Ana DIMISHKOVSKA

UDK: 162: 165
Original research paper

IN THE OFFICE OF DOCTOR HOUSE: LESSONS IN ABDUCTIVE REASONING

Abstract

Abduction, often defined as inference to the best explanation, is a type of reasoning that is employed in situations where there is some kind of puzzling evidence, which is to be explained by the best hypothesis available. Amongst the different fields of application of abductive reasoning, the medical field plays an especially important role, primarily in its diagnostic aspect, where an accurate diagnosis of the cause of a patient's condition is to be established.

In this paper, an attempt is made to elaborate on the logical and epistemological aspects of the diagnostic application of abductive reasoning. The work of a fictitious medical diagnostic genius, David Shore's Doctor House, is used as an illustrative example of the complexity and the challenging nature of this kind of reasoning. The main purpose of the analysis presented in the paper is to test the plausibility of the dominant theoretical explanations of abductive reasoning, especially in regard to its structure, dynamics and practical usability in the medical field, and to identify its elements that deserve a more comprehensive theoretical treatment from an epistemological point of view.

Key words: *ABDUCTION, INFERENCE TO THE BEST EXPLANATION, DIAGNOSTIC REASONING, GENERATION OF HYPOTHESES, JUSTIFICATION OF HYPOTHESES, DOCTOR HOUSE*

Introduction

Who is Doctor House? For the passionate admirers of contemporary medical TV dramas, this question is, most probably, a rhetorical one. Who, amongst them, could possibly ignore Gregory House, the highly idiosyncratic title character of the American medical drama series *House*,[1] brilliantly portrayed by the English actor Hugh Laurie? For those, however, who are less familiar with the popular products of the American TV entertainment industry and have no clue who Doctor House might be, he can be described as a fictitious person who, in a hypothetical encounter with him in the real life, would surely inspire strong, mixed feelings in most of us.

[1] This series originally ran on the *Fox* network from 2004 to 2012; the conception of the title character is primarily attributed to David Shore, also credited as the creator of the series. (https://en.wikipedia.org/wiki/House_(TV_series))

This kind of reaction would, in fact, be due not only to his extremely difficult – misanthropic, cynic and narcissist – character, but also to his professional position. In the TV series, Gregory House leads a team of diagnosticians as the Head of Diagnostic Medicine at the fictional Princeton-Plainsboro Teaching Hospital in New Jersey. He is portrayed as a medical genius on a mission to resolve the most difficult diagnostic cases, a kind of "Sherlock Holmes" in the medical field. That is why, from the patient's point of view, to get the information that House is appointed as his/her doctor, is a mixture of bad news and good news. On the one hand, it means not only that the case is almost hopeless, but also that the patient would be obliged to maintain a painful, stresssful collaboration with a doctor who has an antisocial, unpleasant, hardly bearable personality structure, additionally complicated by his addiction to pain-killer medication. But on the other hand, it also means that if there is a slightest chance to resolve the medical puzzle under the time constraints of the illness' progression, House is most probably the only one who can succeed in it.

But - one can legitimately ask – what is the reason behind making this fascinating fictional character into an object of theoretical interest, and, what is more, not from a medical but, instead, from a logical, epistemological, and more broadly, philosophical point of view? The answer to this question directly points out to the main theoretical motivation of this paper: in its framework, the character of Doctor House is treated as an ideal example of a brilliant "logician in action". His personality convincingly illustrates the insight that the making of the correct medical diagnosis, which is the key factor in the successful treatment of a difficult health problem, is not just a matter of mechanically applying the general diagnostic protocols and accumulated medical knowledge; rather, it is an intellectual challenge that requires hard, in-depth, bold and case-sensitive thinking, in which analytical and synthetical skills, creativity and inferential capacity are inextricably intertwined.

