The ampliative leap in diagnostics: the advantages of abductive inference in clinical reasoning

Alexander L. Gungov[1]

1 *St. Kliment Ohridski University of Sofia*
15 Tsar Osvoboditel Blvd., 1504 Sofia Center, Sofia, Bulgaria

Corresponding author: Alexander L. Gungov (agungov@phls.uni-sofia.bg)

Received: 27 September 2018 **Accepted:** 23 November 2018

Citation: Gungov AL (2018) The ampliative leap in diagnostics: the advantages of abductive inference in clinical reasoning. History of Medicine 5(4): 233–242.

Abstract

Examining diagnostics in logical terms, attention is usually paid to the interaction between deductive and inductive reasoning. This article discusses Ch.S. Peirce's theory of abductive inference in the clinical diagnosis. The process of diagnostics is seen as a logical transition from the effect (patient's symptoms and signs) to the cause (the current health disorder), which is the direction common to abductive reasoning. For Peirce, abduction is performed through the transposition of the conclusion and the major premise in the categorical syllogism or, in his later writings, of the result and the rule. An emphasis is put on the ampliative leap from the premise (individual clinical signs and symptoms) to the conclusion (particular diagnosis) abduction features; the universal rule (the nosological unit) mediates between the individual clinical picture and the particular patient's diagnosis.

The abductive inference draws on Kantian view on reflective judgment and G.B. Vico's ideas about imaginative universals. Reflective judgment aims at identifying a concept for some sensible data, whereas imaginative universals are not rational concepts but contain general characteristics like the regular concepts; formation of an imaginative universal resembles giving a diagnosis where an imagination drive inference is performed based on the combination of general elements of the relevant nosological unit and individual clinical signs and symptoms.

Attention is also paid to the principles of coherence and teleology in performing an abductive inference in diagnostics as well as to the dual criterion of its truthfulness based both on coherence and correspondence. Examples from various medical fields are offered to illustrate the validity of the above logical claims in clinical practice.

Keywords

clinical reasoning, the ampliative leap, clinical diagnosis, logical inferences in diagnostics

Types of logical inference in clinical practice

In diagnostics, the mere combination of deductive and inductive methods is believed not to suffice for securing appropriate outcomes. In this article, we will be trying to show that alongside deduction and induction, in diagnostics, a third logical type of inference appears, abduction. The theory of abduction is developed by Charles Sanders Peirce; an interpretation of his ideas will be adopted and followed in this study.

In his early works, Peirce is convinced that both induction and abduction follow the pattern of deduction and they can be derived from deduction through the formal procedure of the transposition of the categorical syllogism. Induction is produced through the transposition of the major premise and the conclusion, whereas abduction is reached when a double transposition is performed leading, first, to changing places of the major premise and the conclusion and, second, to transposition of minor and major premises. After 1883, statistic deduction is substituted for the categorical syllogism and accordingly induction is viewed as transposition of the rule and the result; abduction is described as a double transposition: first, of the rule and the result and then, of the case and the rule:

Deductive reasoning:

Rule (universality): The proportion *r* of all patients suffering from tuberculosis are coughing up blood.

Case (particularity): $s_1, s_2, \ldots, s_n$ belonging to the numerous set S of patients taken at random from among all patients suffering from tuberculosis.

Result (individuality): The proportion *r* of patients belonging to S are coughing up blood (probably and approximately).

Inductive reasoning:

Result (individuality): The proportion *r* of patients belonging to S are coughing up blood.

Case (particularity): $s_1, s_2, \ldots, s_n$ belonging to the numerous set S of patients taken at random from among all patients suffering from tuberculosis.

Rule (universality): The proportion *r* of all patients suffering from tuberculosis that are coughing up blood (probably and approximately).

Abductive reasoning:[1]

Result (individuality): The proportion *r* of patients belonging to S that are coughing up blood.

Rule (universality): The proportion *r* of all patients suffering from tuberculosis that are coughing up blood.

Case (particularity): $s_1, s_2, \ldots, s_n$ belonging to the numerous set S of all patients taken at random from among patients suffering from tuberculosis (probably and approximately).[2]

It is a commonplace idea that deduction leads to necessary conclusions while induction provides only probable results that in the long run prove to be true or false. In the case of statistical deduction, both induction and deduction are characterized by different kinds of probability: "The deduction, then, is probable in this sense, that though its conclusion may in a particular case be falsified, yet similar conclusions (with the same ratio!) would generally prove approximately true; while the induction is probable in this sense, that though it may happen to give a false conclusion, yet in most cases in which the same precept of inference was followed, a different and approximately true inference (with the right value of !) would be drawn".[3]

Abductive probability is yet another kind. It is contextual and relies on one's experience as well as on the decision-making strategy of the researcher or diagnostician. In his late writings, Peirce considers the initial data of the probabilistic reasoning as "input" for enriching the beliefs the inquirer holds and not as premises. This allows him to abandon deduction as the exemplary mode of reasoning to which induction and abduction are supposed to refer to (Levi 2006, p. 278–280). "The pragmatic or pragmaticist principle is the fundamental principle of abduction. It is not a general principle for distinguishing truth-value-bearing judgments from other kinds of judgments. It distinguishes between propositions that qualify as potential answers to the problem under investigation and propositions that do not by reference to their testable consequences. [...] Since the background knowledge can change, the conditions for being a potential answer can change. Peirce's pragmatic principle is not a verificationist surrogate for truth" (Levi 2006, p. 282).

