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Erotetic Logic and Explanation by Specification

1. The deductive-nomological (DN) account of explanation conceives subsumption under a law as its core part. Generally speaking, to explain (an event, a regularity, etc.) is to find/indicate a "law of nature" such that the law, together with the (descriptions of) relevant initial conditions entail the *explanandum*. It is well-known, however, that there are decent forms of explanation which are not nomological. Intentional explanations of actions, functional explanations of biological traits, and causal explanation of abnormal events provide examples here.

2. Let us consider questions falling under the schemata:

Why did person a perform action b? (1)

Why did organisms of type a have trait b? (2)

Why did abnormal event b occur to system a? (3)

Clearly, (1) – (3) express explanation-seeking questions. As any other why-questions, they pose a challenge to a logical analysis: it is not clear what sentences count as principal possible answers (ppa's) to them.

3. A partial solution emerges when the following *what-questions* are taken into consideration:

What was the intended goal of person a with his/her performance of action b? (4)

What is the biological function of trait b of organisms of type a? (5)

What was the cause of abnormal event b that occurred to system a? (6)

Direct answers to questions (4) – (6) fall under the schemata:

Person a performed action b with the intention of approaching g. (7)

$$\text{The biological function of trait } \boldsymbol{b} \text{ of organisms of type } \boldsymbol{a} \text{ is } f. \tag{8}$$

$$\text{Abnormal event } \boldsymbol{b} \text{ occurred to system } \boldsymbol{a} \text{ due to } \boldsymbol{c}. \tag{9}$$

where g, f, and c refer to: a goal, a biological function, and an abnormal causal factor, respectively.

For sure, it is not the case that all the ppa's to the why-questions considered are just direct answers to the corresponding what-questions. But, on the other hand, a sentence of the form (7) can be regarded as a principal possible answer to a why-question of the form (1), and similarly in the remaining cases.

4. In a series of papers Theo Kuipers put forward the idea of *explanation by specification* (hereafter: EBS).[1] EBS departs from the DN schema: one does not subsume under a "law of nature", but, instead, provides a "specification" of a certain existential generalization. Depending on the type of EBS, the existential generalizations considered fall under the following schemata:

$$\text{There exists a goal } x \text{ such that person } \boldsymbol{a} \text{ performed action } \boldsymbol{b} \text{ with the intention of approaching } x. \tag{10}$$

$$\text{There exists a biological function } x \text{ such that } x \text{ is the biological function of trait } \boldsymbol{b} \text{ of organisms of type } \boldsymbol{a}. \tag{11}$$

$$\text{There exists a causal factor } x \text{ such that abnormal event } \boldsymbol{b} \text{ occurred to system } \boldsymbol{a} \text{ due to } x. \tag{12}$$

Looking from the erotetic point of view, (10) – (12) are *presuppositions* of questions (4) – (6), while answers of the form (7) – (8) are substitution instances/"specifications" of the sentential functions that occur in the presuppositions.

An answer of the above kind provides an explanation by specification given that some statements are verified hypotheses. These statements are determined by a meaning postulate. The relevant meaning postulates differ depending on the type of EBS under consideration. In the case of intentional explanation of actions we have:

(MP1) Person $\boldsymbol{a}$ performed action $\boldsymbol{b}$ with the intention of approaching goal x iff

1. person $\boldsymbol{a}$ performed action $\boldsymbol{b}$,
2. person $\boldsymbol{a}$ desired x,
3. person $\boldsymbol{a}$ believed $\boldsymbol{b}$ to be useful to approach x,

[1] Cf. Kuipers (1985), (1986a), (1986b), (1996).