From that point of view, it is argued that House's way of solving medical puzzles represents, in a very illuminative manner, the main logical mechanism of a specific kind of reasoning, known as "abductive reasoning", as well as the numerous challenges that this kind of reasoning presents for logic and epistemology as theoretical disciplenes. Consequently, the main idea of this paper is the attempt to discern and to analyse the specificities of abductive reasoning, reflected in the way in which Doctor House approaches the most complicated medical cases. The goal of this analysis would consist in identifying the elements of this kind of reasoning that deserve a more comprehensive theoretical treatment, and in pointing out some possible directions for further research on abduction as an important logical and epistemological instrument.[2]

[2] Although, from a methodological point of view, this goal may also be served with the analysis of some real-life examples of abductive reasoning in the medical field, here the domain of fiction is deliberately chosen as a kind ot theoretical laboratory for studying the abductive phenomena. This choice is motivated by the consideration that the imaginary nature of the plot and the characters in the series give greater liberty in the combination of circumstances and factors that constitute the complex medical puzzles and their solutions. The fictional nature of the script ma-

1. The concept and scope of abductive reasoning

Although in contemporary logical and epistemological literature there is no universally accepted definition of the concept of abduction, for the purpose of this paper it can be understood as a reasoning process that is employed in situations where there is some kind of evidence (most often, evidence that has some puzzling or unusual features), which is to be explained by the best hypothesis available. Thus, for example, John Josephson (Josephson and Josephson, 5) defines abduction as "a form of inference that goes from data describing something to a hypothesis that best explains or accounts for the data. Thus abduction is a kind of theory-forming or interpretive inference".[3]

From a historical point of view, the role of the "founding father" of abduction is usually ascribed to the American pragmatist philosopher and logician, Charles Sanders Peirce, although there are also opinions that the Aristotelian concept of *apagoge* broadly corresponds to the contemporary conceptions of abductive reasoning (Aliseda, 28). Peirce pleaded for an enlargement of the traditional dichotomy of deductive and inductive forms of reasoning, introducing abduction as a third fundamental type of reasoning (cf. Kapitan, 1992). According to Peirce, abduction is a process "where we find some very curious circumstance, which would be explained by the supposition that it was a case of a certain general rule, and thereupon adopt that supposition" (CP, 2.624). Thus, Pierce's general pattern of abductive inference is the following:

> 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 (CP, 5, 189).

This Peircean conceptualization of the abduction puts emphasis on the curious and surprising nature of the facts and circumstances that activate the application of abductive mechanisms. According to Aliseda (2000, 47) novelty and the anomaly of the observed data function as triggers for abductive procedures, pointing out to an epistemic perplexity that should be explained away. However, in the abductive framework, this goal is not attained by the simple acquisition of new knowledge that would resolve the initial difficulty. Developing this important point, John Woods describes abductions, generally, as specific kind of "responses to ignorance problems". Problems of this kind arise when an agent is facing "an epistemic target that cannot be hit by the cogni-

---

kes it possible to better isolate their underlying logical elements, and, at the same time, vividly emphasizes the relevance of these elements for one of the most basic human preoccupations – preservation of life and health.

[3] On the basis of this characteristic, in contemporary research, abduction is often treated as synonymous with the inference to the best explanation (Harman, 1965, Walton, 2005, Lipton, 2007). However, the unqualified identification of these two concepts is not universally accepted, because of the distinction of abduction as 1) explanatory reasoning in *generating* hypotheses and 2) explanatory reasoning in their *justifying*. It is argued that only in this second sense abduction can indeed be treated as equivalent to the inference to the best explanation (Douven, 2017).

tive resources presently at his command, or within easy and timely reach of it" (Woods, 218). In the framework of this account, abduction is treated as an "ignorance-preserving" mode of reasoning, which does not, nevertheless, mean that its goal is to keep the epistemic agent in the state of ignorance and passivity. Quite the contrary, abduction is highly beneficial as a proactive way of dealing with ignorance problems, because it "offers the agent a reasoned basis for action in the presence of his ignorance" (Woods, 218).[4]

The above-mentioned approaches to the concept of abduction make it possible to clearly identify some of its most important logical characteristics. Thus, it is obvious that, unlike deductive inferences, abductive inferences are non-monotonic in nature; that is, in the framework of an abductive argument, adding new premises can invalidate previous conclusions, because the abductive conclusions have, in principle, a tentative character. This, in turn, means that they enable the epistemic agent to draw defeasible conclusions from incomplete (and sometimes inconsistent) information and, consequently, to act in the given circumstances despite the impossibility to reach deductively valid conclusions on the basis of that kind of information.

