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ABSTRACT: Abduction is a widely used but deductively invalid type of reasoning. In this paper I will develop a tool for the assessment of argumentation based on abduction that can be used to analyse and evaluate the type of argumentation as it occurs in institutionalized contexts like science and medical diagnosis. I will summarize the most important definitions of abduction and propose an argumentative pattern on the basis of a critical examination of two extant dialectical accounts of the argument scheme involved.

KEYWORDS: abduction, abductive reasoning, argument scheme, argumentative pattern, inference to the best explanation.

1. INTRODUCTION

Abduction is a type of reasoning in which the presence of a certain cause is inferred from the presence of its effects. The type of reasoning is conventionally valid in various institutionalized contexts, e.g. the practice of medical diagnosis and that of scientific explanation, but logically invalid because it affirms the consequent. This raises the question what norms should be applied when assessing argumentative patterns in which abductive reasoning plays a role. In this contribution, I will develop a comprehensive tool for the analysis and evaluation of such 'argumentation based on abduction'.

First, I shall briefly describe the background of the present-day conception of abduction, more in particular Peirce's seminal account of abduction as one of the three modes of reasoning, his later formulation of abduction as reasoning from an observed fact to its explanation, and the nowadays widely used description of abduction as 'inference to the best explanation'.

Then, I shall explain what I mean by 'argumentation based on abduction' and critically examine two extant dialectical accounts of the argument schemes involved in such argumentation. The first of these accounts is the one offered by Walton, Reed, and Macagno (2008), in which argumentation based on abduction is analyzed in terms of the argument scheme from effect to cause. The second account is the one offered by pragma-dialectics, in which argumentation based on abduction is not recognized as such, but can be analyzed in terms of a so-called 'variant' of the argument scheme of causal argumentation.

Finally, I shall propose an argumentative pattern of argumentation based on abduction and illustrate how to use the pattern by analyzing an example from the field of astronomy.

2. WHAT IS ARGUMENTATION BASED ON ABDUCTION?

Viewed historically, abduction (or a type of reasoning similar to abduction) has been described under various labels until Peirce presented a seminal account of deduction, induction, and abduction as the three main types of reasoning. Peirce's concept of 'abduction' resembles Aristotle's concept of '*apagogê*,' Laplace 's concept of 'reasoning from effect to cause' as well as Rescher's concept of 'retroduction'.[1]

In general, scholars do not agree as to the status of abduction in relation to the other two main types of reasoning. According to some, abduction is like induction, since both types of reasoning produce conclusions that are plausibly true rather than necessarily true. For this reason, they classify abduction as a subtype of induction, holding that there are only two main types of reasoning: deduction, where the conclusion follows with necessity, and induction, where the conclusion is only plausible.

Other scholars emphasize the difference between abduction and induction. They note that these types of reasoning produce a different type of conclusion, since in the case of induction the conclusion is of a general nature, whereas in the case of abduction the conclusion is of a particular nature. At the same time they point at a commonality between abduction and deduction, namely that one of the two premises involved is of a general nature and the other of a particular.

These differences and commonalities are reflected in Peirce's distinction between deduction, induction and abduction as the three main types of reasoning. Peirce takes as a starting point that these types of reasoning have the form of a syllogism consisting of two premises and a conclusion, one of which three elements being a general statement and the other two particular statements. By systematically changing the order of these elements, it can easily be shown that there are exactly three different types of reasoning. Peirce (1974, 2.623) provides the following example of 'abduction', which is his name for the form of reasoning that has a particular and a general statement as its premises and a particular statement as its conclusion:

> These beans are white
> All the beans from this bag are white
> --
> These beans are from this bag

Pierce in a later work describes abduction as a key operation in the process of generating a hypothesis that functions as an explanation of certain facts:

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[1] See Aliseda (2006, pp. 28, 38).

