respondent greater freedom to provide information or opinions on a topic, while a close question calls for an answer of a specific type. Here we deal only with close questions classified into three basic types, to wit Yes-No questions, Wh-questions, and exclusive-or questions.

Yes-No questions like "Did you stop smoking?", "Did the Pope visit Prague?" present a proposition whose actual truth-value the inquirer would like to know. We explicate propositions as possible-world (PWS) intensions, i.e. functions with the domain of possible worlds enriched with temporal parameters. Thus where ω is the set of possible worlds and τ the set of time moments, propositions are mappings from ω to chronologies of truth values of type o, which is denoted by '$((o\tau)\omega)$', or '$o_{\tau\omega}$' for short.

In case of *Wh-questions* like "Who is the Pope?", "When did you stop smoking?", "Who are the members of the European Union?", "Why did you come?" the type of the denoted intension is determined by possible direct answers. In general, it can be an object of any type α; an individual, a set of individuals, time moment, location, property, proposition, etc. Thus the denoted α-intension is of a type $((\alpha\tau)\omega)$, or $\alpha_{\tau\omega}$ for short. In case of *exclusive-or questions* like "Are you going by train or by car?", "Is Tom an assistant or a professor?" the adequate answer does not provide a truth-value; instead, it conveys information on which of the alternatives is the case.

We also need to characterize the notions of *direct* and *complete* answer. As mentioned above, an empirical question poses an α-*intension* whose α-value the inquirer would like to know. Thus a direct answer provides directly this α-value. A complete answer is the proposition that the α-value of the asked α-intension is an α-object. For instance, the direct answer to the Wh-question "Who is the No.1 player in WTA ranking singles" is 'Williams Serena', while the complete answer is "Williams Serena is the No.1 player in WTA ranking singles". Obviously, to each direct answer there is the respective complete answer.

3 Presuppositions of Questions

3.1 What is a Presupposition of a Question?

Presupposition is generally characterized as the information that is presupposed or taken for granted. Levinson ([14, p. 179]) characterizes a presupposition as a background belief, relating to an utterance, that (a) must be mutually known or assumed by the speaker and addressee for the utterance to be considered appropriate in context, (b) generally will remain a necessary assumption whether the utterance is placed in the form of an assertion, denial, or question, and (c) can generally be associated with a specific lexical item or grammatical feature (*presupposition trigger*) in the utterance. Presupposition of a question is mostly defined by two conditions:[5]

– Usability; the truth of a presupposition is a necessary condition for an interrogative act to be successful.
– Inference from possible answers; presupposition of a question is entailed by each possible answer to the question.

Yet, as we are going to show, none of these definitions is satisfactory. In an effort to deal with presuppositions of a question, many distinguish between presuppositions of a *semantic* and *pragmatic* nature.[6] Frege-Strawson tradition deals with semantic models, while Stalnaker offered pragmatic models.[7]

In case of declarative sentences, the modern treatment of presupposition has followed Frege-Strawson in treating survival under negation as the most important test for presupposition. That is, if it is implied that *P*, both in an assertion of a sentence *S* and in an assertion of the negation of *S*, then it is presupposed that *P* in those assertions. For instance,

[4] See, for instance, a questioning toolkit, The Educational Technology Journal, vol. 7, No. 3, 1997, http://www.fno.org/nov97/toolkit.html, [retrieved on April 7, 2015].

[5] See, for instance, [6, 12, 13].

[6] See, for instance [1, 17].

[7] See [21, 22, 23].

1. The King of France died in misery
2. The King of France did not die in misery

both presuppose that 'the King of France' had reference. Other typical examples include (cf. [14, 178–81])

3. John managed [didn't manage] to stop in time

implying that John tried to stop in time, and

4. Martha regrets [doesn't regret] drinking John's home brew

implying that Martha drank John's home brew.

But it seems that in (3) and (4) presupposition is of a pragmatic nature, because it can be cancelled by a context. If somebody is asking whether John managed to stop in time, then according to Pagin [17] the negative answer can be "No, he did not; he didn't even try". This indicates that in this case the presupposition is a pragmatic phenomenon. It is the speaker or speech act rather than the sentence or the proposition expressed that presupposes something. Yet, Pagin continues, in asking the speaker normally assumes that John tried and is only asking about the success.

In this paper we deal with semantic presuppositions of questions. Our main thesis is this. Negative direct answers are often ambiguous. Thus, a negative direct answer 'No' as a reaction to (3) can mean that

a) John tried but did not manage to stop in time
b) John did not even try to stop in time.

Yet, if the responder behaves fairly enough aiming to provide maximum information, they shouldn't answer directly 'No' in the second case. Instead, they should convey information that the *presupposition* is not true by providing the complete answer "John did not try to stop in time". If we accept this, then the direct answer 'No' will be unambiguously understood as meaning (a).

Similarly, when asking (4) in such a situation that the presupposition that Martha drank John's home brew is not true, there is no unambiguous direct answer Yes/No. The responder should thus provide a complete answer by negating the presupposition: "Martha did not drink John's home brew".

This is in good harmony with Strawson's [23] definition of presupposition:

One sentence S presupposes
another sentence P iff
whenever S is true or false, P is true.