In virtue of this characteristic it is not difficult to explain the phenomenon of what is called "the ubiquity of abduction" - to wit, the presence of its mechanisms in many different fields, ranging from everyday reasoning, through philosophical and scientific discovery and theory forming, to interpretation of linguistic phenomena, criminal investigation, legal reasoning, artificial intelligence and other areas (cf. Gonzalez and Haselager, 2005; Magnani, 2005, 2014; Neal, 2000; Paul, 1993; Peng and Reggia, 1990; Poole, 1990; Sun, Finnie and Weber, 2005; Walton, 2005). The research in all these areas open many conceptual problems related to the abductive reasoning. These problems include (but are not restricted to) the following issues: the relation between abductive and inductive reasoning as different forms of non-deductive inference; the criteria for forming and evaluating plausible hypotheses for explaining the observed facts; the presence of deductive elements in the drawing of logical consequences from different hypotheses; the taxonomy of abductive arguments; the normative status of abductive reasoning etc. The theoretical, but also the practical importance of these and related problems is, in a specific way, reflected in the functioning of abduction in the field of medical diagnostic, which represents one of the paradigmatic areas that may help us to understand the essence of abductive reasoning.

2. The role of abduction in medical diagnostic

Abduction in the medical field plays an especially important role, primarily in its diagnostic aspect (Console and Torasso, 1991; Dragulinescu, 2016; Vertue and Haig, 2008; Ward and Haig, 1997). Here, the trigger for the application of abductive reasoning

[4] Woods developed this conception of abduction in collaboration with Dov Gabbay, hence it is also known as the "GW-model".

is the combination of a patient's symptoms, especially the findings that show abnormal values. Starting from this perplexing evidence, the diagnostic effort aims at producing an explanation that best accounts for those symptoms. The explanatory hypotheses that are used in the diagnostic process have the character of "malfunction hypotheses" because their goal is to make plausible guesses about the origin of the dysfunctionality manifested in the patient's symptoms (Josephson and Josephson, 9). From a logical point of view, their operation fits the general pattern of abductive inference: "Given evidence E and candidate explanations $H_1,...,H_n$ of E, if H_i explains E better than any of the other hypotheses, infer that H_i is closer to the truth than any of the other hypotheses" (Douven, 2017). Applied to the area of medical diagnostic, this would mean that a correct diagnostic conclusion should 1) explain the symptoms, i.e. the evidence in the case 2) be plausible as a potential candidate explanation and 3) be significantly better than alternative explanations (ibid.).

Here, it should be emphasized that the whole process of arriving at a medical diagnostic conclusion has a complex logical structure in which the abductive elements are combined with the inductive and deductive elements at different stages of the diagnostic procedures. This structure is adequately captured in the "S-T (select and test) model" developed by Magnani and other authors, as an epistemological model of diagnostic reasoning (Magnani, 2000; for its relation to Hempel's "hypothetico-deductive model" of scientific reasoning cf. op. cit., 21, 39). The whole process starts with some observed data, from which the clinical evidence that should be explained is abstracted. Then, the diagnostic space is initially structured by the process of "selective abduction", which results in arriving to a "set of plausible diagnostic hypotheses". The next step involves a deductive development of their consequences, and a subsequent testing of them by a comparison with available patient data in order to "increase the plausibility of a hypothesis" or "to refute all hypotheses but one". However, if the expected data don't correspond with the newly observed data or if new information emerges during the first cycle, the previous diagnostic space can be expanded with the introduction of new hypotheses, and thus a new cycle can be initiated (Magnani, 23-24).

This complicated, multi-cyclical nature of the diagnostic process in hard medical cases seems to be systematically reflected in the work of our (in fact, David Shore's) fictional medical genius, Doctor House. The general pattern that, despite all the differences of the cases treated in each episode of the show, represents a common epistemological denominator of all of them, is, in fact, reducible to the above-mentioned "select and test" procedure. The innumerable subtleties that are characteristic of particular cases emphasize the peculiar logical nature of abductive diagnostic hypotheses, which, while giving the doctor a "reasoned base for action in the presence of his ignorance" (Woods, supra) regarding the real cause of the patient's illness, can also lead him/her to different kinds of predictable and unpredictable errors. Thus, in the rest of the paper, this claim will be illustrated with a short analysis of the relevant aspects of only one of the imaginary cases treated by House, in the episode with a philosophically very indicative name – "Occam's razor".

3. House's abductions: Occam's razor and the simplicity of explanation

In order to facilitate the analysis of the epistemological aspects of the case treated in this episode (here, understandably, presented in a very simplified way), let us invoke the five-step default pattern of reaching/justifying the diagnostic conclusion, described by Michael Tanner and John Josephson (Josephson and Josephson, 10), and use it as a guide in the successive stages of diagnostic reasoning of House and his team.

