Andrzej Wiśniewski

Erotetic Logic and Explanation by Abnormic Hypotheses*

General rules might be false or even known not to apply to all relevant cases, but nevertheless these are the general rules which usually govern our expectations, since they enable us to predict the most "typical" outcomes. When such a prediction fails, however, the need for explanation usually arises. The explanation called for is not simply an explanation of the failure of our prediction: we want to explain why such-and-such outcome took place rather than the expected one. In the simplest case this situation may be schematically described as follows. We have a general rule of the form:

(GR) $\forall x(F_1(x) \wedge \ldots \wedge F_m(x) \rightarrow E(x))$

which has proved its usefulness in many cases. On the other hand, we have found an object a of which the following holds: $F_1(a) \wedge \ldots \wedge F_m(a)$, $R(a)$, where $R(a)$ describes something that is the case and which is such that the statement $R(a) \rightarrow \neg E(a)$ is true. So we ask the question: Why is it the case that $R(a)$?

How can one find an acceptable answer to this question? A possible way is to formulate and/or apply a hypothesis of a special kind (called an *abnormic hypothesis*) which completes the general rule. In most cases a hypothesis of this kind determines a class of possible correct answers to the explanation-seeking why-question within which some selection should be made. The core of the selection procedure consists in performing a series of valid erotetic inferences, that is, roughly, inferences which have questions and/or declaratives as premises and questions as conclusions. If the selection procedure is successful, an acceptable answer to the explanation-seeking question is found, a deductive-nomological explanation of the analysed departure from a general rule becomes possible and the degree of confirmation of the proposed hypothesis rises. If, however, the selection procedure ends

*First published in *Synthese* **120**, 1999, pp. 295–309. Published here with kind permission from Springer Science+Business Media; minor linguistic alterations have been made.

with the rejection of all the relevant possible correct answers to the why-question, the hypothesis should be modified.

Let us analyse this in detail.

1. What are abnormic hypotheses? In his famous paper "Why-questions" Sylvain Bromberger introduced the concept of abnormic law.[1] There are abnormic laws of two kinds: general and special. Here are two examples of general abnormic laws:[2]

> (L_1) The level of liquid in a cylindrical container on which a melting object is floating at room temperature will rise unless the object is made of a substance whose density in liquid form is the same or is greater than that of the original liquid at room temperature. If the density is the same, the level will remain the same; if the density is greater, the level will go down.

> (L_2) All French nouns form their plural by adding *s* unless they end in *al* (except *bal, cal, carnaval*, etc.) or in *eu*, or in *au*, or in *ou* (except *chou, genou*, etc.), or *x*, or *z*, or *s*. If and only if they end in *al* (except *bal*, etc.) they form their plural by dropping the last syllable and replacing it with *aux*; if and only if they end in *eu* or *ou* or *au* (except *chou*, etc.) they form their plural by adding *x*; if and only if they end in *x* or *z* or *s* they form their plural by adding nothing.

The following are examples of special abnormic laws:

> (L_3) The velocity of an object does not change unless the net force on it is not equal to zero.

> (L_4) No sample of gas expands unless its temperature is kept constant but its pressure decreases, or its pressure is kept constant but its temperature increases, or its absolute temperature increases by a larger factor than its pressure, or its pressure decreases by a larger factor than its absolute temperature.

By and large, a general abnormic law states that if some initial conditions are met, then a given effect takes place provided that some additional conditions are not met. If, however, any of the additional conditions is met, then the result is different. Moreover, a general abnormic law catalogues all the

[1]This paper was published for the first time in: R. G. Colodny (ed.), *Mind and Cosmos: Essays in Contemporary Science and Philosophy*, vol. 3, Pittsburgh 1966, and reprinted with some corrections in Bromberger's book *On What we Know We Don't Know: Explanation, Theory, Linguistics, and How Questions Shape Them*, Chicago/London/Stanford 1992, pp. 75–100. We will use the later version here.