These three types of logical inference specialize in fulfilling different tasks and the one dedicated to abduction is being instrumental in forming heuristic hypotheses (Levi 2006, p. 281). Furthermore, they differ in their degree of generality. The major premise in the categorical syllogism and the Rule in the statistical deduction represent the universality. The minor premise or case intermediating this inference feature the particularity, whereas the conclusion and, accordingly, the result contain the individuality. In deduction, the individuality (result) is inferred from universality (rule) through particularity (case). Inductive reasoning is directed from the individuality (result) to the generality (rule). In this approach, the meditating role is once again played by the particularity (case). The degree of probability ascribed to the inductive ratiocination is due to the presence of universality in a certain form within the individuality and the particularity securing the practical possibility that universality is somehow to be extracted from the individuality through the particularity and to be stated on its own. Finally, abduction aims at finding, for a certain individuality in the result, the corresponding particular case reached in the abductive conclusion with the help of the universality contained in the rule. That is, the inference proceeds from the individuality to the particularity through the universality. This reasoning is based on an intellectual leap from the individuality viewed in light of the universality to an assertion about the particularity. The conclusion about the particularity depends on the individuality and the universality but features an ampliative element that goes beyond what is contained in the universality. The ratiocination from individual symptoms and signs of a patient to the particular diagnosis explaining these findings with the help of the universal contained in the most appropriate nosological unit is exactly that heuristic function played by abduction in diagnostics. "The strategic calculations made in abductive puzzles are not made on the basis of probability [*more precisely, they belong to*

[1] Although Peirce reflections on abduction are based on transposition of statistic deduction and various logical characteristics that follow from here, the use of abduction in clinical diagnostics seems to fit better as an illustration of permutations of the categorical syllogism:

Result (conclusion): This patient is coughing up blood.

Rule (major premise): All patients suffering from tuberculosis are coughing up blood.

Case (minor premise): This patient suffers from tuberculosis.

[2] These examples follow the ones used by John Kaag (Kaag 2014, p. 78) as well as Isaac Levi (Levi 2006, p. 264).

[3] Peirce Ch. cited by Levi I. Beware of Syllogism Statistical Reasoning and Conjecturing according to Peirce (Levi 2006, p. 277).

a different kind of probability – A.G.], that is, by way of induction, but on the basis of an ability to see and anticipate the way that a possible hypothesis might *plausibly* contribute to a future harmonious strategy" (Kaag 2014, p. 86).

Abduction is reminded by what Carlo Ginzburg calls "*paradigma indiziario*" (conjectural paradigm), which based on signs, traces or symptoms is capable of identifying their cause or author. It is very useful in order to discover indirectly a certain object, event, style of drawing, etc. via various hints left by what is searched for. According to Ginzburg, in the late 19th century, human sciences widely adopted the conjectural paradigm and medicine was not an exception; even more, medical semiotics became the pattern for this approach (Ginzburg 1979, p. 8). Still, there is a difference between "*paradigma indiziario*" and abduction since the later aims at finding a unique item following unique signs, whereas abduction beginning in a similar manner with individual signs and symptoms but proceeds to the particular diagnosis relying on and being informed by the universal nosological unit. This connection of abduction with the universal is a source of a different process of conjecture that features an ampliative leap lacking in Ginzburg's method; this is the reason why abduction is a more appropriate form of reasoning for clinical practice and in particular, for diagnostics.

Diagnostic methods from a logical perspective

The symptom of coughing up blood corresponds to dozens of disorders, the most common of which, besides tuberculosis, are bronchitis, pneumonia, and lung cancer. In order to identify the actual disease, the routine procedure of differential diagnosis is employed whereby a doctor hypothesizes the disorder that most closely corresponds to the patient's illness from several presumed diseases described with similar symptoms and signs in clinical manuals. From a logical point of view, to a differential diagnosis a twofold interpretation can be given depending on whether a certain case concerns disease or syndrome. In the case of a disease, the diagnosis can be considered as an antecedent in a mixed conditional syllogism, while the symptoms and signs represent the consequent. In contrast, in a syndrome the symptoms and signs play the role of an antecedent and the diagnosis is the consequent. We will discuss mainly the logical relations in diagnosing a disease. In this case, it is about a mixed hypothetical syllogism in its two valid forms:

$A \supset B; A \vdash B$ – *modus ponens,*

$A \supset B; \sim B \vdash \sim A$ – *modus tollens*

The reasoning behind defining the actual diagnosis from the options of the differential diagnosis moves in a manner much like a combination of the above two modi: it starts from the consequent "B", i.e. the symptoms and the conclusion is made about antecedent "A," which is the diagnosis. The proceeding of the logical inference reminds of *modus tollens* – from "B" to "A," but unlike it the two variables are affirmative similarly to *modus ponens*. The bottom line is that the diagnostician is forced to make an invalid deductive inference through which to reach (if not always, then in most cases) a truthful conclusion.

How is the doctor expected to select the correct possibility to help the patient? Translated into logical language, this question demands that those facilities be found which will transform the "invalid by definition" combination of *modus ponens* and *modus tollens* into a logical inference, leading to useful conclusions. This is a question in which, quite apart from the presence of theoretical interest, the road to patients' health and life is revealed. The classical route is to examine absent symptoms and signs in order to get rid of corresponding diagnoses that would contain them. This is performed either via exclusive deduction, *modus tollens* inferring from the absence of "B" to the absence of "A," or via eliminative induction going in the same direction from the lack of effect to the lack of the efficient cause. Besides, this routine procedure, there are several more sophisticated techniques, which help to overcome the logically misleading situation requiring to find out the antecedent through the presence of the consequent or, using another terminology, to determine the cause through the effect.

