



Mariusz Urbański
Andrzej Klawiter

ABDUCTION: SOME CONCEPTUAL ISSUES

Abstract. We claim that abduction should primarily be studied from the perspective of its use. The big question “What is abduction?” is most often interpreted substantively and this distracts attention from the instrumental aspect of this form of reasoning. We propose to address the problem by asking “How abduction is used?”. As a result of our approach we see the fact that abduction needs to be construed as concerned with both generation and evaluation of hypotheses, and, furthermore, that abduction is a compound form of reasoning.

Keywords: reasoning; abduction; deduction; cognitive turn in logic

1. The Big Question

What is abduction, besides that it forms “the fundamental problem of contemporary epistemology”, as Hintikka [1999] concisely states? It is not the case, that the number of answers to the initial Big Question equals the number of answerers, they may not be even close to each other; still, the number of answers commonly agreed upon is alarmingly distant from one.

There are a number of dimensions along which different concepts of abduction may be elaborated. Examples include: explanatory vs not, factual vs theoretical, and selective vs creative [Minnameier, 2017]. However, a pivotal point of difference in characterising abductive reasoning is this: does abduction consist in just the generation of hypotheses, or is some evaluation of them intrinsic to this reasoning as well? There are reasonable arguments for each of these two positions; for support for the

‘just generation’ stance see [Minnameier, 2017; Yu and Zenker, 2017] and [Magnani, 2009; Schurz, 2017] for the other one. What all these accounts in their current form have in common is that they attempt to answer the Big Question from the same vantage point, which is the point of view of a kind of substantialism, or essentialism (in the sense stemming from Aristotle’s essential predication; *Analytica Posteriora*, I, 22). Read that way the Big Question is concerned with the essence, or nature, or substance of abductive reasoning and a satisfactory answer must provide a definition offering to its subject what definition in terms of logical entailment offers to deductive reasoning. Mind you, a “satisfactory answer” means, *int. al.*, a direct one in terms of Belnap [1969, p. 124], that is, an answer “directly and precisely responsive to the question, giving neither more nor less information than what is called for”. Our aim in this paper is to propose a shift of perspective or a different vantage point from which the Big Question should be formulated. In order to do this we need to characterise the possible alternatives. However, first we need to establish some non-controversial framework within which to pursue our research. The one we are going to adopt is offered by four theses, which according to Hintikka [2007, p. 38], quoting Kapitan [1997, pp. 447–448], characterise the Peircean concept of abduction.

Inferential Thesis: Abduction is, or includes, inferential process, or processes.

Thesis of Purpose: The purpose of “scientific” abduction is both to generate new hypotheses, and to select hypotheses for further examination. Hence, a central aim of such abduction is “to recommend a course of action”.

Comprehension Thesis: Scientific abduction includes all the operations whereby theories are engendered.

Autonomy Thesis: Abduction is, or embodies, reasoning that is distinct from, and irreducible to, either deduction or induction.

Being (fairly) non-controversial, it is a quite general framework and raises, or points at, some problems. Still, it forms a reasonably safe starting point for further deliberations. We shall begin with outlining a couple of proposals elaborating the concept of abduction, pre-starting from Aristotle and starting from Peirce. Then we shall address the fundamental issue of what question, exactly, needs to be answered in search for the answer to the Big One, and what question typically is answered. We shall strengthen our argument by rooting it in the paradigm of the cognitive,

or practical, turn in logic [Gabbay and Woods, 2005b]. On this basis, we shall go back to the pivotal point and the framework offered by Hintikka-Kapitan's theses, supporting ourselves with some empirical results.

2. Let us collect some answers

What, then, is abduction? We may begin with Aristotle's *reductio simpliciter* (*Analytica Priora* II, 25, 69a 20–85):

We have Reduction¹ (1) when it is obvious that the first term applies to the middle, but that the middle applies to the last term is not obvious, yet nevertheless is more probable or not less probable² than the conclusion; or (2) if there are not many intermediate terms between the last and the middle; for in all such cases the effect is to bring us nearer to knowledge.

Whether this really is abduction as we (ambiguously) construe it nowadays is debatable; Proni [2016], following Burnyeat [1982], argues that some passages from *Analytica Posteriora* (I, 34, 89b, 10–15) would much better fit the bill. Even if what we find here is not a beacon for the theory of abduction but just some light in the tunnel what is obvious is that this is a kind of reasoning in which we aim at filling some gap in our knowledge or beliefs. Or, as Thagard and Shelley [1997] put it, abduction serves the purpose of making sense of puzzling facts. The un-debatable beacon is the Peircean [CP, 5.189] schema of abductive reasoning:

The surprising fact, C , is observed.

