Abduction and Bayesianism in Medical Diagnosis

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In this paper the authors consider a very interesting but rather complicated case of the diagnosis of a neurological condition. They then analyze the patterns of reasoning used by the doctors. Roughly speaking, they conclude that the reasoning used consisted of abduction leading to (p. 13) "advances by conjecture and refutation." One interesting point here is that Popper himself never accepted abductive inference, and held the view that conjectures should be freely invented by scientists. Nonetheless, his scheme of conjectures and refutations fits very well with abduction. The conjectures are generated by abduction, and then tested out in the way that Popper recommends. This combination of abduction and conjectures and refutations gives an excellent account of the example considered, and it seems to me that it is one of the principal schemes used in medical reasoning. In this comment, I would like to raise the question of how this reasoning scheme relates to another scheme which has been applied to medicine with some success, namely Bayesianism.

Bayesianism has had many applications in medicine, but one interesting case which is simple in character and yet very illuminating is the work carried out by De Dombal and his group in 1972. I analyze this example in my 2006.

De Dombal and his group devised a computer-based diagnostic system using a Bayesian approach. The probability of a patient's having a particular condition given a set of symptoms was calculated using Bayes theorem, where the probabilities employed had been estimated from a large sample of previous patients. The system worked very well, and this was because it was designed for use in the following relatively simple situation.

Patients were admitted to the department of surgery of a Leeds hospital because of the onset of acute abdominal pain. The problem was to diag-

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nose the cause of their pain and, in particular, decide whether an operation was necessary. Leaving aside a small 'other' or 'miscellaneous' category comprising less than 4 per cent of cases, the patients were diagnosed as having just one of the following seven conditions: appendicitis (just over a quarter of the cases), cholecystitis, small bowel obstruction, perforated duodenal ulcer, pancreatitis, diverticular disease, and, last but not least, non-specific abdominal pain, which accounted for about half the cases. The last condition is of course not a disease, but covers those cases where no cause for the pain could be found. This situation is obviously suitable for statistical treatment because of the limited number of mutually exclusive possibilities, and also because during the course of the treatment, often an operation, the cause of the pain could in most cases be definitely established, thereby establishing the correctness or incorrectness of the initial diagnosis.

The efficiency of de Dombal, et al's computer system was compared with that of the hospital clinicians in a sample of 304 patients admitted between 1 January 1971 and 1 December 1971. The overall result (de Dombal, et al. 1972, p. 9) was that the computer system was correct in 91.8 per cent of the cases, and the senior member of the clinical team handling the patient in 79.6 per cent of the cases. Some of the detailed differences are also interesting. One of the most difficult, but at the same time crucial problems in this area is to distinguish between appendicitis and non-specific abdominal pain. If a case of appendicitis is wrongly classified as non-specific abdominal pain, the result could be a delay in operating which results in the appendix perforating or forming an abscess. Conversely, however, if non-specific abdominal pain is wrongly diagnosed as appendicitis, this could result in the patient going through an entirely unnecessary operation—known in the business as a 'negative laparotomy'.

De Dombal, et al., describe the relative performance in this area of the computer and the humans as follows (1972, p. 12):

> ... the computer system accurately classified 84 out of a possible 85 patients with acute appendicitis, ... This contrasts with the clinicians' performance, where only 75 diagnoses of appendicitis were made, and six patients were originally classified as non-specific abdominal pain. ... Moreover, although the computer erroneously classified six non-specific abdominal pain patients with the 'appendicitis' category, the corresponding figure for the clinical team was no fewer than 27 patients. ... Had we slavishly followed the computer's predictions, six negative laparotomies would have been performed, but in no case of appendicitis would surgery have been delayed. What actually happened was rather different. Twenty-odd negative laparotomies were performed, and six cases of appendicitis were 'observed' for over eight hours before the decision to operate was taken.

How are we to explain the very different type of reasoning used in the De Dombal case (Bayesianism) and in the Rodriguez de Romo, Aliseda, and Arauz case (abduction and conjectures and refutations)? Actually, the difference here might not surprise Rodriguez de Romo, Aliseda, and Arauz, for they say (p. 27): “One may well ask whether ... logical thinking has levels and, if so, if the same level is required for different fields of medicine.” In the De Dombal case, there was a single violent symptom (acute abdominal pain), and this symptom could be explained by a limited number of standard conditions. The Rodriguez de Romo, Aliseda, and Arauz case was much more complicated and open-ended. The patient was a woman aged sixty who had a variety of neurological symptoms and had been diagnosed several years earlier with hyperthyroidism. The neurological symptoms observed could have been caused by a large variety of different conditions, and the final diagnosis (p. 10) “paraneoplastic degeneration of the cerebellum secondary to a thyroidal carcinoma” was of a very unusual, if not unique, condition. Thus it would clearly have been impossible to apply the De Dombal approach to the Rodriguez de Romo, Aliseda, and Arauz case. No one could have written down a list of all possible neurological causes, and then used Bayesian reasoning. It was necessary to proceed in a more piecemeal way by formulating conjectures using abduction, and then testing them out against the evidence. Quite a number of possibilities were eliminated before the doctors hit on the correct diagnosis. It is interesting to note how both abduction and refutations were necessary to the reasoning process. As regards refutations, Rodriguez de Romo, Aliseda, and Arauz say (p. 10):

> In the concrete case of this woman the results of cerebral imaging studies showed a reduction in the volume of the cerebellum, but no other lesion. *This ... ruled out the presence of a brain tumor or vascular disease* [my italics—D.G.] and supported the diagnosis of paraneoplastic degeneration.

A good example of the need for abduction is the following (Rodriguez de Romo, Aliseda, and Arauz, p. 10):

> *Because of the patient’s antecedents* [my italics—D.G.], they first requested thyroid function tests and images of the thyroid gland, and those tests did indeed reveal the presence of a thyroidal tumor, which a subsequent biopsy proved was malignant.

Note that the doctors inferred that there might be a tumor in the thyroid gland because the patient had earlier suffered from hyperthyroidism. This is a very clear example of abductive reasoning. Without this abduction, they might have searched for a tumor in vain for a long time.

Although the Rodriguez de Romo, Aliseda, and Arauz case is much more complicated that the De Dombal case, there is one respect in which it was easier to handle. The imaging techniques enabled some conjectures to be directly refuted. For example, the conjecture that the woman might have a brain tumor was refuted by cerebral imaging. No such imaging techniques are available for the case of appendicitis. An operation has to be carried out in order to refute definitely the conjecture that a patient's appendix is diseased, and no one wants to carry out unnecessary operations. Thus the method of conjectures and refutations cannot be applied here, and instead Bayesian reasoning is used to estimate the probability of a patient having appendicitis on the basis of symptoms and other tests. It is worth noting that, despite Popper's opposition to Bayesianism, falsificationism can be considered as a special case of Bayesianism in which the posterior probability becomes zero.

These considerations suggest that it might in some cases be necessary to combine abduction with Bayesianism. A number of conjectures could be obtained by abduction. The prior probabilities of these conjectures could be estimated from databases of medical statistics, and Bayesianism used to calculate the posterior probabilities of these conjectures in the light of the observations on a particular patient.

So to conclude, the paper of Rodriguez de Romo, Aliseda, and Arauz seems to me a very important one because it has made explicit an important pattern of reasoning used in medical diagnosis. It is also highly stimulating for further research which could be carried out in this key area, since it raises questions about how the abduction and conjectures and refutations pattern of reasoning might be combined with other patterns such as Bayesianism.

REFERENCES

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