One approach in resolving this difficulty would be to start with the so-called *Gestalt*, which is a picture of a disease, stamped in the clinician's mind. When the appearance of a patient is compared to the picture of the disease, acquired by the diagnostician as a result of training and clinical experience, s/he could easily select the correct diagnosis from several possibilities of differential diagnosis, reasoning from the effect towards the cause, that is, from the consequent to the antecedent. The *Gestalt* is often used in diagnostic of skin diseases, but can be useful in many other cases. An experienced clinician will have no doubt about what is the reason for the dragged and unsteady gait of a patient with Parkinson's disease and s/he will not mistake it for imbalance due to poor blood supply to the brain as a result of atherosclerotic changes, exostosis or heart failure. For a medical practitioner a myxedema-suffering person's face will be an unmistakable sign for the correct diagnosis (Murphy 1997, p. 305; Peters 2007, p. 387, 435). The characteristic red rush in the form of a butterfly on the cheeks and the nose in lupus erythematosus also will not escape the attention of a clinician (Peters 2007, p. 349). Regrettably, despite the often brilliant results, the recourse to *Gestalt* can sometimes mislead the doctor.

Another, more accurate, strategy, is the thorough examination of all possibilities. This strategy is safer

than the others, yet it is sometimes inefficient, because time-consuming. A diagnostician needs to bear in mind all the possibilities of differential diagnosis and compare them one by one with the available symptoms in the patient. This approach is similar to the looking up of a word in a dictionary. If we decide to search for the word "diagnosis," we will have a vague idea where to open the dictionary – somewhere at a certain point at first – and with several attempts at skipping back-and-forth between the pages we will find it. The more often we work with a dictionary, the more easily we will find the word we are looking for. The diagnostician acts in a similar way – the more experienced she or she is, the less incorrect guesses he or she will make and the faster and more safely he or she will reach an accurate diagnosis (Murphy 1997, p. 306).

Yet another method which is known to give accurate results is analysis through the multiple branching process.[4] In it, searching can start at a random place and every step depends on where we are in the analysis and not how we have reached this given state. This is an algorithm in which every question gets an answer and which in turn leads to a new question. Computer-assisted diagnosis draws upon analysis through the multiple branching process and it is its most elaborated version. This method is especially successful in the examination of hereditary anomalies of the heart as well as in various diseases of the blood. Its biggest advantage is its systematic character. Its most serious drawback is that it is inflexible and does not allow skipping some stages of reasoning to make the process of diagnostics more efficient (obviously, when computers are used this is not a big issue) (Murphy 1997, p. 306–307).

Especially interesting and promising is the fourth manner of looking for the proper diagnosis in the method of searching for the maximum. An analogy with a mathematical method is suggested here. It concerns finding certain values of variables that determine the maximum values of a function in which they are involved. Applying this scheme to the process of diagnostics requires seeking the maximum probability of a given diagnosis. It is believed that, above all, the probability of the spread of a disease must first be calculated and from there one should infer its existence in the particular patient. In this context different medical proverbs are known, which represent through allegory the frequency of a given disease and try to deter the willingness of novices to the medical profession to search for exotic diagnoses. For instance, the expressions "if you hear hoofbeats in Texas, look out for horses and not for zebras" or "if you see three birds perched on a branch, think about sparrows and not canaries" have become classics in the medical community.

The next step would be to judge which, from the common diseases, is the most probable and for it to be adopted as a diagnosis. Here, of crucial importance, is to pay attention to "the leading symptom," which took the patient to the doctor; this symptom serves as a starting point of the diagnosis and can help with the discovery of other symptoms. Meanwhile, one must bear in mind that the leading symptom does not always reflect the most essential disease of the patient. In this process, effective inquiry about the history of the patient's health condition and interpretation of the answers have a decisive function. What is more, casual remarks of the patient and his relatives or unexpected data from various tests could change the direction of the search for the actual diagnosis. That is why, the diagnostician must have a flexible set of hypotheses inferring from the degree of probability, the causation, and the patient's individual health condition (Marcum 2008, p. 206).

It is obvious that the process of searching for the most probable diagnosis has a flexibility that is not inherent to an analysis through the multiple branching of possibilities. The following example serves as an illustration of the advantages of searching for the most probable diagnosis. A pain in the lower part of the sternum can be a symptom of several diseases of which coronary disease and disease of duodenum would be considered most likely. This is the first step in directing to the maximum, i.e. to the most probable diagnosis in the domain of probable diseases. The next step would be to define the particular disease of the individual patient in the most effective way. It turns out that there is one question in the history of the patient, whose positive answer would quite accurately define what malady it is about. If the pain lasts no more than ten minutes the chance of angina pectoris is considerable, and if it lasts for more than thirty minutes, angina could be excluded with a high degree of certainty. In a similar way, if the patient has been taking antacids and has felt relief, duodenal ulcers can be considered (Murphy 1997, p. 309). The lack of short-lived pain (the presence of more lasting pain) and the lack of effect when antacids are taken[5] proves with certainty respectively the absence of coronary disease as well as the absence of disease of the duodenum; because this inference carries the necessarily deductive validity of *modus tollens*: $A \supset B$; $\sim B \vdash \sim A$. Precisely due to this in the theory of diagnostics, two of its aspects are discussed – diagnostics establishes what diseases are not present (diagnostics *per exclusionem*) and what are present; with an emphasis on the fact that the first aspect is more reliable.

Logical certainty of diagnostics through exclusion is due precisely to the validity of *modus tollens*, which

[4] This term is used in the sense of "multiple divergence of possibilities".