But if A were true, C would be a matter of course.

Hence, there is reason to suspect that A is true.

The problem is that this beacon is somewhat deceptive, as it raises some fundamental issues: What does it mean that C is surprising? What does it mean that it would become a matter of course? What is the reason to suspect that A is true, and what is the relation between A and C ? What is A (and C , for that matter)? (see [Woods, 2017, p. 138] for a similar list).

¹ The original term ἀπαγωγὴ was translated into Latin as *abductio* by Giulio Pace [1584]; usually it is translated as *reductio*.

² Or 'credible'; see [Proni, 2016, p. 3].

Different solutions to these issues yield different concepts of abduction, elaborated along different lines; some of these lines we mentioned in the Introduction. In general, models, or concepts, of abduction fall into one of the two traditions: philosophical or computational (or AI). The terminology we use here is quite similar to the one of Gabbay and Woods [2005b, pp. 87–88]; they draw the line between philosophical and AI approaches as between inherently explanationist and not inherently explanationist (and do propose some ‘ecumenical’ stance). Our rationale is different. We see the models falling into the philosophical tradition as the ones which aim at answering the Big Question, which quest is concerned with substantialist task of determining the essence of the concept of abduction, which adventures would end by revealing abduction’s true identity. On the other hand, models in the computational tradition are oriented towards a more humble goal, albeit still an ambitious one. It is to offer either a computationally tractable account of how to perform abduction or – more often – how to compute good abductive hypotheses (Aliseda [2006] offers insightful comments on this process-product distinction).

Interestingly, it is typical for models of a philosophical provenance to carefully avoid answering the Big Question unequivocally by providing a direct answer. Thagard offers a direct answer to a slightly different question: abduction is “reasoning in which explanatory hypotheses are formed and evaluated” [Thagard and Shelley, 1997, p. 413] (see also [Thagard, 2007]). Schurz [2017] lists different kinds of patterns of abduction, claiming that “the epistemological role and the evaluation criteria of abduction are different for the different patterns of abduction”, all of which share the same crucial function “as a search strategy that leads us, for a given kind of scenario, to the most promising explanatory conjecture, which may then subject to further test” [Schurz, 2017, pp. 153–154] (see also [Thagard, 2007] for a similar account on abduction in different domains). Minnameier [2017] sticks to Peircean concepts, distinguishing three basic kinds of inference: deduction, induction and abduction, designing a framework within which all the inferences “ought to be reducible to one of these three basic forms, its inverse forms, or a particular subprocesses within one inferential type” [Minnameier, 2017, p. 193], with the possible exception of analogical reasoning. Gabbay and Woods [2005b] propose a slight shift in perspective, according to which the defining property of abduction is of epistemological character: it is ignorance-preservation (but see [Woods, 2017] for a critical discussion

of that stance). [Magnani \[2009\]](#) broadens the picture with manipulative abduction and his Eco-Cognitive model. [Urbański \[2009\]](#) offers a typology of abductive models based on types of explanatory or non-explanatory character of reasoning and, in the former case, on the type of explanation provided. Computational models, for their part [[Aliseda, 1997, 2006](#); [d'Avila Garcez et al., 2007](#); [Josephson, 1998, 2000](#)], focus on the concept of abductive problem and types of solutions to it, following in general the Peircean schema but limiting it one way or another, in order to make abduction computable, process- or at least product-wise.

In the recent past, the big divide between different approaches to abduction used to be the issue of the explanatory character of this type of reasoning. In particular, the question of Inference to the Best Explanation (or to the Best Available Explanation [[Schurz, 2017](#), p. 152]) being synonymous to abduction was a highly discussed topic [see, e.g., [Douven, 2017](#); [Kuipers, 2004](#); [Schurz, 2017](#); [Yu and Zenker, 2017](#) for conflicting views]. The next candidate for such an issue would be probably ignorance-preservation [[Gabbay and Woods, 2005b](#)], or, more generally, an epistemic rather than alethic interpretation of abductive reasoning. However, [Woods \[2017\]](#) himself apparently disarmed it. So, the most current big divide is the generation/evaluation (further on G/E) question: does abduction consist in just the generation of hypotheses or is it intrinsically concerned with their evaluation as well? This problem is a real one only for models stemming from the philosophical tradition. In case of computational one the 'both' answer to the G/E question is more than obvious, mostly because this is how abduction works. Aiming at the computational tractability of abduction must be inherently connected with limiting the space of possible solutions, ultimately through searching for the good ones, even if they are not the best ones.