Hence if a presupposition P of a proposition S is not true, then S *does not have any truth-value*, and when asking whether S, there is no direct Yes/No answer with narrow scope negation. In other words, P is entailed both by S and *non-S.* Yet we have to distinguish between presupposition and mere entailment. Schematically, if |= is the relation of analytic entailment, the difference is this:

P is a *presupposition of S*:
(S |= P) and (*non-S* |= P)

P is merely entailed by S: (S |= P),
but neither (*non-S* |= P) nor (*non-S* |= *non-P*).

Thus in case of mere entailment we cannot infer anything about the truth-value of P on the basis of S not being true. Pagin (ibid.) is inclined to pragmatic treatment of presupposition P in case P is not entailed by negated S, because, as he says, presupposition can be denied by context. We do not side with this inclination because this is often the case of mere entailment. For instance, the sentence

5. Police found the murderer of JFK

entails that the murderer exists. Yet this is *not* the case of existential presupposition because (5) can be false in two different situations. Either the murderer does not exist, or the search was not successful because the police failed in their effort. Yet the sentence presupposes that police were looking for the murderer. Hence if it is no so, then when asking whether (5), an adequate answer would not be simply 'No'. Rather, the responder should provide a complete answer "No, the police were not looking for the murderer". The simple direct answer 'No' should thus be understood as meaning that the police were looking for the murderer but the search was not successful (either because the murderer does not exist, or because the police failed in their effort).

As mentioned above, Pagin (ibid.) takes the presupposition of (3) that John was trying to stop in time also as of pragmatic nature, because negative answer can seemingly deny the presupposition. In our opinion, this is not the pragmatic case. If John did not try, then an adequate unambiguous answer to the question whether (3) is not simply 'No'. Rather, the responder should answer "It is not true that John managed to stop in time because he even didn't try".

Moreover, in the logic of partial functions such as TIL the two negations, to wit

(N_1) "John did not manage to stop in time"

(N_2) "It is not true that John managed to stop in time"

are not strictly equivalent in the sense of denoting one and the same proposition.

The issue is this. If John did not even try to stop, proposition denoted by (N_1) has *no* truth-value while the proposition denoted by (N_2) has the truth-value **T**. The latter is due to the fact that the presupposition that John tried to stop in time is not true and thus the proposition that John managed to stop in time does indeed not have the truth-value **T**, because it has a truth-value gap. Hence, the two propositions are not identical.

For this reason we distinguish between *narrow-scope* and *wide-scope negation*.[8] In [4] Duží analyzes these two kinds of negation and shows that Russellian wide-scope negation negates the entire proposition (it is not true that the respective proposition has the truth-value **T**, hence it has the value **F** or no truth-value), while Strawsonian narrow-scope negation negates the respective property or relation; negation is propagated in. In [1] these two kinds of negation are called presupposition preserving and presupposition denying negation, respectively. Yet the latter does not deny that there is a presupposition. Rather, it denies the truth of the presupposition. Hence, as an unambiguous negative direct answer, we admit only the one applying narrow-scope negation, and our main thesis is this:

> Instead of the direct answer applying the wide-scope negation, an adequate response is the complete answer conveying the negated presupposition.

Now we are in a position to define *presupposition of a question.*

Definition 1. *Presupposition of an empirical question Q* is a proposition *P* that is entailed by each complete answer corresponding to an unambiguous direct answer.

3.2 Presupposition Triggers

It might seem that questions that come attached with a presupposition are only a special case of Yes/No questions, because Wh-questions do not have a presupposition. Some authors incline to this opinion. For instance, Fitzpatrick in [6] argues that Wh-questions do not have an existential presupposition. Moreover, he argues that only the factive wh-operator *how come* is truly presuppositional in English and that evidence for semantic presuppositions in other wh-questions is better treated through pragmatic principles of question asking, because presupposition can be denied by negation. We will however show that even Wh-questions have a semantic presupposition. To this end we apply the above explained principle of distinguishing narrow-scope and wide-scope negation.

3.2.1 Existential Presupposition

The problem whether a question has an existential presupposition is not simple, because sentences of natural language are often ambiguous. The ambiguity we have in mind concerns different *topic-focus* articulations.[9] For instance, the question "When did the Pope visit Prague?" is ambiguous. If topic is 'the (current) Pope' then 'the Pope' occurs with supposition *de re* and the question has an existential presupposition that the Papal office is occupied. Each positive direct answer completed to a complete answer entails that the Pope exists. The negative answer 'never' would be ambiguous in case we did not take into

[8] This distinction can be found, e.g., in [6, 7].

[9] Hajičová in [7] argues that the analysis of topic-focus articulation is a semantic rather than pragmatic issue. For logical analysis of sentences with topic-focus articulation see [2].

account the existential presupposition. It might mean that the existing Pope never visited Prague, or that the Pope does not exist. Yet, in the latter case the wide-scope negation is applied, which we do not admit as an adequate answer. Hence it is necessary to take into account the semantic existential presupposition, and if it is not true, the correct unambiguous answer is “It is not true that the Pope visited Prague because the Pope does not exist”.

The situation is different if the topic is ‘the visit of Prague’. In this case there is no presupposition that the Pope exists, and the sentence should be better formulated in passive: “When has Prague been visited by a/the Pope?” Now the answer ‘never’ is unambiguous meaning that the set of dates when Prague was honored by papal visit is empty. The term ‘Pope’ occurs with supposition *de dicto*. In languages that do not use articles such as Czech or Russian there is another ambiguity, namely, whether the question concerns the visits of the current Pope or any of the (current and previous) Popes. In such a case our agents reply by asking for disambiguation of the question.