[2]All the examples of abnormic laws presented below are taken from Bromberger's paper.

possible outcomes different from the "main" one and associates with each of these some condition(s) whose satisfaction, together with the satisfaction of the initial conditions, produces the relevant outcome. A special abnormic law, in turn, states that if some initial conditions are met and some additional conditions are not satisfied, the outcome is so and so, but if any of the additional conditions is satisfied, the result is just the opposite.

Abnormic laws are regarded as *completions* of general rules. In particular, (L_1) completes the general rule:

> (G_1) The level of liquid in a cylindrical container on which a melting object is floating at room temperature will rise.

whereas (L_2) completes the following:

> (G_2) All French nouns form their plural by adding *s*.

Similarly, the general rules:

> (G_3) The velocity of an object does not change.
>
> (G_4) No sample of gas expands.

are completed by (L_3) and (L_4), respectively.

We may say[3] that a general abnormic law has the following logical form:

$$\begin{aligned}\text{(GA)}\quad & \forall x(F_1(x) \wedge \ldots \wedge F_m(x) \rightarrow ((\neg E(x) \leftrightarrow P_{1_1}(x) \vee \ldots \vee P_{1_n}(x) \\ & \vee P_{2_1}(x) \vee \ldots \vee P_{2_j}(x) \vee \ldots \vee P_{k_1}(x) \vee \ldots \vee P_{k_v}(x)) \\ & \wedge (P_{1_1}(x) \vee \ldots \vee P_{1_n}(x) \leftrightarrow R_1(x)) \\ & \wedge (P_{2_1}(x) \vee \ldots \vee P_{2_j}(x) \leftrightarrow R_2(x)) \\ & \wedge \ldots \\ & \wedge (P_{k_1}(x) \vee \ldots \vee P_{k_v}(x) \leftrightarrow R_k(x))))\end{aligned}$$

where $m \geq 1$, $k \geq 1$, $n > 1$, and $F_1, \ldots, F_m$, $P_{1_1}, \ldots, P_{1_n}$, $P_{2_1}, \ldots, P_{2_j}, \ldots$, $P_{k_1}, \ldots, P_{k_v}$, $R_1, \ldots, R_k$ are distinct one-place predicates. A special abnormic law has the following logical form:

$$\text{(SA)}\quad \forall x(F_1(x) \wedge \ldots \wedge F_m(x) \rightarrow (\neg E(x) \leftrightarrow P_1(x) \vee \ldots \vee P_n(x)))$$

where $m \geq 1$, $n > 1$ and $F_1, \ldots, F_m$, $E, P_1, \ldots, P_n$ are distinct one-place predicates. The general rule completed by a general or special abnormic law of the form (GA) or (SA) has the logical form of (GR).

[3]Following Bromberger's exposition, we will use one-place (i.e. monadic) predicates as constituents of abnormic hypotheses. As Bromberger points out, a generalization to n-place predicates ($n > 0$) is straightforward. Moreover, the results presented below would not change essentially if polyadic predicates were allowed (only the relevant questions and instantiations would have to be adjusted appropriately).

Let us stress that the above schemata only show what is the logical form of abnormic laws. It is not the case that any statement having the form of (GA) or (SA) is an abnormic law. Bromberger imposes here some further constraints. The most important are lawlikeness and truth; there are also other requirements (cf. Bromberger 1992, pp. 89–90). Yet, we want to speak here about abnormic hypotheses instead of abnormic laws. So we will say that a *general abnormic hypothesis* is a hypothesis of the form (GA). Similarly, a *special abnormic hypothesis* is a hypothesis of the form (SA). We neither assume nor deny that an abnormic hypothesis is true; yet, for obvious reasons, we retain the lawlikeness requirement. By the general rule completed by an abnormic hypothesis of the form (GA) or (SA) we mean the corresponding statement of the form (GR).

In order to continue we also need the concept of an *antonymic predicate* of an abnormic hypothesis (law).