All these contemporary solutions to the fundamental problem of epistemology share one implicit assumption: as it is not known what abduction really is, a reasonable course of action seems to be to approach the issue from a different point of view and to answer a slightly different question, concerning the use of abduction. As we are going to claim this really is a reasonable course of action and it is worth making this shift explicit.

Let us go back to Hintikka-Kapitan's four theses and focus on two of them. Recently, the Authonomy Thesis has come to prominence. A lot of effort has been made to identify abduction as irreducible, resulting in rejecting, e.g., Inference to the Best Explanation as a case of ab-

duction on the grounds that it is too inductive [Minnameier, 2016; see also Schurz, 2017; Yu and Zenker, 2017]. Our claim is that prominence should be given to the Thesis of Purpose and that before answering the Big Question we should seek an answer to the Even Bigger Question: How do we make use of abduction? It is quite indicative that in characterising abduction most authors follow the order identified by Kapitan [2000]:³

1. What is the purpose or goal of abductive reasoning?
2. What is the basic form, or forms, of abductive reasoning?

But what is the rationale for that? Why not start with question no. 2, the substantialist one? Here is our argument.

There are three types of questions answers to which could be of interest in any scientific endeavour. The first one is substantialist question: What is X ? This is a question concerning the essence, or nature, or definition of a phenomenon or object under consideration. The second, functionalist question asks: What X is for? What is its function? Finally, the instrumentalist question concerns the use of X : how it is used?

Of crucial importance to our argument is the fact, that in some contexts some of these questions are of a more fundamental character than others. Sometimes even, to put it bluntly, asking some of them does not make much sense. As an example let us consider research on brain and mind. On the one hand, we cannot deliberately use our brain. It is an organ similar to lungs, liver or stomach. We know how to study the brain's architecture and the functioning of its systems, but it does not make much sense to ask the instrumentalist question of how we use particular systems of the brain. It is different, however, in the case of the mind: here, the instrumentalist question is of fundamental importance, and the remaining ones are auxiliary to it.

We claim that this is the case with abduction too. The instrumentalist question precedes the remaining two, because it is the workings of abduction which define it, not the structure or premises-conclusion relation; these are just the consequences of the purpose, or goal, which

³ Kapitan [2000, p. 1] claims that “care must be taken in piecing together a coherent *Peircean* account of abduction that will secure mutually consistent answers to the following questions” and goes on with listing four of them. The remaining two are: “3. What sorts of premises and conclusions typify abductive reasoning? 4. Insofar as abductive inferences are “valid” or “correct”, is this correctness distinct from that which typifies valid deductive arguments or strong inductive arguments?”.

abduction serves. But why should the case of abduction be different than the case of deduction and induction, in which we may safely start with the substantialist question? Our answer is: because in case of deduction and induction we do have unequivocal and well-grounded answers to the respective substantialist questions. Whether in these cases they underlie or follow from the answers to the instrumentalist questions is debatable, and is not that crucial. The mere presence of normative yardsticks for definitions in these two cases is enough to make use of it, whether it is offered in terms of structure (induction) or the premises-conclusion relation (deduction). In abduction we start with episodes of real reasoning and the answer to the Big Question may be construed in terms of the abstraction and explication of these episodes only. Moreover, it is not that different in the case of deduction either. It just depends on how we approach the substantialist account of deductive reasoning. We shall focus on this in the next section.

3. And what about the cognitive turn in logic?

The cognitive, or practical [[Gabbay and Woods, 2005a](#)] turn in logic, which started two decades ago, in a sense consists in rediscovering the Aristotelian purpose of logical investigation: to develop a tool for performing, analysing and evaluating information processing (with all due respect paid to the idea of Aristotelian logic as concerned also with theory of logical systems [[Lear, 1980](#)]). But since Aristotle the scope of applications of logical systems has been widened: it is no longer just about science or argumentation. The mathematical turn in logic resulted in the development of formal methods and a plethora of logical systems: one for every occasion and more. Logic as a consequence of the cognitive turn not only acquires a new task of “systematically keeping track of changing representations of information” [[van Benthem, 2008](#), p. 73], but is fully up to it. In a sense, logic has once again opened its eyes to the outside world after a ‘prolonged blink’ of mathematical contemplation of its own inner reality.