[5] In this possibility, the diagnostician is at risk to come across an insurmountable difficulty, as the patient might have just taken antacids and because of this has no idea of their effect.

is applied in this approach. In the negative mode of reasoning, the conclusion is reached by the negation of the consequent, i.e. the negation of the symptom, leading to the negation of the antecedent, which is the negation of the disease, whereas in the affirmative mode one begins from the presence of the consequent, the symptom to the presence of the antecedent, the disease, which is an invalid inference and can be true only accidentally. Besides, when more than one diagnosis is excluded it can be considered that eliminative induction has been used, which is also a very reliable instrument. In both cases, exclusion of certain diagnoses either via *modus tollens* or via eliminative induction, yet another step has to be performed to determine the disease a given person is suffering from: employing the exclusive disjunctive syllogism (Federspil 2010, p. 285).

In the abovementioned scenario, the lack of a symptom belonging to a certain disease speaks in favor of another disease, since the field of possibilities in this example is tentatively divided into two cases. The negation of one of the possibilities automatically leads to the affirmation of the other possibility and vice versa, the affirmation of one of the possibilities requires the exclusion of the other. The last two relationships are valid since the division of the domain of possibilities is made strictly on the principle of the exclusive disjunction in which, unlike the inclusive disjunction, only the validity of one of the assumptions can be admitted, and not both of them.[6] Thus, according to the two valid modi of the disjunctive syllogism, the characteristic symptom of one of the diseases guarantees the absence of the other disease; whilst, the lack of the symptom of one of them leads to the conclusion about the presence of the other disease. If we denote with "c" coronary disease, and with "d" – the duodenum ulcer, then the following conclusions would be valid:

$A \vee B; A \vdash \sim B$ – *modus ponendo tollens*

$A \vee B; \sim B \vdash A$ – *modus tollendo ponens*

Of course, this way of reasoning is a very efficient and reliable but simplified scheme, which, however, cannot be viewed as a mandatory formula. Above all, diseases sometimes give unusual symptoms and then the absence of some of the symptoms is still not a guarantee that the disorder itself is not present. This is especially true in elderly people where symptoms are often modified. Another reason for doubts is that the self-observations of patients or their way of expressing themselves may not be quite accurate and can create a wrong impression of the picture of the disease. On the one hand, the field of possibilities was conventionally divided into two – angina pectoris and duodenal ulcer – in order to establish the most probable diagnosis. The field of possibilities, though, also contains other diagnoses which are not so common and therefore, less probable, but, in return, are extremely important because they are life-threatening. In this sense, in a complaint of pain in the lower part of the chest, it is completely unacceptable to exclude without further evidence coronary thrombosis (Murphy 1997, p. 309) or dissecans aneurysm of the aorta (Groopman 2008, p. 31). On the other hand, the diagnosis as a functional syndrome, characterized by such symptoms, can be ignored, due to insignificant prognostic and therapeutic importance.

In the example viewed above, possible cases are mentioned where physicians employ the method of excluding certain diseases "A" on the basis of absence of basic symptom(s), "B". In this case, recourse is made to the valid logical conclusion *modus tollens*: $A \supset B; \sim B \vdash \sim A$, where the negation of the consequent, by necessity, also entails the negation of the antecedent. In our case, the absence of short-term pain in the lower part of the sternum or the absence of improvement when antacids are taken, inevitably leads to the conclusion that angina pectoris and duodenal ulcer respectively are not present. In comparison, the presence of shortness of breath and increased acidity, which are, respectively usual symptoms of angina pectoris and of the duodenal ulcer do not necessarily entail the presence of the disease whose symptoms they usually are. As already mentioned, this is due to the invalid logical inference, which underlines this kind of reasoning: $A \supset B; B \vdash A$ (here "A" is angina pectoris, and "B" the shortness of breath). The above inference is affirmative, but it is not a *modus ponens*, because it proceeds from the presence of the consequent to the presence of the antecedent, while in *modus ponens* the conclusion proceeds from the antecedent to the consequent.

Making the diagnosis through an affirmative inference

Is it possible, nevertheless, in defining a diagnosis to follow a real *modus ponens* or an affirming inference in general? More precisely, to what extent this is possible in clinical diagnosis? For, in pathophysiological diagnosis, inference begins with morphological changes viewed as causes for impaired functions on which explanation of a disorder or to the reduction in the patient's probability for survival is based (Federspil 2010, p. 283). Pathophysiological diagnosis proceeds from

[6] The presence of short-term pain in the lower part of the sternum not only establishes the first possibility, i.e. coronary disease, but it also rejects the other one – the disease of the duodenum. In a similar way the favorable effect of the antacids proves duodenal ulcers and, on the other hand, excludes angina pectoris. One must bear in mind, however that the patient can suffer from both diseases simultaneously. In this case, the valid logical constant is inclusive disjunction. Because of this, the affirmation of the first disease will not lead by necessity to the exclusion of the other one.

the cause to effect and in terms of logic it follows the form of *modus ponens*. Pathologist usually is provided with preliminary information by the attending clinician who presents the case of a given patient; in this way, the scope for pathophysiological diagnosis is drawn by the clinical one.

Speaking about clinical diagnosis, an affirmative diagnostic inference could be performed via a pathognomonic symptom. Neurosyphilis, for instance, always deductively guarantees the presence of Argyll-Robertson's pupil – a pathognomonic symptom – where there is no reaction to light with preserved reflex of accommodation and convergence.[7] The logical relationship of this unique correspondence between a pathognomonic symptom and a disease is equivalence, A≡B. The rule, which characterizes equivalence, is that both of its elements are always present and always absent together. The presence of Argyll-Robertson's pupil is always accompanied by neurosyphilis; the absence of neurosyphilis guarantees the absence of Argyll-Robertson's pupil.