4. both ***a***'s desiring of x and ***a***'s belief that ***b*** was useful in approaching x were causally effective for ***a***'s performance of ***b***.[2]

The clause (1) is called a trivial meaning component, the remaining ones are non-trivial meaning components. A statement of the form:

$$\text{Person } \boldsymbol{a} \text{ performed action } \boldsymbol{b} \text{ with the intention of approaching goal } \boldsymbol{g}. \tag{13}$$

where ***g*** refers to an external goal (that is, a goal different from the internal goal of action ***b***), *provides* an intentional explanation by specification of person's ***a*** performance of action ***b*** if the following are verified hypotheses:

$$\text{Person } \boldsymbol{a} \text{ desired } \boldsymbol{g}. \tag{14}$$

$$\text{Person } \boldsymbol{a} \text{ believed } \boldsymbol{b} \text{ to be useful to approach } \boldsymbol{g}. \tag{15}$$

$$\text{Both } \boldsymbol{a}\text{'s desiring of } \boldsymbol{g} \text{ and } \boldsymbol{a}\text{'s belief that } \boldsymbol{b} \text{ was useful in approaching } \boldsymbol{g} \text{ were causally effective for } \boldsymbol{a}\text{'s performance of } \boldsymbol{b}. \tag{16}$$

A *potential EBS* of the analysed kind is an argument in favour of a statement of the form (13). The set of premises of the argument comprises the corresponding statements (14), (15), (16), the (justified) claim that person ***a*** performed action ***b***, and the relevant instance of (**MP1**). A potential EBS becomes an *actual EBS* when its non-analytical premises (14), (15), and (16) are verified hypotheses.

5. The cases of functional explanations of biological traits and causal explanation of abnormal events are similar; the differences lie in the meaning postulates employed. Here are the postulates:

(MP2) The biological function of trait ***b*** of organisms of type ***a*** is x iff

1. organisms of type ***a*** have trait ***b***,
2. ***b*** of ***a*** is a positive causal factor for x,
3. x is a positive causal factor for the reproduction and survival of organisms of type ***a***,
4. both ***b*** and x were causally, i.e. evolutionary, effective for ***a*** having ***b***.

(MP3) An abnormal event ***b*** occurred to system ***a*** due to x iff

1. abnormal event ***b*** occurred to system ***a***,
2. x occurred to ***a*** as an abnormal causal factor,

[2] In Kuipers (2001) this clause is expressed more cautiously: both ***a***'s desiring of x and ***a***'s belief that ***b*** was useful in approaching x were causally effective for ***a***'s having had the plan to perform ***b***.

3. there were normal causal factors occurring to system ***a*** such that these together with *x* caused the occurrence of event ***b*** to system ***a***,
4. *x* was causally effective in the causation of the occurrence of event ***b*** to system ***a*** along the suggested causal line.

The postulate (**MP3**) is substantially refined in Kuipers (2001).[3] However, the refinement does not affect the logical structure: the structure is common to all the types of EBS considered.[4]

6. In Kuipers and Wiśniewski (1994) a schematic train of thought which can give an EBS as the outcome is characterized. It is shown that all inferences involved, both standard (i.e. leading from declaratives to declaratives) and erotetic (i.e. having questions as conclusions) are valid. In this essay we will present an analysis of EBS employing another tool developed within erotetic logic[5], namely the concept of *erotetic search scenario* (e-scenario for short).[6] We will concentrate upon intentional explanation of actions. Other kinds of EBS can be analysed analogously.

7. The process of arriving at an EBS has at least three phases.

PHASE 1: QUESTION REFINEMENT

The initial explanation-seeking question:

Q: Why did person ***a*** perform action ***b***?

in the presence of the following assumptions:

(i) Person ***a*** performed action ***b***.

(ii) Person's ***a*** performance of action ***b*** was intentional.

transforms into the question:

Q^*: What was the intended goal of person ***a*** with his/her performance of action ***b***?

Note that (i) is a factual statement, but (ii) is only a hypothesis. The transition from the question *Q* to the question Q^* is based on (i), (ii) *and* the

[3]See Kuipers (2001), pp. 124–126. Cf. also Grobler & Wiśniewski (2005).