The antonymic predicates of (GA) are $E, R_1, R_2, \ldots, R_k$; they are the antonymic predicates of the corresponding general abnormic hypothesis (law). Thus, for example, the antonymic predicates of the law (L_2) are the following: "Forms the plural by adding *s*", "Forms the plural by dropping the last syllable and replacing it with *aux*", "Forms the plural by adding *x*", "Forms the plural by adding nothing".

The antonymic predicates of an abnormic hypothesis of the form (SA) (and thus also of the corresponding special abnormic hypothesis or law) are E and E^*, where E^* is the negation of the predicate E. In what follows, instead of defining the concept of negation of a predicate, we will simply assume that the formula $\forall x(E^*(x) \leftrightarrow \neg E(x))$ always holds. The antonymic predicates of (L_3) are: "The velocity of ... changes", "The velocity of ... does not change", whereas the antonymic predicates of (L_4) are: "expands" and "does not expand".

A general abnormic hypothesis of the form (GA) involves biconditional(s) of the form $(P_{i_1}(x) \vee \ldots \vee P_{i_s}(x) \leftrightarrow R_i(x))$, where $R_i (i = 1, \ldots, k)$ is an antonymic predicate of the hypothesis; we say that P_{i_1}, ..., P_{i_s} are predicates associated with R_i in the hypothesis.

2. Answers to why-questions. Why-questions pose a challenge to erotetic logicians, since it is hard to define what counts as a "principal" possible (that is – in terms of different theories – direct, or proper, or conclusive, etc.) answer to a why-question. The (partial) solution to this problem proposed in this paper will be based on (but not identical with) that proposed by Bromberger in his paper "Why-questions".

Bromberger's analysis is restricted to why-questions in the so called normal form, that is, why-questions which can be put in English in the form of an interrogative sentence which fulfils the following conditions: (a) it begins with the word *why*; (b) the remainder of the sentence has the (surface) structure of a yes-no question; (c) the sentence contains no parenthetical verbs. The *inner question* of a why-question in the normal form is the yes-no question expressed by the interrogative sentence which can be obtained from the why-question by deleting the word *why*; the *presupposition* of a why-question in the normal form is the sentence which expresses the affirmative answer to its inner question. For example, in the case of the question:

(1) Why is the plural of the French noun *cheval chevaux*, that is, formed by dropping the last syllable and replacing it with *aux*?

the inner question is:

(2) Is the plural of the French noun *cheval chevaux*, that is, formed by dropping the last syllable and replacing it with *aux*?

whereas the presupposition is:

(3) The plural of the French noun *cheval* is *chevaux*, that is, formed by dropping the last syllable and replacing it with *aux*.

One of the merits of Bromberger's analysis is that it supplements the concept of correct answer to a why-question with a precisely defined meaning.[4] *Correct answers* to why-questions are defined as follows:

> **b** is the correct answer to the why-question whose presupposition is **a** if and only if (1) there is an abnormic law *L* (general or special) and **a** is an instantiation of one of *L*'s antonymic predicates; (2) **b** is a member of a set of premises that together with *L* constitute a deductive nomological explanation whose conclusion is **a**; (3) the remaining premises together with the general rule completed by *L* constitute a deduction in every respect like a deductive nomological explanation – except for a false lawlike premise and a false conclusion, whose conclusion is a contrary of **a**; (4) the general rule completed by *L* cannot be completed into a true abnormic law when the conjunction in its antecedent is replaced by an expression properly entailed by that conjunction (i.e., not also entailing that conjunction.) (Bromberger 1992, p.92)

For example, the correct answer to (1) is: (Because) *cheval* ends in *al*.

Since the explanans of a deductive-nomological explanation is supposed to consist of truths, each correct answer to a why-question must be true.

[4]Contrary to, inter alia, van Fraassen (cf. van Fraassen's *The Scientific Image*), in whose theory the crucial concept of "relevance relation" is left undefined.

On the other hand, if a general rule can be completed by more than one abnormic law, the corresponding why-question can have more than one correct answer.

We shall now define a weaker, relativized concept of a possible correct answer to a why-question.