Anemia, strictly speaking, as a decrease in the total amount of red blood cells (RBCs) or, more precisely, a decrease in total circulating red-cell mass[8] also features logical equivalence. This relation is tautological, because a decrease in total circulating red-cell mass is anemia by another name, as well as the breaking of a bone is a fracture, and a torn aneurysm of the aorta is a ruptured aortic aneurysm. The essential difference between the deductive rules of inference, *modus ponens* and *modus tollens* and the relationship of equivalence consists in the fact that in *modus ponens*, only from the presence of the first element, the antecedent follows by necessity the presence of the second, the consequent; however, the consequent does not imply the antecedent. While in equivalence from the conventionally chosen first element follows the second and, vice versa, from the second follows the first. In other words, in deductive rules of inference, only by the absence of the second element, the consequent the lack of the first element, the antecedent can be inferred (*modus tollens*), but not the presence of the first element from the presence of the second one. Unlike it, equivalence admits as the inference of the absence of the conventionally chosen first element from the absence of the second one, so the inference from the presence of the conventionally chosen second element to the presence of the first one.

Here is relevant yet another valid rule of inference, known as contraposition, $A \supset B \equiv \sim B \supset \sim A$ *based on the logical equivalence*. Translated into the language of clinical diagnosis, this means that, if acute tonsillitis is present, there is inflammation of the palatine tonsils, and when there is no such inflammation, there is no tonsillitis either. But the statement "if there is inflammation of the tonsils, the patient suffers from acute tonsillitis" would be false if we assume that the inflammation of the tonsils is not a pathognomonic sign of acute tonsillitis in the strict sense of the word. This difference is crucial for diagnosis. Diagnosis based on the relationship of equivalence is relatively easy and, what is most important, its accuracy is guaranteed in most cases by the apodicticity of this logical constant.

Coalescence of logical orderliness and heuristics in clinical reasoning

The ampliative character of the abductive reasoning discussed above is a source for making an affirmative inference of a different type beginning from the result, that is, the symptom, in order to figure out a particular case. The ampliative leap from an individual symptom (set of symptoms and signs) to a particular presence of a certain disorder based on the knowledge about a universal nosological unit is guided foremost by the principle of coherency. An example of coherency is taking into account the medical history of a patient. The doctor is expected to assess whether the anamnesis is a coherent whole, consisting of rationally linked statements, forming an interconnected unity. This judgment has to be made simultaneously from two perspectives: on the one hand, comparing the usual manifestation of the presumed diseases and the information that the patient reports (Marcum 2008, p. 156) and, on the other, deciding whether a patient's story is consistent or contradicts itself and allows discrepancies.

Underestimating the principle of coherency and the faults to which its violation leads is illustrated by the following example. A middle-aged woman complains mainly from swellings in her legs (edema) and reports previous recurrent swellings in the abdomen (ascites) as well as of her entire body (anasarca). From the three most probable possibilities of differential diagnosis – liver disease, kidney impairment, and heart insufficiency – the attending physician chooses the first. He is driven by the case history data, which he interprets as speaking in favor of liver disease. The doctor pays attention neither to the patient's complaint about suffocation, nor is he disturbed by the fact that she has dilated neck veins, nor is he alerted by unusual sounds in the heart during auscultation. He goes so far as to refer the patient for a liver biopsy and hesitates only when the morphological findings fail to show any serious deviations. The real diagnosis turns out to be mitral stenosis (Marcum 2008, p. 160).

[7] In ophthalmology, accommodation means the adaptation of the eye to the distant and near vision, and by convergence is meant nearing of the eyes towards the nose.

[8] I am grateful to Prof. M.D. Friedrich C. Luft, Director, Max-Delbrück-Center for Molecular Medicine for his comments on anemia, homeostasis, and the difference between pathological and clinical diagnosis.

The affirmative non-deductive inference in diagnostics gains insight from Immanuel Kant's views on cognition, aesthetic, and teleological judgment as well as from Peirce's ideas about abduction. Kant praises imagination as the middle ground between rationality of the faculty of understanding and sensibility of perception. Empowering the faculty of judgment, imagination produces two types of judgments, determining and reflective.[9] In the determining judgment, sensible data are subsumed under universal categories, while in the reflexive judgment an appropriate general concept is searched for given data.[10] Kant claims that in organisms "[t]he concept of a thing [...] may be used by reflective judgement as a regulative concept for guiding our investigation of objects of this kind by a remote analogy with our own causality according to ends generally [...]." (Kant 2007, p. 203) In the human body, homeostasis appears as a special kind of causality which goes astray from the common idea of causality. Examining homeostasis, it becomes clear that homeostasis acts due to the presence of some ends which as if guide it. Therefore, we say that when physically loaded, the heart accelerates the pulse to deliver more oxygen and energy substrates to the working muscles. Similarly, we state that hyperglycemia stimulates the secretion of insulin to reduce the amount of glucose entering the cells (Federspil 2010, p. 283).

Under homeostasis, the mechanisms restoring the suitable conditions common for the body before a deviation occurs are determined (Murphy 1997, p. 139). The activity of homeostasis, as a metabolic balance in living systems, requires energy for its maintenance. Homeostasis, for example, is actively involved in temperature exceeding 38°C, as well as in the lower range, below 36°C. In the first case, it is manifested in erythema, sweating, and seeking to expose as large an area of the body as possible for it to be cooled. As temperature drops, a narrowing of the blood vessels is observed under the influence of homeostasis, sweating is deterred, a tremor appears, and the body shrinks in such a way as to minimize cooling.