What is important is that this cognitive turn has also resulted in some new problems — not new in the sense of newly-born but rather in the sense of being newly-discovered and studied. The logic we are talking about is deductive logic, and as its eyes are opening wider and wider, the context of empirical research on performing deductive reasoning and on

deductive competences in humans is becoming more and more relevant, along with the uncomfortable gap between what is normatively correct and what is really happening. This is well exemplified by the “mother of all reasoning tasks” [Stenning and van Lambalgen, 2008], the Wason Selection Task and the interpretation of its typical results (for details, we refer the reader to chapter 3 of [Stenning and van Lambalgen, 2008]). In view of the fact that subjects typically pass the test successfully around 5–20% of the time (in its original abstract form) we may come to a number of different conclusions. One would be that humans are not that fluent in deductive reasoning [Wason, 1968]. Another would be that it is all about the context: if it is familiar and not abstract, deduction is easy [Griggs and Cox, 1982]. Yet another would be that deductive reasoning has its uses, but they are rather limited and specific. This is the essence of Evans’s [2012] story of two paradigms in the research on deduction. As Evans claims, the ‘old’ paradigm in research on deductive reasoning is being replaced by the ‘new’ one. The former is characterized by an abstract approach to deduction. It starts with logical entailment as its constitutive property and only eventually proceeds to noticing that deduction is sometimes used in episodes of real reasoning. The latter paradigm, characterized by a situated approach, starts with the identification of the contexts in which deduction is used. As a result, within the ‘new’ paradigm deduction loses its privileged status as the ultimate normative yardstick for the evaluation of the correctness of reasoning and becomes more a strategic concept, “a form of reasoning that high-ability participants might engage in when suitably instructed and motivated to make deductive effort. [...] Rather than being a built-in function of the human mind, deductive reasoning can be seen as just one of many kinds of problem solving and formal thinking in which people of sufficient IQ can engage” [Evans, 2012, pp. 7–8].

In terms of the three types of questions the ‘old’ paradigm is concerned mostly with the substantialist question and neglects the instrumentalist one. The ‘new’ one starts with answering the instrumentalist question (and the functionalist one, to some extent). What is important in the case of deduction is that there exists a satisfactory answer to the substantialist question; that is, we have a clear-cut and precise definition of deduction. As a result we can argue about the relation between answers to substantialist and instrumentalist questions and the primacy of the one over the other, and this tension leads to the two paradigms mentioned.

In the case of abduction we face a completely different situation. There is no satisfactory (that is, most of all, commonly accepted) answer to the substantialist question concerning abduction: we do not have a precise definition of this type of reasoning. Moreover, attempts at designing such a definition suggest that in the case of abduction it is an answer to the instrumentalist question which is of crucial importance, an answer to the functionalist question is a derivative and to the substantialist question — a nice bonus.

In deduction we may start with the definition, go to the data, if needed, and then go back, if necessary. In abduction we start with some idea — but not a definition — addressing, in fact, the instrumentalist issue of the use to which we put abductive reasoning. And we have to immediately go to the data, because they form the only foundation on which we can base the concept of abduction.

This is why we find abductive mechanisms, or processes, in cognitive activities which do not necessarily reach the level of reasoning [Magnani, 2009], like natural language understanding [Hobbs, 2006; Hobbs et al., 1990], or empathy [Ottens et al., 1995]: it is the use to which we put them that matters, this making sense of puzzling phenomena. This is also why there are so few paradigms for empirical research on abduction, and all of them are rooted in specific contexts for which some normative criteria may be established, like scientific reasoning [Kwon et al., 2008; Lee, 2012; Oh, 2008], medical diagnosis [Donnelly et al., 1990; Mirza, 2015], or abstract Wason’s reasoning task [Russo and Meloy, 2002].⁴

4. Abduction: generation, evaluation, decision

If this ‘data priority’ approach is right, then there is an important consequence for the answer to the G/E question. While making sense of puzzling phenomena — that is, in typical abductive contexts — we do not perform abduction, or employ abductive mechanisms, in order to produce a vast range of hypotheses. The cognitive target is to fill some gap in our beliefs (or some database, if a more neutral term is needed). Thus abduction is intrinsically practical (to various degrees: [Gabbay and Woods, 2005b, p. 58]) and its purpose is to ‘recommend a course of action’ [Peirce, 1909, MS637:5]:

⁴ These papers report empirical research on the generation and/or evaluation of hypotheses; in not all cases is the term “abduction” mentioned.