The topic-focus articulation is important not only in the case that the topic concerns definite descriptions like ‘the Pope’, ‘the first man in Space’, ‘Miss World’, etc. that denote offices or roles occupied by at most one individual but also in case of general terms.

For instance, the question “Did all the trucks deliver ordered cargo?” has an existential presupposition that there were some trucks delivering the ordered cargo provided ‘delivering trucks’ is the topic. If there are no such trucks, we should answer by denying the truth of the presupposition and inform the inquirer that there are no trucks, because the unambiguous negative answer necessarily implies that some trucks did not deliver their goods, which in turn entails that there are some trucks delivering. However, if we reglement such a question in the language of FOL, we obtain a formula like this:

$$\forall x\ [Truck\ (x) \supset Delivered\_Cargo\ (x)].$$

This formula is true under every interpretation assigning an empty set of individuals to the predicate ‘*Truck*’. Thus, in FOL whenever the presupposition that there are some trucks is not true, the sentence “All the trucks delivered their cargo” will be true. Imagine, however, communication of agents in a multi-agent system based on this principle:

Q: Did all the trucks deliver their cargo?
A: Yes.
(because there are no trucks delivering any cargo)
Q: OK, thus all the delivered cargo can be offered for selling?
A: Yes.
(because there is no delivered cargo)
Q: Perfect, I will inform the sellers that the goods have arrived.
A: ???

You would certainly agree that such a communication is not very intelligible and the system is prone to inconsistencies. An intelligible conversation should look like this:

Q: Did all the trucks deliver their cargo?
A: There are no trucks delivering cargo.
Q: How come, what has happened?
A: We are waiting for the results of the tendering process.

Obviously, the explicit reglementation of a question should take into account presuppositions, and doing so is beyond the expressive power of FOL system. We need a more expressive system of the logic of *partial* functions that makes it possible to work with propositions lacking a truth-value.

3.2.2 Activity Verbs

To another kind of questions with presuppositions belong those that contain as a constituent an activity verb. Verbs expressing an activity come attached with a presupposition whenever we ask whether the respective activity came to an end or continues. In that case there is a presupposition that the activity in question began. To adduce a frequent example, consider the question “Did Tom stop beating his wife?” It is generally taken for granted that this question is connected with presuppositions that Tom had been married and that he did beat his wife. And we side with this opinion. Again, it might be contested whether a negative answer ‘no’ means that Tom did not stop beating his wife or that it is not true that Tom stopped beating his wife (because he has never been married or never beat his wife). But this is again the case of narrow vs. wide-scope negation. Our agents should reply unambiguously and provide maximum information. Hence, in the latter case an adequate response is the complete answer denying the truth of the presupposition. For instance, that Tom has never been married.

3.2.3 Questions in Past or Future Tense

Questions in past or future with reference time when this or that happened or will happen come with a presupposition that the reference time is in a proper relation to the time of evaluation. Consider, for instance, the question "Shall we meet today at 17:00"? Both a positive and negative answer entail that the question has been evaluated *before* 17:00. If it is not so, the respondent cannot reply 'No'. Rather, they should reply by denying the truth of the presupposition: "It is later than 17:00".

A correct analysis of such questions with reference time is again important in particular for a smooth and consistent communication of agents in a multi-agent system. For instance, a question in future tense can reach the addressee too late due to technical problems (e.g. the agent is out of the range of a mobile signal). In such a case the responder informs the inquirer that the message came too late.[10]

3.2.4 Factive Verbs

Questions on attitudes with factive verbs like 'know that', 'regret that', etc. have a presupposition that the proposition denoted by the embedded clause is true. For instance, the question "Does Tom know that he came late?" presupposes that Tom came late. Again, both positive answer "Yes, he does know it" and negative answer with narrow scope negation "No, he doesn't know it" entail that Tom came late. If it is not so, the appropriate reaction is just informing the inquirer about the situation by negating the presupposition, to wit "Tom didn't come late".

It might seem doubtful whether 'regret' is a factive verb as well. In general, it is not. A declarative sentence like "Tom regrets his coming late" can be false in two situations. Either Tom came late but he isn't sorry for that, or Tom did not come late. Yet, in our opinion, when asking whether Tom regrets his coming late, the topic of the question is Tom's coming late, which is presupposed. Of course, the situation would be different if the topic were Tom's regretting something. This is a pragmatic factor that comes into the game here. Yet on the natural former reading the question presupposes that Tom did come late. Hence, again, if it is not the case, then instead of the ambiguous wide-scope negation answer the agent conveys the fact that the presupposition is not true, i.e. Tom did not come late.