> Long before I first classed abduction as an inference it was recognized by logicians that the operation of adopting an explanatory hypothesis – which is just what abduction is – was subject to certain conditions. Namely, the hypothesis cannot be admitted, even as a hypothesis, unless it be supposed that it would account for the facts or some of them. The form of inference, therefore, is this:
>
> > 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.
>
> Thus, A cannot be abductively inferred, or if you prefer the expression, cannot be abductively conjectured until its entire content is already present in the premiss, "If A were true, C would be a matter of course." (Peirce, 1974, 5.189)

As Douven (2011) remarks, abduction as described above should be seen "not so much as a process of *inventing* hypotheses but rather as one of *adopting* hypotheses, where the adoption of the hypothesis is not as being true or verified or confirmed, but as being a worthy candidate for further investigation" (pp. 35-36). In argumentation theoretical terms, then, Peirce's description of abduction can be reconstructed as containing the standpoint "There is reason to suspect that A is true" and the arguments "Fact C is observed" and "If A were true, C would be a matter of course".

Apart from the description above, one may also encounter a somewhat different description of abductive reasoning. Starting from the idea that abduction plays a key role in the process of finding explanations of observed facts, some philosophers have argued that abduction does not only involve the process of generating hypotheses, but also involves the consecutive process of selecting the "best candidate" from the hypotheses that have been generated.[2] This has led to a tradition in which abduction is described as a form of reasoning that involves the process of selection. Within this tradition, abduction is defined as 'inference to the best explanation'.[3]

The main difference between the two definitions of abduction is that where the 'generative' definition involves reasoning from observed facts to a possible explanation of those facts, the 'selective' definition involves making a choice between a number of possible explanations on the basis of certain criteria:

> In textbooks on epistemology or the philosophy of science, one often encounters something like the following as a formulation of abduction:
>
> ABD1   Given evidence E and candidate explanations H_1, ..., H_n of E, infer the truth of
> *that H_i* which best explains E.
>
> An observation that is frequently made about this rule, and that points to a potential problem for it, is that it presupposes the notions of candidate explanation and best explanation, neither of which has a straightforward interpretation. While some still hope that the former can be spelled out in purely logical, or at least purely formal,

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[2] Aliseda (2007, p. 267) makes a useful distinction between two processes that are related to abduction, namely the process of 'generation' and the process of 'selection' of explanations.

[3] On the differences between the two definitions to abduction see for instance Campos (2011), Minnameier (2004), and Paavola (2006).

terms, it is often said that the latter must appeal to the so-called theoretical virtues, like simplicity, generality, and coherence with well-established theories; the best explanation would then be the hypothesis which, on balance, does best with respect to these virtues. (Douven, 2011, pp. 10-11)

The notions of 'candidate explanation' and 'best explanation' mentioned in the quote above can be used in order to reconstruct this second type of abduction in argumentation theoretical terms. Abduction defined as 'inference to the best explanation' involves a standpoint that can be formulated as "H_i is the best explanation of E" and an argument that can be formulated as "Of candidate explanations H_1, ..., H_n of E, H_i meets criteria C_1, ..., C_n best" (the theoretical virtues mentioned in the quote being examples of such criteria).

In order to get a clearer view on what theoretical tools may be useful in constructing an argumentative pattern for the assessment of argumentation based on abduction, I will now explore two extant dialectical accounts of such argumentation.

3. A CRITICAL ANALYSIS OF TWO EXTANT ACCOUNTS

Argumentation theorists widely use the term 'argument(ation) scheme' in order to describe various types of defeasible arguments. Every scheme goes with specific 'critical questions' that can be used to assess the type of argument at issue. In the case of argumentation based on abduction – which is clearly a type of argument that is not deductively valid but takes the form of the fallacy of affirming the consequent – Walton, Reed, and Macagno (2008, p. 171) present the following scheme and associated critical questions:

Abductive Argumentation Scheme

F is a finding or given set of facts. *E* is a satisfactory explanation of *F*. No alternative explanation *E'* given so far is as satisfactory as *E*. Therefore, *E* is plausible, as a hypothesis.