DEFINITION 1. *A statement B is a* possible correct answer *to the question "Why is it the case that A?"* with respect to a background knowledge $\boldsymbol{K}$ and an abnormic hypothesis H *(general or special) iff*

1. *A is an instantiation of one of H's antonymic predicates,*
2. *there are statements $C_1, \ldots, C_n \in \boldsymbol{K}$ such that:*
   - $\{C_1, \ldots, C_n\} \cap \{H, B\} = \emptyset$,
   - *the set $\{H, C_1, \ldots, C_n, B\}$ is consistent,*
   - *A is entailed by $\{H, C_1, \ldots, C_n, B\}$, but by no proper subset of $\{H, C_1, \ldots, C_n, B\}$,*
   - *$\neg A$ is entailed by the set $\{H^*, C_1, \ldots, C_n\}$, where H^* is the general rule completed by H.*

We have:

FACT 1. *Let H be a general abnormic hypothesis and let:*

$$\forall x(F_1(x) \wedge \ldots \wedge F_m(x) \rightarrow E(x))$$

be the general rule completed by H. Let R be an antonymic predicate of H different from E and let $P_1, \ldots, P_s$ be the predicates associated with R in H. Assume that $\boldsymbol{K}$ contains the following statements:

(I) $F_1(a) \wedge \ldots \wedge F_m(a)$,

(II) $R(a) \rightarrow \neg E(a)$.

Then the sentences $P_1(a), \ldots, P_s(a)$ are possible correct answers to the question:

(▼) *Why is it the case that $R(a)$?*

with respect to $\boldsymbol{K}$ and H.

In other words, if the presupposition of a why-question says that an object a has the property R, where R is an antonymic predicate of a general abnormic hypothesis such that R does not occur in the general rule completed by it (that is, roughly, the presupposition expresses a departure from the general rule), and the background knowledge $\boldsymbol{K}$ contains the corresponding statements (I) and (II), then each sentence which says that the object a has the property P_i, where P_i is a predicate associated with R in the general abnormic hypothesis, is a possible correct answer to the why-question with respect to $\boldsymbol{K}$ and the hypothesis. In the case of special abnormic hypotheses we have:

FACT 2. *Assume that the following statements belong to* $\boldsymbol{K}$*:*

(I) $F_1(a) \wedge \ldots \wedge F_m(a)$,

(III) $E^*(x) \leftrightarrow \neg E(a)$.

Then the sentences $P_1(a), \ldots, P_n(a)$ *are possible correct answers to the question:*

(▲) *Why is it the case that* $E^*(a)$*?*

with respect to $\boldsymbol{K}$ *and the special abnormic hypothesis:*

$$\forall x(F_1(x) \wedge \ldots \wedge F_m(x) \rightarrow (\neg E(x) \leftrightarrow P_1(x) \vee \ldots \vee P_n(x))).$$

It seems that the above consequences comply with intuitions. Note that a possible correct answer to a why-question need not be true (but of course can be). We also do not assume that an item of a background knowledge must consist of truths. We require that the relevant abnormic hypothesis must be consistent with the relevant pieces of a background knowledge, but, for the sake of generality, we do not impose further conditions here. Let us finally observe that a possible correct answer to (▼) of the form $P_i(a)$ $(1 \leq i \leq s)$, the corresponding general abnormic hypothesis, and the statements (I) and (II) jointly constitute the explanans of a potential deductive-nomological explanation whose explanandum is $R(a)$. Similarly, a possible correct answer to (▲) of the form $P_j(a)$ $(1 \leq j \leq n)$, the relevant special abnormic hypothesis, and the statements (I) and (III) jointly constitute the explanans of a potential deductive-nomological explanation whose explanandum is $E^*(a)$ In both cases an answer to the why-question is the necessary premise which makes the (potential) deductive-nomological explanation possible.

3. Explaining departures from a general rule. Establishing what sentences can play the role of possible correct answers to a given why-question is one thing; finding an acceptable answer to this question is another.