As always, we should distinguish between a presupposition and a mere entailment. For instance, finding after the forgoing search is connected with the presupposition that the search took place. Thus finding in this sense means that the activity of seeking came to a successful end, which is the case that we dealt with in paragraph 3.2.2. However, there is no presupposition that the sought object exists; it is only entailed by the success in search. In case of not finding, the failure could be due to seeker's incompetence or non-existence of the sought object. For instance, the question "Did police find the murderer of JFK?" is connected with the presupposition that the police looked for the murderer.[11] If they did not, then the adequate answer is "Police was not seeking the murderer of JFK". The answer 'no' means that the police did seek but did not succeed –either because the murderer escaped without being identified or the murderer does not even exist. Such verbs like 'find', 'find out', 'discover' are characterized by Karttunen in [11] as *semifactives*.[12]

3.2.5 Exclusive-or Questions

These questions come attached with a presupposition that only one of the two alternatives is the case. For instance, the question "Is WTA No. 1 ranked player Williams Serena, or Kvitová Petra?" is not Yes-No question, of course. The inquirer does not require the answer Yes or No. They want to know which one of the two ladies occupies the role of WTA number 1 ranked player in singles, and they presuppose that only one of

[10] For the analyses of tenses see [3, 25].

[11] We now assume that 'the murderer of JFK' is not the topic.

[12] See also [6].

the alternatives is the case. If it is not so, the respondent should convey this information by negating the presupposition.[13]

4 Analysis of Questions in TIL

4.1 The Foundations of TIL

In this paper we apply only a fragment of TIL consisting of *first-order types* and four kinds of *constructions*.[14] The syntax of TIL is Church's (higher-order) typed λ-calculus, but with the all-important difference that the syntax has been assigned a procedural (as opposed to set-theoretical denotational) semantics, according to which a linguistic sense is an abstract procedure detailing how to arrive at an object of a particular logical type. TIL *constructions* are such procedures. Thus, λ-*abstraction* transforms into the molecular procedure of forming a function, *application* into the molecular procedure of applying a function to an argument, and *variables* into atomic procedures for arriving at their values assigned to them by valuation.

TIL constructions represent our interpretation of Frege's notion of *Sinn* and are kindred to Church's notion of *concept*. Constructions are linguistic senses, as well as modes of presentation of objects. While the Frege-Church connection makes it obvious that constructions are not formulae, it is crucial to emphasize that constructions are not functions conceived as set-theoretical mappings. Rather, technically speaking, some constructions are modes of presentation of functions, including 0-place functions such as individuals and truth-values, and the rest are modes of presentation of other constructions. Thus, with constructions of constructions, constructions of functions, functions, and functional values in our stratified ontology, we need to keep track of the traffic between multiple logical strata. The ramified type hierarchy does just that.

The types of order 1 include all objects that are not constructions. Therefore, they include not only the standard objects of individuals, truth-values, sets, etc., but also functions defined on possible worlds (i.e., the intensions germane to possible-world semantics).

Definition 2 (*types of order 1*). Let *B* be a *base*, where a base is a collection of pairwise disjoint, non-empty sets. Then

(i) Every member of *B* is an elementary *type of order 1 over B.*
(ii) Let α, β_1, ..., β_m ($m > 0$) be types of order 1 over *B*. Then the collection ($\alpha\ \beta_1 \ldots \beta_m$) of all *m*-ary partial mappings from $\beta_1 \times \ldots \times \beta_m$ into α is a functional *type of* order *1 over B.*
(iii) Nothing is a *type of order 1 over B* unless it so follows from (i) and (ii).

For the purposes of natural language analysis, we assume the following base of ground types, which is part of the ontological commitments of TIL:

ο: the set of truth-values {**T, F**};
ι: the set of individuals (the universe of discourse);
τ: the set of real numbers (doubling as discrete times);
ω: the set of logically possible worlds (the logical space).

We model sets and relations by their characteristic functions. Thus, for instance, (οι) is the type of a set of individuals, while (οιι) is the type of a relation-in-extension between individuals.

Definition 3 (*constructions*)

(i) *Variables x*, *y*, … are *constructions* that construct objects of the respective types dependently on a valuation *v*; they *v*-construct.
(ii) Where *X* is an object whatsoever (an extension, an intension or a *construction*), ${}^0X$ is the *construction Trivialization.* It constructs *X* without any change.
(iii) *Composition* [$X\ Y_1 \ldots Y_m$] is the following *construction*. If *X v-constructs* a function *f* of type ($\alpha\beta_1 \ldots \beta_m$), and Y_1, …, Y_m *v-construct* entities B_1, …, B_m of types β_1, …, β_m,

[13] Alternative questions known from questionnaires are a more general case. They presuppose that at least one of the alternatives is the case. For this reason, there is often the alternative 'other' or 'none of the above'.

[14] For the (much larger) full TIL theory, see [5, Ch.2].

respectively, then the *Composition* $[X\ Y_1 \ldots Y_m]$ *v-constructs* the value (an entity, if any, of type α) of *f* on the tuple argument $\langle B_1, \ldots, B_m \rangle$. Otherwise, the *Composition* $[X\ Y_1 \ldots Y_m]$ does not *v-construct* anything and so is *v-improper*.

(iv) *Closure* $[\lambda x_1 \ldots x_m\ Y]$ is the following *construction*. Let $x_1, x_2, \ldots, x_m$ be pairwise distinct variables *v*-constructing entities of types $\beta_1, \ldots, \beta_m$ and *Y* a construction *v*-constructing an α-entity. Then $[\lambda x_1 \ldots x_m\ Y]$ is the *construction* λ-*Closure* (or *Closure*). It *v-constructs* the following function *f* of the type $(\alpha\beta_1 \ldots \beta_m)$. Let $v(B_1/x_1, \ldots, B_m/x_m)$ be a valuation identical with *v* at least up to assigning objects $B_1/\beta_1, \ldots, B_m/\beta_m$ to variables $x_1, \ldots, x_m$. If *Y* is $v(B_1/x_1, \ldots, B_m/x_m)$-improper (see iii), then *f* is undefined at the tuple $\langle B_1, \ldots, B_m \rangle$. Otherwise, the value of *f* at $\langle B_1, \ldots, B_m \rangle$ is the α-entity $v(B_1/x_1, \ldots, B_m/x_m)$-constructed by *Y*.