1. *There is a finding that must be explained.*

In the beginning of the episode, we meet a young college student that is admitted to the hospital with an inexplicable mixture of symptoms: cough, rash, abdominal pain, nausea, fever and low blood pressure that doesn't react to IV fluids. This unusual, or as House describes it, "weird" fact triggers the diagnostic abductive process, in the form of formulating diagnostic hypotheses performed by House's team.

2. The finding may be explained in a number of ways.

During the process of searching for differential diagnosis, House's colleagues formulate several alternative hypotheses. Thus, absidia (fungal infection), arthritis, allergy and carcinoid are listed as possible causes of the patient's symptoms. In terms of the previously mentioned S-T model, this stage represents the initial "structuring of the diagnostic space" with several preliminary hypotheses.

3, 4. *Some of these ways are judged to be irrelevant and/or implausible because expected consequences do not appear, or because they do not explain important findings.* [5]

However, in their discussion, the members of the diagnostic team rule out each of the proposed diagnostic hypotheses: absidia infection wouldn't cause a rash or a cough, arthritis wouldn't cause blood pressure problems, and allergy hypothesis cannot explain the presence of the abdominal pain. The carcinoid hypothesis is eliminated on similar grounds. At this stage of the process, from an epistemological point of view, the deductive elements of the diagnostic procedures come into play; the logical consequences of each hypothesis are being developed and then compared to the actual data of the case, in order to increase or decrease its initial plausibility. The ideal outcome of this process would be to confirm one of the preliminary hypotheses and rule out all the others.

5. *Out of the plausible explanations that remain the best is the diagnostic conclusion.*

At this point, nevertheless, House's struggle with the complicated case starts to deviate from the simple, paradigmatic diagnostic pattern. Thus, after concluding that "no condition explains all the symptoms" and excluding all the preliminary hypotheses, there is no final diagnostic conclusion that could be qualified as the best explanation of the patient's symptoms. But the doctors as epistemic agents are also practical agents on a mission to save the patient's life; their being blocked by the current igno-

[5] Here, step 3 and 4 of the original pattern are integrated into one step.

rance of the real cause of the illness and not taking any practical treating measures can put him in grave danger. That is why the diagnostic process must go on with the initiation of a new cycle of generation and justification of the hypotheses.

House's next step is to act following the hypothesis that the patient is struggling with some kind of abdominal infection; consequently, he administers antibiotics for possible sepsis. Unfortunately, the antibiotics only aggravate the patient's condition: his kidneys are shutting down, adding another symptom to the previous ones. Then, not accepting the suggestion of one of his colleagues that the underlying condition might be some rare form of cardiac viral infection, House presents the hypothesis that there is a combination of two pathological conditions (sinus infection and hypothyroidism) that would cover all the symptoms, and starts treatment for both of the supposed illnesses. This decision, nevertheless, is contested by the protagonist of the "cardiac infection" hypothesis, who thinks that House's theory that the patient has simultaneously contracted two completely unrelated diseases is highly improbable and goes against the Occam's Razor principle – "the simplest explanation is the best".[6]

Here, we encounter another controversial epistemological detail, related to the theoretically "hot" question of the criteria that an abductive hypothesis must meet in order to be promising. In his treatment of abduction, Peirce emphasized the importance of the Occam's Razor, which he considers to be the soundest logical maxim of scientific procedure (CP 5.60). According to the conception inspired by this maxim, one of the most important features of a plausible hypothesis, besides its explanatory capacity and testability, is its logical economy or simplicity, understood as a quality of containing fewer independent factors. Nevertheless, House is problematizing the idea that the number of factors involved in a tentative explanation of a medical problem is the sole criterion of its simplicity, and, consequently, of its plausibility. In fact, he is arguing that his hypothesis, based on the combination of two independent, but more common illnesses, is still more probable than the "viral cardiac infection" hypothesis, based on one factor, but with much rarer occurrence. In his unique style, he is mocking the objection of his colleague, asking the question: "Why is one simpler than two? It is lower, lonelier... is it simpler?"