Apparently, homeostasis is an expression of a teleological process, i.e., of a final cause acting behind the scenes. Unlike the significantly more popular efficient cause, the final cause does not chronologically precede effect but paradoxically appears well after it in time. This unusual feature of homeostasis, involving the final cause of restoring the optimal state, undoubtedly impacts all reasoning in clinical settings. The system of purposefulness established by homeostasis substitutes the determining category under which sensible data are subsumed according to Kant's theory of experience; on this system of purposefulness the abductive reasoning is grounded leading the physician towards making up his/her mind about what particular disorder is present in a given patient. The particular diagnosis of an individual patient, that is, "hypothesis formation, like Kantian aesthetic judgment, is not prescribed by any *a priori* rule or constraint but rather discovers *and* develops the constraints of an evolving situation" (Kaag 2014, p. 97). The special purposefulness established by homeostasis enlightens and assists the ampliative abduction in figuring out the most appropriate/productive diagnosis.

The abductive reasoning in diagnostics features yet another peculiarity linked with the fact that clinical medicine is an ideographic science. It differs from nomothetical (normative) sciences, which infer deductively (in a non-contradictory manner and necessarily) individual statements from general laws. Ideographic sciences, unlike the nomothetical, are occupied with the explanation of individual events, which cannot be immediately deduced from general premises by universal principles. Typical questions, to which ideographic sciences should be able to find an answer, are: why dinosaurs disappeared, why Napoleon lost the Battle of Waterloo or why Peter gets ill, while Paul stays healthy in the same circumstances (Federspil 2010, p. 286). The ideographic character of abduction consists in comprehending and working on the individual manifestation of a certain nosological unit, assumed as the universal premise/the rule, in a particular case. The putative disease that an individual patient suffers from comes forth in a specific form. More often than not, symptoms and signs being present in an individual patient will go astray from the standard textbook description of a medical disorder. The uncommon characteristics might speak in favor of a new nosological unit but this option should be considered as the last possibility. Most probably, this situation is an expression of an already known malady but in a specific new way of appearance that might require modification of the protocol regiment of treatment and, first of all, recognition of this unusual set of characteristics as a familiar disease (Gabbani 2013, p. 20–21). The elegant art of diagnostics consists in the clinician's skill to discern an existing nosological unit behind individually shaped signs and symptoms of a given patient. Missing or uncommon characteristics should not be an obstacle for linking the particular manifestation of a certain health disorder to the universality of the corresponding disease description. Grasping individuality in a particular case does not mean having in disposal all the characteristics; as a rule, an experienced diagnostician is capable to recognize the universality that does not coincide with the full complex of its characteristics just by a few of them, while being aware that "each patient is potentially

[9] See (Kant 1998).

[10] See (Kant 2007).

[...] an anomalous instance of disease".[11] Due to this, a given particular case can be considered as a reliable and valuable representation of the universality of the respective nosological unit as well as a generic representative of the entire class of cases coming under the same diagnosis.[12]

Determining a diagnosis is always recognition (Antiseri et al. 2003, p. 35, 101) of already familiar disease appearing in an individual patient (with the exception of the rare cases when the health disorder turns out to be an unknown disease). This recognition is performed by comparing the description of the standard nosological unit with the individual pieces of evidence discovered among the signs and symptoms of the patient under treatment. The method of *Gestalt*, however, only seldom helps this comparative recognition. In the usual case, a diagnostician does not proceed via formal matching but uses the principle of coherence in order to intertwine the patient's available data within the acknowledged medical information about the presumed disease and the personal clinical experience of the physician (Antiseri et al. 2003, p. 105). Building a coherent picture of a disease requires practicing a special art of medical hermeneutics beginning with the initial, still vague, idea of the diagnosis made by the examining doctor and by asking appropriate questions making the diagnosis more adequate to the actual health condition of the patient (Antiseri et al. 2003, p. 29).

The popular saying meant to facilitate the recognition in dubious cases, "if it looks like a duck, walks like a duck, and quacks like a duck, then it's a duck" seems to be an indispensable tool with its disarming simplicity and clearness. The trick, nonetheless is how to recognize with certainty the diagnostic duck's look, walk, and quack; and even if one is sure that has identified exactly each of these single features, there is still no guarantee that their combination forms this special kind of duck and not a diagnostic goose. If the physician had no doubts about how a diagnostic duck looks like and behaves, he/she could apply, let's say, Edmund Husserl's free variations of phantasy in order to determine the limits of a duck and the point from which on the duck is turning into a goose. As this is not the case in diagnostics, the clinician cannot employ formalistically a number of signs and symptoms in order to conclude finally that one has encountered a duck. To claim that a person is depressed, for instance, when one features a certain number of common symptoms of depression, might have a high probability of truthfulness but still some patients with these symptoms will have no depression; they will be misdiagnosed. A mechanistic usage of a set of signs and symptoms to recognize a disease is always vulnerable and jeopardizes patients safety. More professional and much better care will be taken of a patient if the recognition based on the principle of coherency is substituted for the formalistic and mechanistic approach in making recognition.