(v) Nothing is a *construction*, unless it so follows from (i) through (iv).[15]

Empirical languages incorporate an element of *contingency* that the non-empirical ones lack. Empirical expressions denote *empirical conditions* that may or may not be satisfied at some world/time pair of evaluation. We model these empirical conditions as possible-world-semantic *(PWS) intensions.* PWS intensions are entities of type $(\beta\omega)$: mappings from possible worlds to an arbitrary type β. The type β is frequently the type of the *chronology* of α-objects, i.e., a mapping of type $(\alpha\tau)$. Thus α-intensions are frequently functions of type $((\alpha\tau)\omega)$, abbreviated as '$\alpha_{\tau\omega}$'. *Extensional entities* are entities of a type α where $\alpha \neq (\beta\omega)$ for any type β.

Examples of frequently used intensions are propositions of type $o_{\tau\omega}$, properties of individuals of type $(o\iota)_{\tau\omega}$, binary relations-in-intension between individuals of type $(o\iota\iota)_{\tau\omega}$, individual offices/roles of type $\iota_{\tau\omega}$.

Where *w* ranges over ω and *t* over τ, the following logical form essentially characterizes the logical syntax of empirical language:

$$\lambda w \lambda t\ [\ldots w \ldots . t \ldots].$$

Logical objects like *truth-functions* and *quantifiers* are extensional: $\wedge$ (conjunction), $\vee$ (disjunction), and $\supset$ (implication) are of type (ooo), and $\neg$ (negation) of type (oo). *Quantifiers* $\forall^\alpha$, $\exists^\alpha$ are type-theoretically polymorphous total functions of type $(o(o\alpha))$, for an arbitrary type α, defined as follows. The *universal quantifier* $\forall^\alpha$ is a function that associates a class *A* of α-elements with **T** if *A* contains all elements of the type α, otherwise with **F**. The *existential quantifier* $\exists^\alpha$ is a function that associates a class *A* of α-elements with **T** if *A* is a non-empty class, otherwise with **F**.

Below, all type indications will be provided outside the formulae in order not to clutter the notation. Furthermore, 'X/α' means that an object *X* is (a member) of type α. '$X \rightarrow_v \alpha$' means that *X* is typed to *v*-construct an object (if any) of type α. We write '$X \rightarrow \alpha$' if what is *v*-constructed does not depend on a valuation *v*. Throughout, it holds that the variables $w \rightarrow_v \omega$ and $t \rightarrow_v \tau$. If $C \rightarrow_v \alpha_{\tau\omega}$ then the frequently used Composition $[[C\ w]\ t]$, which is the intensional descent (a.k.a. extensionalization) of the α-intension *v*-constructed by *C*, will be encoded as 'C_{wt}'.

4.2 Logical Analysis of Questions

Analysis of the semantic core of an empirical interrogative sentence is a construction of an α-intension whose α-value in the actual possible world and time the inquirer wants to know. *Yes-No questions* denote propositions, i.e. objects of type $o_{\tau\omega}$, and the analysis is a construction of a proposition. For instance, the analysis of the interrogative sentence "Is Tom walking?" comes down to the construction of proposition:

$$\lambda w \lambda t\ [{}^0Walking_{wt}\ {}^0Tom] \rightarrow o_{\tau\omega},$$

types: $Walking/(o\iota)_{\tau\omega}$; Tom/ι.

In case of *Wh-questions* the denoted object is an α-intension where α is any type different from o. The type α is determined by possible direct

[15] There are two additional constructions, Single and Double Execution, that we do not need in this paper. See, for instance, [4, 5].

answers because these are values of the α-intension in question. Consider, for instance, the question

(1) Who are the first five players in WTA ranking singles?

Possible direct answers specify a set of individuals, currently {Serena Williams, Maria Sharapova, Simona Halep, Muguruza Garbine, Petra Kvitová}, which is an object of type (οι). Thus the semantic core of this question is a construction of the property of individuals, object of type $(οι)_{τω}$:

(1*) $\lambda w \lambda t\, \lambda x\, [[{}^0 Order\_WTA_{wt}\ x] \leq {}^0 5] \rightarrow (οι)_{τω}$

Types: $x \rightarrow_v ι$; $Order\_WTA/(τι)_{τω}$: attribute of an individual that is a function assigning to individuals their current position (if any) in WTA ranking singles; 5/τ.

If the set of individuals obtained by evaluating the question (1) in a given world *w* and time *t* were empty, then the unambiguous direct answer is simply 'no one'. Hence there is no existential presupposition attached to this question.

Similarly, when somebody asks who is the Mayor of Ostrava, they want to know the actual value of the office. The analysis is a construction of the ι-office.

(2) Who is the Mayor of Ostrava?

(2*) $\lambda w \lambda t\, [{}^0 Mayor\_of_{wt}\ {}^0 Ostrava] \rightarrow ι_{τω}$

where $Mayor\_of/(ιι)_{τω}$; $Ostrava/ι$.