Proposals for hypotheses inundate us in an overwhelming flood, while the process of verification to which each one must be subjected before it can count as at all an item, even of likely knowledge, is so very costly in time, energy, and money – and consequently in ideas which might have been had for that time, energy, and money, that Economy would override every other consideration even if there were any other serious considerations. In fact there are no others.⁵ [CP, 5.602]

Certainly, a whole lot of new problems arise. One of them is to establish criteria for evaluation of abductive hypotheses. One may aim at general ones, like Thagard’s consilience, simplicity, analogy and overarching coherence [Thagard, 1988, 2000], or Peirce’s own economy [CP, 1.120, 6.532, 7.220], explanatory power [CP, 7.220] and testability [CP, 5.599]. Otherwise, the criteria may be related to a particular abductive pattern [Schurz, 2017], depending on whether abduction is interpreted as a specific, or a strong method of reasoning, vs a non-specific, or a weak one ([Kurtz et al., 1999]; see also [Komosinski et al., 2014] for a more computationally-oriented approach to hypotheses evaluation). Another is the problem of the abductive trigger – why do we search for abductive hypotheses? What triggers the pursuance to make sense of this phenomenon rather than that one? Here the idea of cognitive irritation [Gabbay and Woods, 2005b, p. 87] needs to be taken seriously, and probably also emotional factors in reasoning [Thagard, 2007].

Admittedly, it is not the abstractly construed concept of abduction, only the reality of performing abductive reasoning which strongly suggests considering evaluation as an essential part of abduction. No wonder this approach accounts well for the empirical data [Kisielewska et al., 2016; Urbański et al., 2016]. Thus in our opinion Minnameier [2017, p. 190] is absolutely right in claiming that “this aspect of selection concerns abduction only from a practical point of view, not from a logical one”. What we question, however, is the choice of the logical point of view as the cornerstone for an adequate account of abduction. There is nothing ‘mere’ in practical importance of selection, or evaluation, as Minnameier claims: practical importance is the only plausible foundation for a theory of abductive reasoning.

Arguably, the choice of a cornerstone is a matter of decision. Nothing forces you to choose the one over another. However, with the logical one

⁵ This passage famously ends with the following statement: “For abduction commits us to nothing. It merely causes a hypothesis to be set down upon our docket of cases to be tried”, which pertains to ascribing truth to hypotheses.

you need to throw overboard too many episodes of reasoning, otherwise fitting the Peircean schema (IBE included). In choosing the logical cornerstone, you aim at a clean-cut typology, or logical division, even, of kinds of reasoning, *membra* of which are deduction, induction and abduction. In choosing the practical one you need to agree that abduction is of different character than the other two (and this is exactly what Yu and Zenker [2017] argue against): abduction is a compound form of reasoning [Ajdukiewicz, 1974]. In the evaluation phase⁶ it often employs deductive reasoning, and sometimes inductive reasoning, too; in an appropriate setup this is revealed not only by verbal protocols, but by eye-tracking data as well [Kisielewska et al., 2016]. As the search for plausible hypotheses may be reconstructed in interrogative terms, the logic of questions also enters the picture, with specific erotetic *modi operandi* (weak erotetic implication in the case of [Urbański et al., 2016]).

To conclude: we claim that in the case of abduction, answering the instrumentalist question concerning the use of this type of reasoning must precede answering the substantialist question concerning its nature or essence. The reason is that there is no normative yardstick underlying abductive reasoning, unlike in the case of deduction, and so working with the data is indispensable. As a result of that we see the fact that abduction needs to be construed as concerned with both generation and evaluation of hypotheses. This may be accepted or not. But if it is, then its consequence should be accepted as well: that abduction is a compound form of reasoning.

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⁶ Whether the phases of the generation and the evaluation of hypotheses may be clearly distinguished or are closely intertwined depends on the problem to be solved and strategy employed; see [Komosinski et al., 2014] and [Chlebowski and Gajda, 2017] for two different examples.

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MARIUSZ URBAŃSKI and ANDRZEJ KLAWITER
Department of Logic and Cognitive Science
Institute of Psychology
Adam Mickiewicz University in Poznań, Poland
{Mariusz.Urbanski, Andrzej.Klawiter}@amu.edu.pl