As a matter of fact, the above recognition incorporating the patient's illness into a coherent unity of the knowledge about and experience of a disease serves as a criterion of the truthfulness of a given diagnosis. Besides by this criterion, the diagnostician is supported by yet another criterion when he/she compares the particular diagnosis ascribed to a certain disorder with the reality of the patient; this criterion is based on the corresponding theory of truth. The innermost reality of the patient is the process of his/her improvement and recovery. Witnessing the patient's improvement in order to identify the diagnosis, regrettably, is possible and acceptable only in very rare cases. In the moment of inferring the diagnosis, the doctor has no other choice but to project the current status of the patient into the future and in such a way, allowing the principle of teleology to figure out the genuine reality of the patient so that to use it as a reference of correspondence for the supposed diagnosis. Therefore, abductive reasoning in diagnostics is supplied with a dual criterion of truth: it consists of a strategy depending on the principle of coherence and of one more strategy that depends on the principle of correspondence. Both principles act concomitantly complementing and mutually strengthening each other. In such a way, the diagnostician receives a reliable guide for reaching the appropriate diagnosis that should significantly contribute to the successful treatment.[13]

Therefore, the concept of tuberculosis affecting the individual patient cannot be the universal nosological unit of "tuberculosis" but is formed via diagnostician's reflective judgment as a universal of imagination. Giambattista Vico's term "imaginative universal" avoiding the rational abstraction of the common rational universals[14] seems to be an appropriate notion here. The imaginative universal will be capable of reconciling the general character of a nosological unit with the uniqueness of an individual and, even more specifically, of a person living in a certain socio-cultural environment. The occurrence of any health disorder "is one of a kind, but it carries a universal meaning" (Verene 2009, p. 90). It refers directly to the patient that is in the processes of being diagnosed and indirectly to an imag-

[11] Hunter KM (1993) Doctors' Stories: The Narrative Structure of Medical Knowledge. Princeton: Princeton University Press. Cit. by Gabbani C. Epistemologia e clinica. Tre saggi. Pisa: Edizioni ETS, 2013 (Gabbani 2013, p. 43).

[12] Hunter KM (1993) Doctors' Stories: The Narrative Structure of Medical Knowledge. Cit. by Gabbani C. (Gabbani 2013, p. 30–31).

[13] Giovanni Federspil and Cesare Scandellari ask a very relevant and very important question about what the truth in clinical medicine consists in (Antiseri et al. 2003, p. 105). My position has been significantly influenced by their reflections.

[14] See (Vico 1984, § 400–501).

inative "patient type," which does not coincide with any person in flesh and blood (Gabbani 2013, p. 43).

Figuring out a diagnosis requires a different notion of the logical principle of identity. The manifestation of the disease and, accordingly, the particular diagnosis of a patient cannot be considered as an extra-temporal[15] identity remaining selfsame, that is, identical to itself, at any time and place, but contains unavoidably an element of difference. The ampliative potential of abductive ratiocination is carried out bearing in mind the principle of coherence and teleology in order to constitute the specific diagnosis of an individual patient. It is neither imprinted on the patient's body, nor can it be found in clinical manuals, nor again can it be contemplated in some sort of Platonic realm of ideas. It is produced by physician's thoughtful abductive reasoning based on a comprehensive picture of clinical symptoms and signs. Donald Phillip Verene's view on Vico's imaginative universal as coinciding with reality well fits and elucidates the formation of a particular diagnosis in the process of diagnostics: "But here the image is not an extension of reality. It is not novelty, in the sense of creating something new from a present reality that could not be expected on the basis of what is given in that reality. It is the making of reality itself. Reality is not being extended or newly viewed or remade. Reality is itself being made" (Verene 2009, p. 94).

In the above example of abductive reasoning about tuberculosis, hemoptysis is assumed as the leading symptom. Nonetheless, tuberculosis often manifests itself, especially in the early stages of the active phase, neither with blood signs in the sputum nor with significant weight loss, nor still with the feeling of malaise. The only symptoms present might be cough, sputum, and fever (Ballinger and Patchett 2007, p. 524; Longmore et al. 2010, p. 399). This set of symptoms, however, does not differ in any specific way from the clinical features of chronic bronchitis or pneumonia (Ballinger and Patchett 2007, p. 498, 517; Longmore et al. 2010, p. 160, 176). The routine differential diagnosis would require excluding from the spectrum of putative diagnoses the ones that do not fit into the overall health condition of a given patient. Whereas diagnostics via ampliative abduction will try to produce a hypothesis relying on clinician's imagination and experience grounded on the principles of coherency and teleology. How a patient complaining of cough, sputum, and fever can be referred to the nosological unit of TB in order to assert that his illness is tuberculosis? This is a typical abductive reasoning, which, first of all, requires to draw a coherent picture of one's health condition. If, on the one hand, the patient belongs to the underprivileged strata of society, is a recent refugee, suffers from drug/alcohol addiction or is under chronic conditions such HIV infection, diabetes mellitus, and silicosis or takes immunosuppressors, the diagnostician will order at least an X-ray, Ziehl-Neelsen stain, and PCR to exclude TB (Ballinger and Patchett 2007, p. 526–527). On the other hand, if the patient is an ordinary member of affluent society, the teleological principle will turn out instrumental. Examining physician is capable of identifying a kind of purposefulness developing in the patient's life and present illness. Homeostasis carries out the teleology in the human body resisting physiological deviations imposed by health impairments. Human life, nevertheless, cannot be reduced to the physiology of preserving and restoring the optimal state. It demands homeostasis be considered within the context of the socio-cultural existence of a person. This is very well captured by the English terms "illness" and "sickness," which focus namely on the personal side of a given malady unlike the objective textbook description, which is named "disease" (Gabbani 2013, p. 47). Deciding about a diagnosis via the method of abduction, the doctor will draw upon the multifaceted teleology of human personality beginning with the patient's medical history; proceeding to the available symptoms and signs; paying attention to posture, gait, and facial expression; listening to the voice intonation and timbre as well as to speech consistency and sophistication; finally, will "look for the illness in the eyes of the patients" (Gadamer 1996, p. 98) and even try to detect it in one's mood. All this happens against the background of the relevant nosological entities, which shed light on the disease, and with the help of the dual diagnostic criterion of truthfulness drawing upon coherency and correspondence.