If the Mayor of Ostrava does not exist then the office is vacant, no individual is obtained by evaluating the question (2) and the answer is 'nobody'. Again, there is no existential presupposition. Only positive answers entail that the Mayor exists. This might indicate that we side with Fitzpatrick (see [6]) that Wh-questions do not have an existential presupposition with the only exception of 'how come'. Yet it is not so. Consider

(3) When did the Mayor of Ostrava visit Brussels?

If the topic of this question is the Mayor of Ostrava, then the sentence is connected with the existential presupposition that the Mayor exists, that is that the office is occupied. The narrow-scope unambiguous negative direct answer 'never' implies that the Mayor exists but never visited Brussels. Instead of the wide-scope interpretation of this negative answer, an adequate answer is just the piece of information that the presupposition is not true, the Mayor does not exist.

4.3 General Analytic Schema for Questions with Presuppositions

In order to take presuppositions into account, we apply the general analytic schema for sentences with a presupposition that has been introduced in [3, 4] together with the definition of the *If-then-else* function. The schema modified for the analysis of a question $Q \rightarrow α_{τω}$ with a presupposition $P \rightarrow ο_{τω}$ is this:

$$\lambda w \lambda t\ \ [If\ P_{wt}\ then\ Q_{wt}\ else\ \neg P_{wt}]$$

Gloss. If the presupposition *P* is true in a given world *w* and time *t* ($If\ P_{wt}$), then evaluate Q_{wt} to provide the answer of type α, else reply by negating the presupposition *P* ($\neg P_{wt}$).

In order to apply this schema to question (3), we have to realize that existence is here a property of the individual office of the Mayor of Ostrava, to wit, that the office is occupied in a given world and time of evaluation. Hence, the presupposition of (3) is constructed by

$$\lambda w \lambda t\, [{}^0 Exist_{wt}\ \lambda w \lambda t\, [{}^0 Mayor\_of_{wt}\ {}^0 Ostrava]]$$

where $Exist/(οι_{τω})_{τω}$ is the property of an office of being occupied.

Now we can apply the schema to (3):

(3*) $\lambda w \lambda t\, [If\ [{}^0 Exist_{wt}\ \lambda w \lambda t\, [{}^0 Mayor\_of_{wt}\ {}^0 Ostrava]]$
$then\ \lambda t'\, [[t' < t] \wedge$
$[{}^0 Visit_{wt'}\, [{}^0 Mayor\_of_{wt}\ {}^0 Ostrava]\ {}^0 Brussels]]$
$else\ \neg[{}^0 Exist_{wt}\ \lambda w \lambda t\, [{}^0 Mayor\_of_{wt}\ {}^0 Ostrava]]]$

Additional types: $Visit/(οιι)_{τω}$; $Brussels/ι$.

Note that the answer is of type (οτ), that is, the set of past times *t'*, namely, those times when the Mayor was visiting Brussels.

The exclusive-or questions have only two possible direct answers, to wit one of the two alternatives. For instance, if one asks

(4) Is Tom a student or a professor?

they want to know the only property selected from $\{Student/(οι)_{τω},\ Professor/(οι)_{τω}\}$ that Tom has.

Thus we construct an office occupied by individual properties, i.e. object of type $((o\iota)_{\tau\omega})_{\tau\omega}$:

(4*) $\lambda w \lambda t\ [{}^0\mathrm{I}\ \lambda p\ [[p_{wt}\ {}^0Tom] \wedge$
$[[p = {}^0Professor] \vee [p = {}^0Student]]]]$

$\rightarrow ((o\iota)_{\tau\omega})_{\tau\omega}$

Types: *Professor*, *Student*/$(o\iota)_{\tau\omega}$; $p \rightarrow_v (o\iota)_{\tau\omega}$; *Tom*/$\iota$; I/$((o\iota)_{\tau\omega}(o(o\iota)_{\tau\omega}))$: singularizer on the set of properties, i.e. the function that assigns to a singleton *M* the only element of *M*, otherwise undefined.

Note that our analysis can be understood as an *instruction* how in any possible world (λw) at any time (λt) to evaluate the question, which amounts for the execution of the procedure in question, and thus convey as a direct answer the value of so-constructed intension, if any. For instance, the above construction (4*) is a specification of this instruction:

In any state-of-affairs ($\lambda w \lambda t$), take the individual Tom (${}^0Tom$), properties of being a professor, and of being a student (${}^0Professor$, ${}^0Student$), assign these properties to the variable *p* ($[[p = {}^0Professor] \vee [p = {}^0Student]]$), and find out which of them *Tom* has ($[p_{wt}\ {}^0Tom]$). Finally, produce the only one of these two properties as the direct answer (${}^0\mathrm{I}\ \lambda p$ […]).