[4]This pertains also to (intentional) EBS of goals and of choices, analysed in Kuipers (2001), pp. 108–111.

[5]More precisely, within Inferential Erotetic Logic (hereafter: IEL). Generally speaking, IEL analyses erotetic inferences and proposes criteria of *validity* for these inferences. For IEL see e.g. Wiśniewski (1995), (1996), (2001), (2013). For the basic concepts of IEL cf. pages 99 – 102 of this book.

[6]See Wiśniewski (2001), (2003), (2004), (2013).

following meaning postulate:

(iii) If person's $\boldsymbol{a}$ performance of action $\boldsymbol{b}$ was intentional, then there exists an intended (external) goal of $\boldsymbol{a}$'s performance of $\boldsymbol{b}$.

The assumption/hypothesis (ii) results from the assumption (i) by the following *default rule*:

(HM) Actions are performed intentionally.

Let us stress that (HM) is not a law-claim, but a heuristic principle which is applicable as long as there is no evidence to the contrary.

PHASE 2: TESTING

A hypothesis of the form:

(H_γ) Person $\boldsymbol{a}$ performed action $\boldsymbol{b}$ with the intention of approaching goal γ.

where γ refers to an external goal, is formulated – as Kuipers puts it, "by idea" – and then tested. The relevant testing procedure may be viewed as the execution of an e-scenario.

For conciseness, let us introduce the following abbreviations:

- $\mathsf{G}(\boldsymbol{a}, \boldsymbol{b}, \gamma)$ abbreviates: "Person $\boldsymbol{a}$ performed action $\boldsymbol{b}$ with the intention of approaching goal γ.";
- $\mathsf{P}(\boldsymbol{a}, \boldsymbol{b})$ stands for: "Person $\boldsymbol{a}$ performed action $\boldsymbol{b}$.";
- $\mathsf{D}(\boldsymbol{a}, \gamma)$ abbreviates: "Person $\boldsymbol{a}$ desired γ.";
- $\mathsf{B}(\boldsymbol{a}, \boldsymbol{b}, \gamma)$ abbreviates: "Person $\boldsymbol{a}$ believed $\boldsymbol{b}$ to be useful to approach γ.";
- $\mathsf{C}(\boldsymbol{a}, \boldsymbol{b}, \gamma)$ stands for: "Both $\boldsymbol{a}$'s desiring of γ and $\boldsymbol{a}$'s belief that $\boldsymbol{b}$ was useful in approaching γ were causally effective for $\boldsymbol{a}$'s performance of $\boldsymbol{b}$.";
- $?\mathsf{G}(\boldsymbol{a}, \boldsymbol{b}, \gamma)$ abbreviates the yes-no question: "Did person $\boldsymbol{a}$ perform action $\boldsymbol{b}$ with the intention of approaching goal γ?";
- $? \pm |\mathsf{D}(\boldsymbol{a}, \gamma), \mathsf{B}(\boldsymbol{a}, \boldsymbol{b}, \gamma), \mathsf{C}(\boldsymbol{a}, \boldsymbol{b}, \gamma)|$ abbreviates the conjunctive question whose direct answers fall under the schema:

$$(\mathsf{D}(\boldsymbol{a}, \gamma))^\circ \wedge (\mathsf{B}(\boldsymbol{a}, \boldsymbol{b}, \gamma))^\circ \wedge (\mathsf{C}(\boldsymbol{a}, \boldsymbol{b}, \gamma))^\circ \tag{17}$$

  where $(A)^\circ$ is either A or $\neg A$[7];

[7] Thus the above question has eight direct answers.

- $?\mathsf{D}(\boldsymbol{a},\gamma)$ stands for the yes-no question: "Did person $\boldsymbol{a}$ desire γ?", and similarly for $?\mathsf{B}(\boldsymbol{a},\boldsymbol{b},\gamma)$ and $?\mathsf{C}(\boldsymbol{a},\boldsymbol{b},\gamma)$.