Let us go back to the beginning of this paper. The analysed cognitive situation was as follows: although all the initial conditions $F_1(x), \ldots, F_m(x)$ of a general rule:

(GR) $\forall x(F_1(x) \wedge \ldots \wedge F_m(x) \rightarrow E(x))$

were fulfilled by an object a, the outcome that took place was $R(a)$, where $R(a)$ is different from $E(a)$ predicted by the rule (and was such that $R(a) \rightarrow \neg E(a)$ is true). So we ask the question:

(4) Why is it the case that $R(a)$?

How can we find an acceptable answer to (4)? There is no recipe that can be applied in all cases. But the following advice can always be given: look for an abnormic hypothesis which has R among its antonymic predicates and which completes the general rule. If there is no such a hypothesis, try to infer it in a legitimate way from your knowledge.

There are cases in which we can deduce a certain possible correct answer to the why-question directly from the relevant general abnormic hypothesis and the initial conditions. For example, if R is an antonymic predicate of a general abnormic hypothesis H such that R is associated in H with exactly one predicate, say, P, that is, the hypothesis contains the clause $P(x) \leftrightarrow R(x)$, then the sentence $P(a)$ is logically entailed by the general abnormic hypothesis on the basis of the presupposition of the question (4) (i.e. the statement $R(a)$) and the corresponding statement of the form (I). On the other hand, $P(a)$ is a possible correct answer to (4) with respect to the general abnormic hypothesis and the background knowledge which contains, inter alia, the corresponding statements of the form (I) and (II) (cf. Fact 1).

In many cases, however, no possible correct answer to (4) is entailed by the set made up of the general abnormic hypothesis, the corresponding statement of the form (I) and the presupposition of (4); for conciseness, let us designate this set by Φ. But if R is an antonymic predicate of the general abnormic hypothesis which is associated in it with at least two distinct predicates, that is, the general abnormic hypothesis contains the clause:

(5) $P_1(x) \vee P_2(x) \vee \ldots \vee P_s(x) \leftrightarrow R(x)$

where $s > 1$ and $P_1, P_2, \ldots, P_s$ are the predicates associated with R in the hypothesis, then the set Φ logically entails the following disjunction of possible correct answers to (4):

(6) $P_1(a) \vee P_2(a) \vee \ldots \vee P_s(a)$

On the basis of (6) we arrive at the following disjunctive question evoked by it:

(7) Is it the case that $P_1(a)$, or is it the case that $P_2(a)$, ..., or is it the case that $P_s(a)$?

From the question (7) on the basis of the premise (6) we can go to the following implied question:

(8) Is it the case that $P_1(a)$?

If the affirmative answer to (8) is justified, an acceptable answer to the initial why-question (4) is found and the procedure is terminated. If, however, the negative answer to (8) is justified, then from the question (7) on the basis of the premise (6) and the negative answer to (8) we go to the implied question:

(9) Is it the case that $P_2(a)$?

Again, if the affirmative answer to (9) is justified, the procedure is terminated since the success has been achieved; if the negative answer to (9) is justified, we go from (7) on the basis of (6) and the negative answers to (8) and (9) to the implied question:

(10) Is it the case that $P_3(a)$?

And so on until an affirmative answer to a certain consecutive yes-no question will be justified. In each case the next step (if any) is determined by the outcome(s) of the previous step(s) in the above-indicated manner. Let us observe that if the sentence (6) is true, then at least one of the consecutive yes-no questions must have a true affirmative answer. Yet, the sentence (6) is a consequence of a hypothesis and thus need not be true. If the procedure described above ends with the negative answers to all the consecutive yes-no questions, the initial abnormic hypothesis needs revision. On the other hand, if an affirmative answer is justified, the degree of confirmation of the abnormic hypothesis rises.

The considerations presented so far pertained to general abnormic hypotheses. The situation is similar in the case of special abnormic hypotheses.