But would this new hypothesis advanced by House and the treatment based on it be more successful than the previous ones? Not really. Lab tests performed in the meantime show that the antibiotics are not the cause of kidney failure, and that the patient doesn't suffer from hypothyroidism; his white cell count is low and his immune system is shutting down. This discrepancy between the expected and the observed data forces House to come up with a new hypothesis – that the patient suffers, in fact, from colchicine poisoning. This hypothesis would account for all of his symptoms, except for the cough. The principal difference between this and all the previous hypotheses is the

[6] In the formulation usually attributed to the renowned scholastic philosopher and logician, William of Occam, this principle reads as follows: „Entia non sunt multiplicanda praeter necessitatem" („Entities are not to be multiplied beyond necessity ").

fact that it introduces a qualitatively new assumption in the explanation of the peculiarity of this case – the human error! House's new guess, in fact, is that as a result of an error of the pharmacist, instead of cough medicine, the patient was given gout medicine – colchicine, which caused the poisoning while leaving untreated the real, primary symptom, the cough.

In the scenario of the episode, the first check of the correctness of this hypothesis with the pharmacy does not reveal any error on the pharmacist's side, and House is forced to give up his theory. However, in the end, after additional complications in the patient's condition and the appearance of new symptoms typical for colchicine poisoning, House reaffirms his former theory, and starts treatment for the poisoning that proves successful. The new check of the pharmacy discovers that, indeed, there was a human error, very difficult to be discovered, which resulted in an unintentional mixing up of the two kinds of pills; that confirms House's previous hypothesis and all the pieces of the puzzle finally came into their right place. This finding also evokes the ironic formulation of Occam's Razor that House came up with earlier in the episode: the simplest explanation, according to him, is almost always that somebody messed up (!).

4. Possible sources of error in diagnostic abductions

The deliberate complexity of this, as well as all the other imaginary cases that House is dealing with, makes it possible to test the explanatory capacity of the epistemological models of diagnostic reasoning not only when it comes to the normal, successful functioning of abductive mechanisms, but also with respect to the possible sources of error that they may generate. Thus, in relation to the five-step default pattern of reaching the diagnostic conclusion, mentioned in the beginning of this section, Tanner and Josephson point out to the fact that at each of its steps there is a possibility of occurrence of some kind of typical error. Thus, (ad 1), something may be wrong with the initial observed data that served as a basis of the abduction that led to the generation of the preliminary hypotheses; (ad 2), the differential may not be broad enough; (ad 3 and 4), some hypotheses may incorrectly have been judged to be implausible, or not to explain important findings, due to the faulty knowledge or missing evidence (as it actually happened when House for the first time formulated the hypothesis of colchicine poisoning due to human error); (ad 5) the diagnostic conclusion may incorrectly be thought to explain the findings, i.e. to be better than it actually was and, consequently, the true answer may, in fact, be underrated (Josephson and Josephson, 10-11).

A more systematic and in-depth analysis of the way in which House and his colleagues, throughout the whole series, reach their diagnostic conclusion, would probably give rich material for practical illustration of all of the above mentioned ways in which things may go wrong in the application of the abductive patterns of diagnostic reasoning. In fact, the plot of each episode revolves precisely around the struggle with uncertainty, based on incomplete and dynamic evidence related to pathological medical conditions and their treatment. This struggle, led through successive cycles of generati-

on and justification of diagnostic hypotheses, making errors and trying to identify and correct them, requires complete mobilization, primarily, of the general logical and epistemological resources of the diagnosticians as a prerequisite for maximizing the effect of their professional medical knowledge. That is why, the complicated work in the diagnostic teams led by House, sends a very important general message through the way in which their members are dealing with the most difficult medical challenges: hard, bold, informed, responsible and imaginative – in one word – high quality thinking in the medical field may save human lives, while the lack of it may irreparably destroy many of them.

Conclusion

This paper is inspired by contemporary epistemological research on abduction as one of the non-monotonic forms of reasoning used in situations in which there is a need to form and justify a theory that would explain some complex data, usually of unexpected or anomalous character. The field of medical diagnostic is, arguably, one of the most intricate and most practically important fields of application of the abductive reasoning mechanisms, which appeals for further theoretical research. The specific epistemological nature of medical diagnoses, which are uncertain, constructed with incomplete and dynamic information and which involve a mixture of reasoning procedures, seems to favour an enlarged theoretical view on abduction. According to this view, the concept of abduction should not be tied exclusively to the process of justification of the hypotheses, but should also be capable to theoretically accommodate the multiple processes of their generation, criticism, acceptance and comparative evaluation. In the framework of such a view, the question of criteria of initial plausibility and comparative quality of alternative diagnostic hypotheses are particularly challenging for future theoretical research.