Critical Questions

CQ1: How satisfactory is E as an explanation of F, apart from the alternative explanations available so far in the dialogue?
CQ2: How much better an explanation is E than the alternative explanations available so far in the dialogue?
CQ3: How far has the dialogue progressed? If the dialogue is an inquiry, how thorough has the investigation of the case been?
CQ4: Would it be better to continue the dialogue further, instead of drawing a conclusion at this point?

Although the scheme and the critical questions presented above are clearly related to the 'selective' definition of abduction as described in the former section, some criticisms can be raised against the way in which this definition has been translated into argumentation theoretical terms. First of all, the scheme does not give a clear picture of the way in which the premises involved in argumentation based on

abduction support the conclusion. All the premises are presented as if they directly support the conclusion, whereas the third premise rather seems to support the implicit premise that expresses the relationship between the first two premises and the conclusion. A similar issue concerns the question as to how exactly the first two premises relate to each other. Are they to be interpreted as coordinative arguments? Or is the second premise to be interpreted as a subordinative argument supporting the relation of the first premise to the conclusion? These questions can only be answered by presenting an argumentation structure in which it is made clear in what way exactly the premises mentioned in the scheme are related to the other premises as well as to the conclusion.

Second, it is not always clear how the critical questions relate to the premises mentioned in the scheme and how they play a role in the evaluation of the argumentation at issue. The first critical question clearly relates to the second premise. But since the question requires a gradual statement as an answer, in remains unclear in which cases the evaluation will yield a positive result. The second critical question clearly relates to the third premise. However, since answering the question how much better an explanation E is than the alternative explanations implies that E is considered to be the best explanation, the question is irrelevant for the evaluation of the argumentation at issue. The third and fourth critical questions do not seem to relate to the scheme, but rather to the process of inquiry as a whole. These questions are also irrelevant for the evaluation of the argumentation at issue, since the third premise contains the qualification 'given so far' for alternative explanations to be taken into account.

An approach in which the structure of argumentation as well as the relation between critical questions and the various arguments presented in the scheme are treated in a more systematic way is the pragma-dialectical theory of argumentation. Although the theory does not recognize argumentation based on abduction as such, the descriptions of such argumentation presented in the previous section can easily be translated into pragma-dialectical terms. The translation of the description of 'generative' abduction would have the form of the variant of causal argumentation in which the cause is mentioned in the standpoint:[4]

    1   *A* is true
    1.1   *C* is observed
    1.1' *A* explains (or causes) *C*

The associated general critical question pertains to the justificatory force of argument 1.1 that is expressed in 1.1' and runs as follows: 'Does *A* really explain (or cause) *C*?'

The translation of the description of 'generative' abduction would have the form of symptomatic argumentation:

> 1 H_i is the best explanation of E
> 1.1   Of candidate explanations H_1, …, H_n of E, H_i meets criteria C_1, …, C_n best
> 1.1'   Meeting criteria C_1, …, C_n best is a sign of being the best explanation of E

The critical question associated with this scheme runs as follows: 'Is meeting criteria C_1, …, C_n best really a sign of being the best explanation of E?'

The pragma-dialectical account of argumentation based on abduction is more systematic, but much less specific than Walton, Reed, and Macagno's account. In order to develop a tool for the assessment of argumentation based on abduction, I will combine the two definitions of abduction as well as the two dialectical accounts discussed above into an argumentative pattern that can be used for the assessment of argumentation based on abduction.[5]

4. THE PATTERN OF ARGUMENTATION BASED ON ABDUCTION

In order for the reconstruction of argumentation based on abduction to take place in a systematic as well as specific way, I propose an argumentative pattern in which both descriptions of abduction have their place, arguments are interpreted as anticipated answers to critical questions, and subordinative arguments may support either the propositional content or the justificatory force of other arguments:

> 1   It may be hypothesized that X_i
> 1.1   It is observed that Y
> 1.1'   Of possible explanations $X_1 - X_n$, X_i is the best explanation of Y
>   1.1'.1 X_i meets criteria $C_1 - C_n$ with scores $S_1 - S_n$
>   1.1'.1'   Decision rule R applies