The relevant e-scenario is displayed in Figure 1.

1. $?\mathsf{G}(\boldsymbol{a},\boldsymbol{b},\gamma)$
2. $\mathsf{G}(\boldsymbol{a},\boldsymbol{b},\gamma) \leftrightarrow \mathsf{P}(\boldsymbol{a},\boldsymbol{b}) \wedge \mathsf{D}(\boldsymbol{a},\gamma) \wedge \mathsf{B}(\boldsymbol{a},\boldsymbol{b},\gamma) \wedge \mathsf{C}(\boldsymbol{a},\boldsymbol{b},\gamma)$
3. $\mathsf{P}(\boldsymbol{a},\boldsymbol{b})$
4. $? \pm |\mathsf{D}(\boldsymbol{a},\gamma), \mathsf{B}(\boldsymbol{a},\boldsymbol{b},\gamma), \mathsf{C}(\boldsymbol{a},\boldsymbol{b},\gamma)|$
5. $?\mathsf{D}(\boldsymbol{a},\gamma)$

6.1. $\neg\mathsf{D}(\boldsymbol{a},\gamma)$ **6.2.** $\mathsf{D}(\boldsymbol{a},\gamma)$
7.1. $\neg\mathsf{G}(\boldsymbol{a},\boldsymbol{b},\gamma)$ **7.2.** $?\mathsf{B}(\boldsymbol{a},\boldsymbol{b},\gamma)$

8.1. $\neg\mathsf{B}(\boldsymbol{a},\boldsymbol{b},\gamma)$ **8.2.** $\mathsf{B}(\boldsymbol{a},\boldsymbol{b},\gamma)$
9.1. $\neg\mathsf{G}(\boldsymbol{a},\boldsymbol{b},\gamma)$ **9.2.** $?\mathsf{C}(\boldsymbol{a},\boldsymbol{b},\gamma)$

10.1. $\neg\mathsf{C}(\boldsymbol{a},\boldsymbol{b},\gamma)$ **10.2.** $\mathsf{C}(\boldsymbol{a},\boldsymbol{b},\gamma)$
11.1. $\neg\mathsf{G}(\boldsymbol{a},\boldsymbol{b},\gamma)$ **11.2.** $\mathsf{G}(\boldsymbol{a},\boldsymbol{b},\gamma)$

Figure 1: *The e-scenario supposed to be executed.*

A digression: e-scenarios. An e-scenario is an abstract entity. E-scenarios can be defined either as families of interconnected sequences of questions and declaratives (declarative sentences/formulas) or, equivalently, as finite labelled trees. We choose the second option, but here we present only an informal description. The exact definition is given in the Appendix.

An e-scenario for a principal question Q relative to a set of declaratives X is a finite and at least two-branched labelled tree. The principal question labels the root and direct answers to the question label the leaves. The remaining nodes are labelled either by declaratives or (auxiliary) questions. The latter are supposed to be erotetically implied – in the sense of IEL – by some questions and declaratives which label preceding nodes of a branch.[8] A node labelled by an auxiliary question is immediately succeeded either by a node labelled by a direct answer to it – in this case the question performs the function of a *query* – or by a node labelled by a further auxiliary question. A declarative that labels a node is either an element of X, or is a direct

[8]In the case of the e-scenario displayed in Figure 1, we have (for brevity, we use numerals instead of formulas themselves): $\mathbf{Im}((\mathbf{1}), \{(\mathbf{2}), (\mathbf{3})\}, (\mathbf{4}))$, $\mathbf{Im}((\mathbf{4}), (\mathbf{5}))$, $\mathbf{Im}((\mathbf{4}), \{(\mathbf{6.2})\}, (\mathbf{7.2}))$, and $\mathbf{Im}((\mathbf{4}), \{(\mathbf{6.2}), (\mathbf{8.2})\}, (\mathbf{9.2}))$.