4. Validity of erotetic steps. The procedure described above involved *erotetic inferences*, that is, inferences in which questions perform the role of conclusions. So one may ask are they *valid* inferences?

When speaking about valid inferences, we usually assume that their premises and conclusions must be declarative sentences, or at least that it is possible to assign truth or falsity to them (since, according to the received view, validity amounts to the transmission of truth). Yet, it is doubtful whether it makes any sense to assign truth or falsity to questions. So the standard concept of validity is inapplicable to erotetic inferences. On the other hand, some erotetic inferences seem to be intuitively valid, whereas some others seem not to be. Moreover, it can be argued that the intuitively valid erotetic inferences have a well-established structure due to the existence of some logical relations between their premises and conclusions.

Defining the concept of validity for erotetic inferences presents a serious challenge: validity is a normative concept and since the appropriate notion of validity is not given by God nor by Tradition, some more or less arbitrary decision has to be made. On the other hand, the intuitively valid erotetic inferences should remain valid in the light of the proposed definition.

The solution to this problem adopted here[5] can be briefly described as follows.

First, two kinds of erotetic inferences are distinguished: the key difference between them lies in the type of premises involved. In the case of *erotetic inferences of the first kind* the premises are declarative sentences, whereas the conclusion is a question. The premises of an *erotetic inference of the second kind* consist of a question and possibly of some declarative sentence(s).

Note that the procedure described above involved erotetic inferences of both kinds.

A *direct answer* is a possible and just-sufficient answer; a question is said to be *sound* iff at least one direct answer to it is true.

Roughly, the following condition of validity pertains to erotetic inferences of both kinds:

($\mathbf{C}_1$) if all the premises are true/sound, then the conclusion must be sound.

Yet, a valid erotetic inference of the first kind must also comply with the following requirement:

($\mathbf{C}_2$) no direct answer to the question, which is the conclusion, is entailed by the premises.

The underlying idea is that the question which is the conclusion *is not logically redundant* with respect to the premises.

In the case of erotetic inferences of the second kind the second condition of validity is:

($\mathbf{C}_3$) for each direct answer B to the question which is the conclusion there exists a non-empty proper subset of the set of all the direct answers to the question which is the premise which must contain at least one true answer if B is true and all the declarative premises are true.

The underlying idea is that the question which is the conclusion is *in each case cognitively useful*: by ($\mathbf{C}_3$) *each* direct answer to the question which is the conclusion, if it is true and if all the declarative premises are true,

[5] For details of the logical analysis of erotetic inferences see Wiśniewski (1995). For a general introduction to the proposed approach see Wiśniewski (1996). *Added in 2013.* Cf. also Wiśniewski (2013).

narrows down (along with the declarative premises) the class within which a true direct answer to the initial question can be found.

In order to define validity in exact terms two semantical concepts are defined: evocation and erotetic implication.

Let $\mathcal{L}$ be a formalized language which consists of two parts: declarative and erotetic. For simplicity, let us assume that the declarative part of $\mathcal{L}$ is a first-order language. As far as the declarative part of $\mathcal{L}$ is concerned, the concepts of term, atomic well-formed formula, (declarative) well-formed formula (d-wff for short), freedom and bondage of variables, etc., are defined as usual; by sentences of $\mathcal{L}$ we mean d-wffs of $\mathcal{L}$ without free variables. Questions are the meaningful expressions of the erotetic part of $\mathcal{L}$; at this moment we do not decide, however, what is the particular form of questions of $\mathcal{L}$. Yet, we assume that to each question Q of $\mathcal{L}$ there is assigned an at least two element set $\mathsf{d}Q$ of *direct answers*, which are sentences of $\mathcal{L}$. We also assume that the declarative part of $\mathcal{L}$ is supplemented with a standard model-theoretic semantics with the concepts of interpretation, satisfaction, truth, etc., defined in the usual way, and that the class of all the interpretations of $\mathcal{L}$ includes a non empty subclass (not necessarily a proper subclass) of *normal interpretations*. Then we introduce the concept of multiple-conclusion entailment:

DEFINITION 2. *A set of d-wffs X of $\mathcal{L}$* multiple-conclusion entails *a set of d-wffs Y of $\mathcal{L}$ (in symbols: $X \,||\!\!= Y$) iff the following condition holds:*

($\bullet$) *for each normal interpretation $\mathfrak{I}$ of $\mathcal{L}$: if all the d-wffs in X are true in $\mathfrak{I}$, then at least one d-wff in Y is true in $\mathfrak{I}$.*

We say that a set of d-wffs X of $\mathcal{L}$ *entails* a d-wff A of $\mathcal{L}$ iff $X \,||\!\!= \{A\}$. Evocation is defined by:[6]

DEFINITION 3. *A set of d-wffs X* evokes *a question Q (in symbols: $\mathbf{E}(X, Q)$) iff*

1. *$X \,||\!\!= \mathsf{d}Q$, and*
2. *for each $A \in \mathsf{d}Q$: $X \,||\!\!\not= \{A\}$.*

Thus X evokes Q just in case Q is sound (has a true direct answer) in each normal interpretation of $\mathcal{L}$ in which all the d-wffs in X are true, but no direct answer to Q is entailed by X.

An erotetic inference of the first kind is said to be *valid* iff the set of premises of this inference evokes the question which is the conclusion of the inference.

[6]For the properties of evocation see Wiśniewski (1995), Chapter 5, or Wiśniewski (1991) (in the latter paper evocation is called *weak generation*).

It is easily seen that evocation warrants the satisfaction of the conditions $(\mathbf{C})_1)$ and $(\mathbf{C}_2)$.

Erotetic implication is defined by:[7]

DEFINITION 4. *A question Q* implies *a question Q_1* on the basis of *a set of d-wffs X (in symbols: $\mathbf{Im}(Q, X, Q_1)$) iff*

1. *for each $A \in \mathsf{d}Q$: $X, A \,||\!\!= \mathsf{d}Q_1$, and*
2. *for each $B \in \mathsf{d}Q_1$ there exists a non-empty proper subset Y of $\mathsf{d}Q$ such that $X, B \,||\!\!= Y$.*

Thus if Q implies Q_1 on the basis of X, then Q_1 must be sound if Q is sound and X consists of truths; moreover, each direct answer B to Q_1 multiple-conclusion entails along with X a certain proper subset of the set of direct answers to Q (which, by the definition of multiple-conclusion entailment, must contain a true answer if B is true and X consists of truths).

An erotetic inference of the second kind is said to be *valid* iff the question which is the premise of the inference implies, on the basis of the (set made of the) declarative premises of the inference, the question which is the conclusion.

Again, it is easily seen that erotetic implication warrants the satisfaction of the conditions $(\mathbf{C}_1)$ and $(\mathbf{C}_3)$.

Let us now be more specific. Let $\mathcal{L}^\star$ be a language of the considered kind which has the language of Classical Predicate Calculus as its declarative part. Assume also that the vocabulary of $\mathcal{L}^\star$ contains the signs: ?, {, }, which are erotetic constants of $\mathcal{L}^\star$. A question of $\mathcal{L}^\star$ is an expression of $\mathcal{L}^\star$ of the form $?\{A_1, \ldots, A_n\}$, where A_1, …, A_n $(n > 1)$ are nonequiform (i.e. pairwise syntactically different) sentences of $\mathcal{L}^\star$. If $?\{A_1, \ldots, A_n\}$ is a question, then the sentences A_1, …, A_n are the direct answers to this question. Suppose that each interpretation of $\mathcal{L}^\star$ is normal (and thus entailment amounts to logical entailment). Let B_1, …, B_n, where $n > 1$, be nonequiform (pairwise syntactically different) *atomic* sentences of $\mathcal{L}^\star$. One can easily verify the following:

(11) $\mathbf{E}(B_1 \vee \ldots \vee B_n, ?\{B_1, \ldots, B_n\})$.