References

Aliseda, A. (2006). *Abductive reasoning: Logical investigations into discovery and explanation*. Dordrecht: Springer.

Console, L. and Torasso, P. (1991). "On the co-operation between abductive and temporal reasoning in medical diagnosis". *Artificial Intelligence in Medicine*, 3, pp. 291-311.

Douven, I. (2017). "Abduction", *The Stanford Encyclopedia of Philosophy* (Summer 2017 Edition), Edward N. Zalta (ed.) https://plato.stanford.edu/archives/sum2017/entries/abduction/ [Accessed 13 May 2018].

https://en.wikipedia.org/wiki/House_(TV_series) [Accessed 13 May 2018].

Dragulinescu, S. (2016). "Inference to the best explanation and mechanisms in medicine". *Theoretical Medicine and Bioethics*, 37(3), pp. 211-232. (doi 10.1007/s11017-016-9365-9)

Gabbay, Dov M. and Kruse, R. (eds.) (2000). *Abductive reasoning and learning*. Dordrecht: Springer.

Gonzalez, M.E.Q and Haselager W.F.G. (2005). "Creativity: Surprise and abductive reasoning". *Semiotica*, 153 (1/4), pp. 325–341.

Harman, G. (1965). "The inference to the best explanation". *The Philosophical Review*, 74 (1), pp. 88-95.

Josephson, J.R. and Josephson, S.G. (1996). *Abductive inference: Computation, philosophy, technology*. Cambridge: Cambridge University Press.

Kapitan, T. (1992). "Peirce and the autonomy of abductive reasoning". *Erkenntnis*, 37, pp. 1-26.

Lipton, P. (2007). "Précis of Inference to the Best Explanation, 2nd Edition". *Philosophy and Phenomenological Research*, LXXIV (2), pp. 421-423.

Magnani, L. (2000). *Abduction, Reason, and Science: Processes of Discovery and Explanation*. New York/Boston/Dordrecht/London/Moscow: Kluwer Academic/Plenum Publishers.

Magnani, L. (2005). "An abductive theory of scientific reasoning". *Semiotica*, 153 (1/4), pp. 261–286.

Magnani, L. (2014). "Abductive theory of cognition. The eco-cognitive model". *RIFL / SFL*, pp. 54-69. (doi10.4396/17SFL2014).

Neal, P. (2000). "Abduction and induction: a real distinction?". In Bunt, H. and Black, W. (eds.) *Abduction, belief and context in dialogue: studies in computational pragmatics*. Amsterdam: John Benjamins Publishing Company, pp. 381-389.

Paul, G. (1993). "Approaches to abductive reasoning: an overview". *Artificial Intelligence Review*, 7, pp. 109-152.

Peirce, Ch. S. (1994). *Collected papers of Charles Sanders Peirce*. Charles Hartshorne, Ch., Weiss, P. and Burks, A. W. (eds.). Thoemmes Continuum.

Peng, Y. and Reggia, J.A. (1990). *Abductive inference models for diagnostic problem-solving*. New York: Springer.

Poole, D. (1990). "A methodology for using a default and abductive reasoning system". *International Journal of Intelligent Systems*, 5, pp. 521-548.

Sun, Zh., Finnie, G. and Weber K. (2005). "Abductive case-based reasoning". *International Journal of Intelligent Systems*, 20, pp. 957–983.

Vertue, F.M. and Haig, B.D. (2008). "An Abductive Perspective on Clinical Reasoning and Case Formulation". *Journal of Clinical Psychology*, 64 (9), pp. 1046 -1068.

Walton, D.N. (2005). *Abductive reasoning*. Alabama: University of Alabama Press.

Ward, T and Haig, B. (1997). "Abductive Reasoning and Clinical Assessment". *Australian Psychologist*, 32, (2), pp. 93-100.

Woods, J. (2010). "Abduction and proof: A criminal paradox". In Gabbay, D. M., Canivez, P., Rahman, Sh. and Thiercelin, A. (eds.) *Approaches to Legal Rationality*. Dordrecht/Heidelberg/London/NewYork: Springer, pp. 217-238.