answer to the question that labels the preceding node of the branch, or is entailed by some declarative(s) that label preceding node(s) on the branch. Moreover, it is assumed that when a question and a direct answer to it label the consecutive nodes of a branch $\mathfrak{b}$ (i.e. the question is a query), then the e-scenario involves branches which do not differ from $\mathfrak{b}$ up to the point at which the question occurs, but then have all the other direct answers to the question/query as labels of the immediate successor of the node labelled by the question; this holds for any branch $\mathfrak{b}$. Only queries have more than one immediate successor; a question which is not a query has exactly one immediate successor, and each declarative that labels a node has at most one immediate successor. Finally, for obvious reasons it is assumed that no direct answer to the principal question is an element of X, and that the principal question (or a question with the same set of direct answers) cannot occur as an auxiliary question.

Consecutive questions of an e-scenario are thus linked by erotetic implication. Erotetic implication secures that an auxiliary question is "locally" relevant (w.r.t. some question that precedes it), while the structure of an e-scenario together with the conditions imposed on declaratives guarantees that the direct answer to the principal question that labels the leaf of a branch is entailed by (the set of) declaratives which label nodes of the branch; this holds for every branch.

Looking from the pragmatic point of view, an e-scenario provides information about possible ways of solving the problem expressed by its principal question: it shows what additional data should be collected if needed and when they should be collected. What is important, an e-scenario provides the appropriate instruction for every possible and just-sufficient, i.e. direct answer to a query: there are no "dead ends".

Let us now come back to the e-scenario displayed in Figure 1. Its topmost query, i.e. "Did person ***a*** desire γ?", is to be asked first. If the affirmative answer happens to be verified, the next query to be asked is: "Did person ***a*** believe ***b*** to be useful to approach γ?". If the affirmative answer to this question becomes verified, the consecutive query is: "Were ***a***'s desiring of γ together with ***a***'s belief that ***b*** was useful in approaching γ causally effective for ***a***'s performance of ***b***?" If the affirmative answer comes to be verified, the principal problem is resolved positively, that is, the affirmative answer to the principal question is arrived at. If, however, a negative answer to any of the above queries happens to be verified, the principal problem is resolved negatively. Moreover, if (**6.1**) is verified, there is no need to ask (**7.2**) and (**9.2**), and if (**8.1**) is verified, question (**9.2**) need not be asked.

PHASE 3: PROVIDING AN EBS OR FORMULATING A NEW HYPOTHESIS

Assume that the affirmative answers to the above queries (i.e. questions (**5**), (**7.2**) and (**9.2**)) have been verified. According to what had been said above, in this situation the tested hypothesis:

(H_γ) Person ***a*** performed action ***b*** with the intention of approaching goal γ.

provides an explanation by specification of person's ***a*** performance of action ***b***. Moreover, we are able to formulate the following argument in favour of the hypothesis (for conciseness, we use the abbreviations introduced above):

(**I**): $\mathsf{G}(\boldsymbol{a}, \boldsymbol{b}, \gamma) \leftrightarrow \mathsf{P}(\boldsymbol{a}, \boldsymbol{b}) \wedge \mathsf{D}(\boldsymbol{a}, \gamma) \wedge \mathsf{B}(\boldsymbol{a}, \boldsymbol{b}, \gamma) \wedge \mathsf{C}(\boldsymbol{a}, \boldsymbol{b}, \gamma)$
$\mathsf{P}(\boldsymbol{a}, \boldsymbol{b})$
$\mathsf{D}(\boldsymbol{a}, \gamma)$
$\mathsf{B}(\boldsymbol{a}, \boldsymbol{b}, \gamma)$
$\mathsf{C}(\boldsymbol{a}, \boldsymbol{b}, \gamma)$
Therefore $\mathsf{G}(\boldsymbol{a}, \boldsymbol{b}, \gamma)$

Given that the non-analytical premises are verified hypotheses, the argument (**I**) is an actual explanation by specification of person's ***a*** performance of action ***b***.