(12) $\mathbf{Im}(?\{B_1, \ldots, B_n\}, B_1 \vee \ldots \vee B_n, ?\{B_1, \neg B_1\})$.

(13) $\mathbf{Im}(?\{B_1, \ldots, B_n\}, B_1 \vee \ldots \vee B_n, \neg B_1, \ldots, \neg B_j, ?\{B_{j+1}, \neg B_{j+1}\})$.
where $j < n$.

[7]For the properties of erotetic implication see Wiśniewski (1995), Chapter 7; cf. also Wiśniewski (1994).

Thus we can say that the erotetic inferences involved in the procedure described above are valid.[8] Let us add that they are very simple examples of valid erotetic inferences.

5. Final remark. The concepts of evocation and (erotetic) implication are defined for formalized languages which fulfil some general conditions[9], which, in turn, restrict the range of applicability of the proposed definition of validity of erotetic inferences. In particular, it is assumed that the questions taken into consideration have well-defined sets of direct answers. It can hardly be said, however, that this is true about why-questions in general as well as of many other epistemically relevant questions. As a consequence, the logical apparatus elaborated on within a logical theory of erotetic inferences (in its present form) cannot be applied in a direct way in the analysis of many problems in the realm of philosophy of science and epistemology. Yet, as we have shown, it is not completely useless here, provided that the relevant questions undergo a conceptual analysis first.

Acknowledgements. *A first draft of this paper was written during my stay at the Netherlands Institute for Advanced Study in the Humanities and Social Sciences in Wassenaar. The present version differs from the version available (under the same title) in the Internet "Archive" of the XX World Congress of Philosophy (Boston 1998).*

I am indebted to Sylvain Bromberger for valuable comments.

References

Bromberger, S., *On What we Know We Don't Know: Explanation, Theory, Linguistics, and How Questions Shape Them*, The University of Chicago Press, Chicago and London / Center for Study of Language and Information, Stanford 1992.

Hintikka, J., and Halonen, I., Semantics and pragmatics for why-questions, *The Journal of Philosophy* **92**, No 12, 1995, pp. 636–657.

Kuipers, T., and Wiśniewski, A., An erotetic approach to explanation by specification, *Erkenntnis* **40**, 1994, pp. 377–402.

Sintonen, M., In search of explanations: From why-questions to Shakespearean questions, *Philosophica* **51**, 1993, pp. 55–81.

van Fraassen, B., *The Scientific Image*, Oxford University Press, New York 1980.

[8] The occurrence of valid erotetic inferences is hardly surprising here; it may be shown that they play an important role in other explanatory procedures as well (cf. Kuipers & Wiśniewski (1994)). For recent approaches to explanation in terms of erotetic logic (but from a different perspective) see also: Hintikka & Halonen (1995), Sintonen (1993), Weber (1996), (1997).

[9] For details, see Wiśniewski (1995), Chapter 8; cf. also Wiśniewski (1996), pp. 9–12.

Weber, E., Explaining, understanding and scientific theories, *Erkenntnis* **44**, 1996, pp. 1–23.

Weber, E., Scientific explanation and the interrogative model of inquiry, in: M. Sintonen (ed.), *Knowledge and Inquiry: Essays on Jaakko Hintikka's Epistemology and Philosophy of Science*, Rodopi, Amsterdam/ Atlanta 1997, pp. 239-259.

Wiśniewski, A., Erotetic arguments: A preliminary analysis, *Studia Logica* **50**, 1991, pp. 261-274.

Wiśniewski, A., Erotetic implications, *Journal of Philosophical Logic* **23**, 1994, pp. 173–195.

Wiśniewski, A., *The Posing of Questions: Logical Foundations of Erotetic Inferences*, Kluwer Academic Publishers, Dordrecht/Boston/London 1995.

Wiśniewski, A., The logic of questions as a theory of erotetic arguments, *Synthese* **109**, 1996, pp. 1–25.

Wiśniewski, A., *Questions, Inferences, and Scenarios*, College Publications, London 2013.