In case Tom has none of these properties or both, the so-constructed set (λp […]) is not a singleton and the singularizer I is undefined. This is as it should be, because in such a case, the presupposition is not true and there is no direct answer. The responding agent should inform the inquirer about this situation and convey information that presupposition is not true, i.e. that there is no such unique property. To this end, we must adjust (4*):

(4**) $\lambda w \lambda t$
$[If\ \exists q\ [q = [{}^0\mathrm{I}\ \lambda p\ [[p_{wt}\ {}^0Tom] \wedge$
$[[p = {}^0Professor] \vee [p = {}^0Student]]]]]$
$then\ [{}^0\mathrm{I}\ \lambda p\ [[p_{wt}\ {}^0Tom] \wedge$
$[[p = {}^0Professor] \vee [p = {}^0Student]]]]$
$else\ \neg\exists q\ [q = [{}^0\mathrm{I}\ \lambda p\ [[p_{wt}\ {}^0Tom] \wedge$
$[[p = {}^0Professor] \vee [p = {}^0Student]]]]]]$

Additional types: $\exists/(o(o(o\iota)_{\tau\omega}))$: the existential quantifier defined on the set of properties; p, $q \rightarrow_v (o\iota)_{\tau\omega}$.

To adduce another example of a question that comes with an existential presupposition, we analyze the question introduced in 3.2.1 with the topic '(delivering) trucks':

(5) Did all the trucks deliver their cargo?

(5*) $\lambda w \lambda t\ [If\ [{}^0\exists\ {}^0Truck_{wt}]$
$then\ [[{}^0All\ {}^0Truck_{wt}]$
$\lambda x\ [{}^0Delivered_{wt}\ x\ [{}^0Ordered\ {}^0Cargo]]]$
$else\ \neg[{}^0\exists\ {}^0Truck_{wt}]]$

Types: *All*/$((o(o\iota))(o\iota))$:restricted quantifier, the function that associates a given set with the set of all its supersets; *Truck*, Cargo/$(o\iota)_{\tau\omega}$; *Delivered*/$(o\iota(o\iota)_{\tau\omega})_{\tau\omega}$; *Ordered*/$((o\iota)_{\tau\omega}(o\iota)_{\tau\omega})$: property modifier.

Questions in past or future come with the presupposition that the reference time interval is in a proper relation to the time *t* of evaluation. Consider, for instance, the question

(6) Will Tom and Peter meet today at 4 p.m.?

This question has a presupposition that the time *t* of evaluation is less than 4 p.m. of the respective date. The term 'today' denotes a function of type $((o\tau)\tau)$ that associates a given time *t* with the interval of the date that contains *t.*

Thus, we have

(6*) $\lambda w \lambda t\ [If\ [t < {}^016]$
$then\ [[[{}^0Meet_w\ {}^016]\ {}^0Tom\ {}^0Petr] \wedge [[{}^0Today\ t]\ {}^016]]$
$else\ [t \geq {}^016]]$

Types: 16/τ: time 4 p.m. of the respective date; *Meet*/$(o\iota\iota)_{\tau\omega}$; *Today*/$((o\tau)\tau)$; *Tom*, *Peter*/$\iota$.

As the last sample example of applying our technique, we analyze the case of a presupposition triggered by a topic-focus articulation combined with a factive verb. Let the following question be understood as articulated with the topic 'coming late':

(7) Does Tom regret his coming late?

On such a reading the sentence comes attached with a presupposition that Tom did come late. Thus, the analysis respects this presupposition:

(7*) $\lambda w \lambda t\ [If\ [{}^0Late_{wt}\ {}^0Tom]$
$then\ [{}^0Regret_{wt}\ {}^0Tom\ \lambda w \lambda t\ [{}^0Late_{wt}\ {}^0Tom]]$
$else\ \neg[{}^0Late_{wt}\ {}^0Tom]]$

Types: *Late*/$(o\iota)_{\tau\omega}$: the property of coming late; *Regret*/$(o\iota o_{\tau\omega})_{\tau\omega}$.

So much for our general analytic schema. As the sample examples illustrate, the analysis is a straightforward application of the schema that respects presupposition of a question. Moreover, the schema complies with our thesis of providing a complete answer informing the inquirer that the presupposition is not true in case it is so, instead of the ambiguous direct answer 'no' understood as a wide-scope negation.

5 Conclusion

In this paper, we dealt with the analysis of empirical questions that come attached with a presupposition. Our main novel results are these. First, we provided a more accurate definition of presupposition of an empirical question. To this end, we adjusted the common definition by inference from possible answers, because we had to meet the problem of the ambiguity connected with negative answers. Thus, we distinguished between 'wide-scope' and 'narrow-scope' negation, and proposed that instead of the ambiguous answer applying the wide-scope negation, the adequate answer is the piece of information that the presupposition is not true, which is another contribution of this paper. Finally, we dealt with five presupposition triggers and provided their logical analysis in Transparent Intensional Logic.

Our results are applicable not only in linguistics but also in the area of artificial intelligence, in particular, for the design of multi-agent systems. In such a system we need to formalize the content of messages in a fine-grained way so that agents' behavior is 'intelligent' and the system is not prone to inconsistencies due to a limited expressive power of the background logical system.