It is easily seen that the conclusion $\mathsf{G}(\boldsymbol{a}, \boldsymbol{b}, \gamma)$ (i.e. "Person ***a*** performed action ***b*** with the intention of approaching goal γ.") is entailed by the premises. On the other hand, the conclusion implies that:

(ii) Person's ***a*** performance of action ***b*** was intentional.

At the beginning (ii) was a hypothesis introduced by means of the default rule (HM). Now (ii) can be regarded as a verified hypothesis.

But what if the result of testing is negative at some stage or no clear results are available? A way out is to formulate a new hypothesis saying that person ***a*** performed action ***b*** with the intention of approaching some external goal different from γ and to test the hypothesis according to the schema described above. The positive result of testing gives an EBS, the negative result produces the need for a new hypothesis, etc. Let us stress that there is no guarantee that the process will terminate in success. The reasons for failure can be diverse: from unavailability (by accessible means and/or at reasonable costs) of answers to queries to the simple fact that person's ***a*** performance of action ***b*** had not been intentional at all.

Remark. One may doubt if a statement of the form:

> Both ***a***'s desiring of γ and ***a***'s belief that ***b*** was useful in approaching γ were causally effective for ***a***'s performance of ***b***.

or even its "cautious" cousin:

> Both ***a***'s desiring of γ and ***a***'s belief that ***b*** was useful in approaching γ were causally effective for ***a***'s having had the plan to perform ***b***.

are empirically testable in any reasonable sense of the term; a philosopher of mind or a cognitive scientist can also be puzzled with the concept of "mental causality" used. A solution proposed in Kuipers (2001) is the following: one gets the above statement(s) from "Person ***a*** desired γ" and "Person ***a*** believed ***b*** to be useful to approach γ" by means of an appropriate *default rule*. If this is so, the relevant e-scenario simplifies to that displayed in Figure 2. The premise (**9.2.***) occurring at the rightmost branch is an instance of the rule.

1. $?\mathsf{G}(a, b, \gamma)$
2. $\mathsf{G}(a, b, \gamma) \leftrightarrow \mathsf{P}(a, b) \wedge \mathsf{D}(a, \gamma) \wedge \mathsf{B}(a, b, \gamma) \wedge \mathsf{C}(a, b, \gamma)$
3. $\mathsf{P}(a, b)$
4. $? \pm |\mathsf{D}(a, \gamma), \mathsf{B}(a, b, \gamma), \mathsf{C}(a, b, \gamma)|$
5. $?\mathsf{D}(a, \gamma)$

6.1. $\neg\mathsf{D}(a, \gamma)$
7.1. $\neg\mathsf{G}(a, b, \gamma)$

6.2. $\mathsf{D}(a, \gamma)$
7.2. $?\mathsf{B}(a, b, \gamma)$

8.1. $\neg\mathsf{B}(a, b, \gamma)$
9.1. $\neg\mathsf{G}(a, b, \gamma)$

8.2. $\mathsf{B}(a, b, \gamma)$
9.2.* $\mathsf{D}(a, \gamma) \wedge \mathsf{B}(a, b, \gamma) \rightarrow \mathsf{C}(a, b, \gamma)$
10.2. $\mathsf{C}(a, b, \gamma)$
11.2. $\mathsf{G}(a, b, \gamma)$

Figure 2: *The simplified e-scenario supposed to be executed.*

8. Explanation-seeking questions are usually asked in a context which, among others, include some items of knowledge and belief concerning the subject matter. An inquirer confronted with a question "Why did person ***a*** perform action ***b***?" construed as a request for an intentional explanation often has some knowledge about possible outcomes of ***b*** as well as some convictions or beliefs concerning person's ***a*** desires and/or beliefs. What an inquirer knows or believes is insufficient to provide an explanation, but sets the space of possible explanatory hypotheses. In other words, an inquirer is able to put forward a hypothesis of the form:

($\star$) The intended goal of person's ***a*** performance of action ***b*** was one of the following: $\gamma_1, \ldots, \gamma_n$.

where $n > 1$, $\gamma_1, \ldots, \gamma_n$ refer to different goals, and the subjective likelihood of γ_i is not greater than the subjective likelihood of γ_{i-1}, for $1 < i \leq n$.