Within this pattern both 'generative' as 'selective' abduction have their place. The first one, abduction defined as reasoning from the observation of a fact to its explanation, is presented as a combination of a standpoint (1), a main argument (1.1) and an argument that expresses the latter's justificatory force (1.1'). The second one, abduction defined as a decision as to which of the candidate explanations is the best explanation of an observed fact, is presented as a sub standpoint (1.1') that coincides with the expression of the justificatory force of the main argument. The sub standpoint is further supported by argumentation concerning the criteria and the scores (1.1'.1) as well as the decision rule involved (1.1'.1').

In order to illustrate how this pattern can be used to reconstruct argumentation based on abduction as it occurs in the field of science, I will provide an analysis of an example described by Douven (2011, p. 7). The example is not taken from a concrete debate held by scientists. Rather, it is a stylized description of

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a debate among astronomers who selected the most plausible explanation of an observed fact on the basis of certain criteria.

Example

At the beginning of the nineteenth century, it was discovered that the orbit of Uranus, one of the seven planets known at the time, departed from the orbit as predicted on the basis of Isaac Newton's theory of universal gravitation and the auxiliary assumption that there were no further planets in the solar system. One possible explanation was, of course, that Newton's theory is false. Given its great empirical successes for (then) more than two centuries, that did not appear to be a very good explanation. Two astronomers, John Couch Adams and Urbain Leverrier, instead suggested (independently of each other but almost simultaneously) that there was an eighth, as yet undiscovered planet in the solar system; that, they thought, provided the best explanation of Uranus' deviating orbit. Not much later, this planet, which is now known as "Neptune," was discovered.

Analysis

1   It may be hypothesized that there is an eighth planet in the solar system

    1.1   It is observed that Uranus departs from its predicted orbit

    1.1'   Of the two explanations considered, the existence of an eighth planet in the solar system is the best explanation of the observation that Uranus departs from its predicted orbit

        1.1'.1 The existence of an eighth planet in the solar system explains the observation and does not ignore the empirical successes of Newton's theory, while the alternative explanation that Newton's theory is not true explains the observation but ignores the empirical successes of Newton's theory

        1.1'.1' The explanation which does not ignore empirical successes of theories is the best

The reconstruction makes clear that both 'generative' and 'selective' abduction may play a role in argumentation based on abduction as it occurs in the field of science. The standpoint (1) contains an explanation of the anomalous observation mentioned in the main argument (1.1) and reflects the process of generating an explanation that is not yet a proven fact, but may turn into a proven fact in the future (in this case, the suggestion that there is an eighth planet in the solar system). The expression of the justificatory force of the main argument (1.1') reflects the process of selecting the best explanation out of a number of candidates. It functions as a sub standpoint that is further supported by argumentation regarding the criteria, the scores, as well as the decision rule involved.

The reconstruction also makes clear that the decision rule involved is related to certain norms for the acceptance of hypotheses in the context at hand. According to Douven, as quoted above, scholars who have written on the subject mostly refer to "the so-called theoretical virtues, like simplicity, generality, and coherence with well-established theories; the best explanation would then be the hypothesis which, on balance, does best with respect to these virtues" (2011, p. 11). In this case, the explanation suggesting that there is an eight planet in the solar system is considered to be the best explanation because it does not ignore the empirical successes of Newton's theory – a criterion that is related to the theoretical virtue of coherence with well-established theories.

4. CONCLUSION

In this paper I have presented an argumentative pattern of argumentation based on abduction. The pattern covers the two general descriptions of abduction found in the literature ('generative' abduction as well as 'selective' abduction) and also indicates the systematic place of arguments supporting the process of 'selective' abduction. The pattern can be used to analyse and evaluate argumentation put forward in institutionalized contexts in which abductive reasoning plays an important role, like science and medical diagnosis. Further research may result in a specification of the criteria and the decision rules involved in the various contexts in which arguers support their explanation of observed facts by putting forward argumentation based on abduction.

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