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References

1. **Beaver, D.I. & Geurts, B. (2014).** Presupposition. In **Edward N. Zalta (ed.)**, *The Stanford Encyclopedia of Philosophy* (Winter 2014 Edition), retrieved April 6, 2015, URL http://plato.stanford.edu/archives/win2014/entries/presupposition/.
2. **Duží, M. (2009).** Topic-focus articulation from the semantic point of view. *Computational Linguistics and Intelligent Text Processing*, LNCS, Vol. 5449, Springer, pp. 220–232. DOI: 10.1007/978-3-642-00382-0_18.
3. **Duží, M. (2010).** Tenses and truth-conditions: a plea for *if-then-else.* In **Peliš, M. (ed.)**, *The Logical Yearbook 2009*, London: College Publications, pp. 63–80.
4. **Duží, M. (2014)**. How to Unify Russellian and Strawsonian Definite Descriptions. In **Roberto Ciuni, Heinrich Wansing, Caroline Willcommen (eds.)**, *Recent Trends in Philosophical Logic*, *Trends in Logic*, Vol. 41, pp. 85–101. DOI: 10.1007/978-3-319-06080-4_7.
5. **Duží, M., Jespersen, B., & Materna P. (2010).** *Procedural Semantics for Hyperintensional Logic. Foundations and Applications of Transparent Intensional Logic*. Berlin: Springer.
6. **Fitzpatrick, J. (2005).** The Whys and How Comes of Presupposition and NPI Licensing in Questions. *Proc. of the 24th West Coast Conference on Formal Linguistics*, pp. 138–145, Somerville, MA: Cascadilla Proc. Project.
7. **Hajičová, E. (2008).** What we are talking about and what we are saying about it. *Computational Linguistics and Intelligent Text Processing*, LNCS, Vol. 4919, Springer, pp. 241–262. DOI: 10.1007/978-3-540-78135-6_21.
8. **Harrah, D. (2002).** The Logic of questions. *Handbook of Philosophical Logic*, Vol. 8, pp. 1–60. DOI: 10.1007/978-94-009-6259-0_12.
9. **Higginbotham, J. (1993).** Interrogatives. In **K. Hale & S. Keyser (eds.)**, *The View from Building 20: Essays in Linguistic in Honor of Sylvain*

Bromberger, The MIT Press, Cambridge, MA, pp. 195–227.

10. **Hintikka, J. (1976).** *The Semantics of Questions and the Questions of Semantics. Case studies in the Interrelations of Logic*. Amsterdam, North Holland.
11. **Karttunen, L. (1970).** Some Observations on Factivity. *45th Annual Meeting of the LSA*, Washington, DC. DOI: 10.1080/08351817109370248.
12. **Katz, J.J. (1972).** *Semantic Theory*. New York: Harper & Row.
13. **Keenan, E.L. & Hull, R.D. (1973).** The Logical Presuppositions of Questions and Answers. In **J. S. Petöfi & D. Franck (eds.)**, *Präsuppositionen in Philosophie und Linguistik*, pp. 441–466, Frankfurt: Athenäum.
14. **Levinson, S.C. (1983).** *Pragmatics.* Cambridge, England: Cambridge University.
15. **Łupkowski, P. (2012).** Erotetic Inferences in Natural Language Dialogues. *Proc. of the Logic & Cognition conference*, May 2012, Poznań, Poland, pp. 39–48.
16. **Łupkowski, P. & Ginzburg, J. (2013).** A corpus-based taxonomy of question responses. *Proc. of the 10th International Conference on Computational Semantics (IWCS 2013)*, March 2013, Potsdam, Germany, Association for Computational Linguistics, pp. 354–361.
17. **Pagin, P. (2014).** Assertion. In *The Stanford Encyclopedia of Philosophy* (Spring 2014 Edition), **Edward N. Zalta (ed.)**, http://plato.stanford.edu/archives/spr2014/entries/assertion.
18. **Peliš, M. (2008).** Consequence Relations in Inferential Erotetic Logic. In **M. Bílková (ed.)**, *Consequence, Inference, Structure*, book series *Miscellanea Logica VII*, Charles University of Prague, pp. 53–88.
19. **Peliš, M. & Majer, O. (2011).** Logic of Questions and Public Announcements. In **N. Bezhanishvili, S. Löbner, K. Schwabe, L. Spada, (eds.)**, 8th *International Tbilisi Symposium on Logic, Language and Computation 2009*, LNCS 2011, Springer, pp. 145–157. DOI: 10.1007/978-3-642-22303-7_9.
20. **Sintonen, M. (1984).** On the Logic of why-Questions. *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association*, University of Chicago Press, pp. 168–176.
21. **Stalnaker, R. (1973).** Presuppositions. *The Journal of Philosophical Logic*, Vol. 2, pp. 447–457.
22. **Stalnaker, R. (1974).** Pragmatic presuppositions. In **M. Munitz & P. Unger (eds.)**, *Semantics and Philosophy*, New York University Press, pp. 197–214.
23. **Strawson, P. (1950).** On referring. *Mind*, Vol. 59, pp. 320–344.
24. **Tichý, P. (1978).** Questions, answers and logic. *American Philosophical Quarterly*, Vol. 15, pp. 275–284. Reprinted in (Tichý 2004, 293–304).
25. **Tichý, P. (1980).** The logic of temporal discourse. *Linguistics and Philsophy*, Vol. 3, pp. 343–369. Reprinted in (Tichý 2004, 373–369). DOI: 10.1007/BF00401690.
26. **Tichý, P. (2004).** Collected Papers in Logic and Philosophy. In **V. Svoboda, B. Jespersen, C. Cheyne (eds.)**, *Prague: Filosofia*, Czech Academy of Science & Dunedin, University of Otago Press.
27. **Wiśniewski, A. (1995)**. *The Posing of Questions: Logical Foundations of Erotetic Inferences*. Kluwer.

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