Hence the question:

Q^*: What was the intended goal of person ***a*** with his/her performance of action ***b***?

on the basis of the hypothesis ($\star$) transforms into:

Q^{**}: Did person ***a*** perform action ***b*** with the intention of approaching goal γ_1, or ..., or did person ***a*** perform action ***b*** with the intention of approaching goal γ_n?

For conciseness, let us abbreviate Q^{**} as:

$$?\{\mathsf{G}(\boldsymbol{a}, \boldsymbol{b}, \gamma_1), \ldots, \mathsf{G}(\boldsymbol{a}, \boldsymbol{b}, \gamma_n)\} \tag{18}$$

The e-scenario displayed in Figure 3 applies to the case.

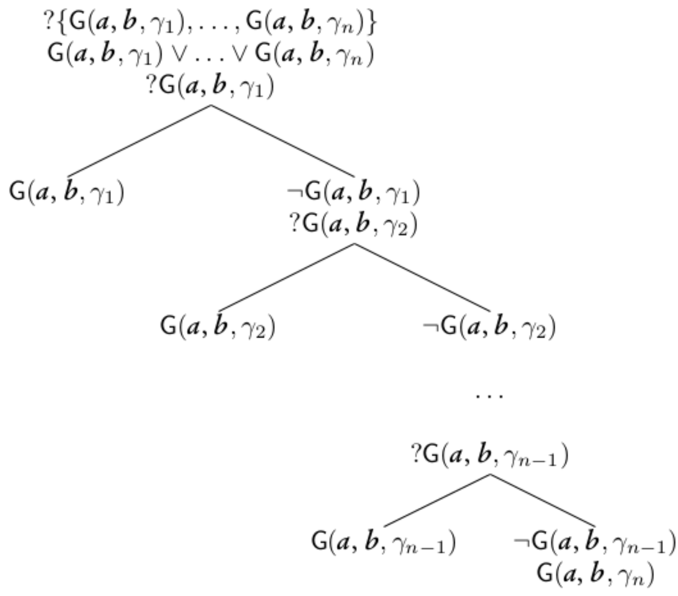

Figure 3: *A decomposition e-scenario.*

The order of queries reflects the conviction that the subjective likelihood of

γ_i is not greater than the subjective likelihood of γ_{i-1}.[9] The e-scenario is supposed to be executed from top to bottom. The consecutive queries can be dealt with according to the pattern presented in Figure 1 (or, if you prefer, in Figure 2). If i-th query ($1 \leq i \leq n-2$) of the rightmost path is resolved to the affirmative, there is no need for asking further queries. Observe that the question $?\mathsf{G}(\boldsymbol{a}, \boldsymbol{b}, \gamma_n)$ is not a query, but its affirmative answer occurs at the rightmost path. This is due to the fact that the last possibility is entailed by ($\star$) together with the negations of the remaining possibilities. As Sherlock Holmes used to say, "Eliminate all other factors, and the one which remains must be the truth."[10] Of course, one has to be cautious here: ($\star$) is only a hypothesis and, as such, can be false.

9. A psychologist or a cognitive scientist may wonder if Kuipers' account of intentionality of actions is conceptually sophisticated enough. However, nothing forbids us from refining the conceptual setting but leaving the logical structure (basically) untouched. An analogous remark pertains to Kuipers' approach to functional explanation by specification. The core of Kuipers' analysis provides a conceptual key to a better understanding of some explanation-related phenomena as well as actual historical episodes, especially, but not only, in the case of causal explanation of abnormal events.[11]

Appendix

For brevity, we write "d-wffs" instead of "declarative well-formed formulas/ sentences". dQ refers to the set of direct answers to question Q; it is assumed that, for any question Q (auxiliary questions included), dQ is an at least two-element set of d-wffs.