The purposefulness underlining human life has no easily defined telos. In spite of this, it constitutes a harmonious order that allows a physician to discern cracks in a patient's life harmony and to figure out his/her disorder in order to resolve the dissonance in one's health condition. Opting for tuberculosis instead for chronic bronchitis or pneumonia in an abductive inference is not due to the highest probability principle; rather, it produces an image of a specific disorder where the clinician has aptly succeeded to coalesce and sublate, in Georg Hegel's sense, the nosological universality. In clinical practice, it is not always possible to carry out exhaustive exclusion of irrelevant diseases within the procedure of differential diagnosis. This is the reason why abductive reasoning serves both as a heuristic device and as a means to increase the adequacy of the diagnosis. Furthermore, abduction based inferences can be of crucial assistance in cases of comorbidity. In instances of the undoubted clinical picture of chronic bronchitis or pneumonia when one or both of these conditions have been diagnosed, nonetheless, it is possible for tuberculosis to be present as well. In this kind of situation, the non-deductive affirmative character of ab-

[15] In the sense that it does not depend on time.

duction may suggest that behind the obvious disease yet another more serious abnormality is eroding the patient's health.

Conclusive remarks

Peirce's notion of abductive reasoning based on a heuristic leap from the individual manifestation of symptoms and signs in an ill person to an assertion about the particular disease while bearing in mind the universal nosological rule seems to be really productive in clinical diagnostics. It supplies the well-trodden path of differential diagnosis through the method of exclusion and disjunctive syllogism with an efficient and logically structured instrument. The abductive reasoning complements the better-known strategies of the *Gestalt*, examining all possibilities, multiple branching process, and searching for the maximum. Its logical character draws upon the principles of coherence and teleology/purposefulness and is supported by the dual criterion of truthfulness relying both on coherence and correspondence. The abductive inference features obvious affinity with Kant's reflective judgment where for an individual event the corresponding concept or universal rule is searched for. The abductive conclusion is an effective hypothesis featuring practical reliability for undertaking further actions and engaging in continuous ratiocination. Abduction leads to a conclusion where imagination plays an active role. In this way, it comes close to Vico's imaginative universal, which fuses universal and particular in a unique fashion.

A physician's conclusion about the proper clinical diagnosis benefits from abduction as this inference allows to figure out the particular diagnosis of an individual patient-person starting from the patient's individual symptoms and signs assessed against the background of the universal nosological unit. The abductive reasoning appeals to the imagination of the diagnostician as well as to his/her grasping of the coherency of patient's health status and teleology involved in human physiology and socio-cultural personality. A clinician's assertion about the proper diagnosis is not as much a discovery of the correct disease as it is a discernment of the image of the specific clinical picture belonging to a given sick person. Deciding the proper diagnosis is not simply an act of accurate comprehension of how the disease has declared itself, but also an expression of the doctor's ingenuity in constituting a specific reality, namely, the particular diagnosis of an individual patient. Establishing such a particular diagnosis is not a goal *per se*, but a guaranty for an appropriate treatment and adequate prognosis.

References

Antiseri D, Federspil G, Scandellari C (2003) Epistemologia, clinica medica e la "questione" delle medicine "eretiche". Rubbettino Editore. 240 p.

Ballinger A, Patchett S (2007) Pocket Essentials of Clinical Medicine. 4th edition. Edinburgh: Sounders Elsevier.

Federspil G (2010) Diagnosi. Filosofia della medicina. Ed. by Pagnini, A. Roma: Carocci editore. 583 p.

Gabbani C (2013) Epistemologia e clinica. Tre saggi. Pisa: Edizioni ETS.

Gadamer H-G (1996) Enigma of Health: The Art of Healing in a Scientific Age. Stanford, CA: Stanford University Press. 192 p.

Ginzburg C (1979) Spie. Radici di un paradigma indiziario. Crisi del la ragione. Nuovi modelli nel rapporto tra sapere e attività umane. A cura di Aldo Gargani. Torino: Einaudi Paperbacks. 366 p.

Groopman J (2008) How Doctors Think. Boston: Houghton Mifflin Company. 307 p.

Hunter KM (1993) Doctors' Stories: The Narrative Structure of Medical Knowledge. Princeton: Princeton University Press. 238 p.

Kaag J (2014) Thinking through Imagination: Aesthetics in Human Cognition. New York: Fordham University Press. 272 p.

Kant I (2007) Critique of Judgement. Oxford: Oxford University Press.

Kant I (1998) Critique of Pure Reason. Cambridge: Cambridge University Press.

Levi I (2006) "Beware of Syllogism Statistical Reasoning and Conjecturing according to Peirce." The Cambridge Companion to Peirce. Cambridge: Cambridge University Press. p. 257–286.

Longmore M, Wilkinson I, Davidson E et al. (2010) Oxford Handbook of Clinical Medicine. The 8th edition. Oxford: Oxford University Press. 863 p.

Marcum JA (2008) An Introductory Philosophy of Medicine: Humanizing Modern Medicine. Springer. 376 p. DOI: 10.1007/978-1-4020-6797-6.

Murphy EA (1997) The Logic of Medicine. Baltimore: The John Hopkins University Press.

Peters A (2007) BMA Illustrated Medical Dictionary. London: DK.

Verene DP (2009) Speculative Philosophy. Lanham: Lexington Books.

Vico GB (1984) The New Science of Giambattista Vico. Ithaca: Cornell University Press.

About the author

Alexander L. Gungov – Ph.D. in Philosophy, Professor of Logic and Continental Philosophy; Chair of the Department of Logic, Ethics, and Aesthetics, the St. Kliment Ohridski University of Sofia, Sofia, Bulgaria. Email: agungov@phls.uni-sofia.bg