DEFINITION 1. *A finite labelled tree $\mathcal{T}$ is an* erotetic search scenario *for a question Q relative to a set of d-wffs X iff*

1. *the nodes of $\mathcal{T}$ are labelled by questions and d-wffs; they are called e-nodes and d-nodes, respectively;*
2. *Q labels the root of $\mathcal{T}$;*
3. *each leaf of $\mathcal{T}$ is labelled by a direct answer to Q;*

[9] For any i such that $1 \leq i \leq n$ it is the case that:

$$\mathbf{Im}(?\{\mathsf{G}(\boldsymbol{a}, \boldsymbol{b}, \gamma_1), \ldots, \mathsf{G}(\boldsymbol{a}, \boldsymbol{b}, \gamma_n)\}, \mathsf{G}(\boldsymbol{a}, \boldsymbol{b}, \gamma_1) \vee \ldots \vee \mathsf{G}(\boldsymbol{a}, \boldsymbol{b}, \gamma_n), ?\mathsf{G}(\boldsymbol{a}, \boldsymbol{b}, \gamma_i)) \quad (19)$$

IEL itself does not determine the order of queries of the rightmost path.

[10] Arthur Conan-Doyle, *The Sign of Four*, Spencer Blackett, London 1890, p. 92.

[11] See Grobler (2006), pp. 112–133, Grobler & Wiśniewski (2005), and Grobler (2011).

4. $\mathsf{d}Q \cap X = \emptyset$;
5. *for each d-node* φ_δ *of* $\mathcal{T}$*: if* A *is the label of* φ_δ*, then*
   a. $A \in X$, *or*
   b. $A \in \mathsf{d}Q^*$, *where* $Q^* \neq Q$ *and* Q^* *labels the immediate predecessor of* φ_δ, *or*
   c. $\{B_1, ..., B_n\}$ *entails* A*, where* B_i $(1 \leq i \leq n)$ *labels a d-node of* $\mathcal{T}$ *that precedes the d-node* φ_δ *in* $\mathcal{T}$*;*
6. *each d-node of* $\mathcal{T}$ *has at most one immediate successor;*
7. *there exists at least one e-node of* $\mathcal{T}$ *which is different from the root;*
8. *for each e-node* φ_ε *of* $\mathcal{T}$ *different from the root: if* Q^* *is the label of* φ_ε*, then* $\mathsf{d}Q^* \neq \mathsf{d}Q$ *and*
   a. $\mathbf{Im}(Q^{**}, Q^*)$ *or* $\mathbf{Im}(Q^{**}, B_1, ..., B_n, Q^*)$*, where* Q^{**} *labels an e-node of* $\mathcal{T}$ *that precedes* φ_ε *in* $\mathcal{T}$ *and* B_i $(1 \leq i \leq n)$ *labels a d-node of* $\mathcal{T}$ *that precedes* φ_ε *in* $\mathcal{T}$*, and*
   b. *an immediate successor of* φ_ε *is either an e-node or is a d-node labelled by a direct answer to the question that labels* φ_ε*; moreover*
      - *if an immediate successor of* φ_ε *is an e-node, it is the only immediate successor of* φ_ε*,*
      - *if an immediate successor of* φ_ε *is not an e-node, then for each direct answer to the question that labels* φ_ε *there exists exactly one immediate successor of* φ_ε *labelled by the answer.*

A *query* of an e-scenario $\mathcal{T}$ can be defined as a question that labels an e-node of $\mathcal{T}$ which is different from the root and whose immediate successor is not an e-node.

It can be shown that e-scenarios defined as families of e-derivations and as labelled trees stay in a 1-1 correspondence.[12] For properties of e-scenarios and operations on them see Wiśniewski (2013), Part 3.

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[12] See Leszczyńska-Jasion (2013).

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