

Albert Einstein is well known as one of the three greatest physicists of all time (the other two being Newton and Maxwell) for being the sole creator of Relativity Theory, both Special and General, and for being the co-creator along with Planck of Quantum Theory, which are the twin pillars of modern physics (1). What is perhaps not so well known are his numerous, highly perceptive writings on the nature and method of science which are easily accessible to interested non-specialists. In this paper, we shall discuss relevance of four pieces from these writings to study of diagnosis.

The first piece is from his obituary notice for Ernest Mach, the well known philosopher of science, in 1916 (2) which we quote below:

“Concepts that have proven useful in ordering things easily achieve such an authority over us that we forget their earthly origins and accept them as unalterable givens. Thus they come to be stamped as ‘necessities of thought’, ‘a priori givens’ etc. The path of scientific advance is often made impassable for a long time through such errors. For that reason, it is by no means an idle game if we become practiced in analyzing the long commonplace concepts and exhibiting those circumstances upon which their justification and usefulness depend, how they have grown up, individually, out of the givens of experience. By this means, their all too great authority will be broken. They will be removed if they cannot be legitimated, corrected if their correlation with given things be far too superfluous, replaced by others if a new system can be established that we prefer for whatever reason”.

The clear message of this passage is, we believe, that every concept, however long established is manmade and is therefore not immutable or written in stone. It is always open to analysis and often subject to correction or replacement by another concept which is better coordinated with observed or experimental facts.

Einstein demonstrated the truth of this passage in his own work by a searching analysis of Newton’s concept of Absolute Time, of Newton’s theory of gravitation as a force of attraction between masses and of wave theory of light, which had been well established for hundreds of years (1).

He replaced these concepts by his concept of relative time in his Special Theory of Relativity, by his concept of gravity as bending of spacetime due to mass in his General Theory of Relativity and by his particle theory of light, which were better coordinated with certain observed and experimental facts (1).

It is this piece which has inspired us to analyze the theory of Bayesian diagnosis which appears to us to be inconsistent with the way diagnosis is performed in practice.

Our analysis reveals that this inconsistency arises due to a marked difference between the reason the Bayesian method was prescribed and our goal in diagnosis in practice(3).

It was prescribed over 50 years back due to its rationality defined as not losing a bet placed on a Bayesian diagnosis (4) which fails to achieve our goal in diagnosis of diagnostic accuracy in every individual patient.

The method which is employed in practice, we have pointed out, is the frequentist method (5) which succeeds in achieving this goal to a great extent.

Despite posting our thoughts about Bayesian diagnosis in dozens of papers on Listserv (Discussion Board in SIDM) in the last few years, we have not received a single meaningful response which leads us to believe that perhaps Bayesian diagnosis is considered 'a necessity of thought' which is immune to any criticism!

The second piece, which we quote below, is from Einstein's celebrated Herbert Spencer lecture, 'On the method of theoretical physics' delivered at Oxford in 1933 (6):

"If you want to find out anything from the theoretical physicists about the methods they use, I advise you to stick closely to one principle, don't listen to their words, fix your attention on their deeds".

We have taken Einstein's advice in our study of the correct method of diagnosis by ignoring what physicians' say this method is and instead focusing our attention on how they diagnose in practice by analyzing diagnostic exercises in real patients such as clinicopathologic conferences (CPCs) and clinical problem solving

exercises which are published regularly in the New England Journal of Medicine (7,8).

One of the most striking findings of this analysis has been that every disease which is suspected from a presentation is formulated as a diagnostic hypothesis without any prior evidence for or against it regardless of its prior probability based on presentation.

This step enables every disease to be diagnosed accurately regardless of its prior probability.

This finding clearly indicates that the prescribed Bayesian method, in which prior probability of a disease represents prior evidence for or against it (9), is not employed for diagnosis in practice.

The prescription of the Bayesian method cannot therefore be considered correct from the point of view of diagnostic accuracy.

We note it is only when we analyze the method employed by physicians in practice that we find out it is the frequentist and not the Bayesian method which is the correct method of diagnosis.

The third piece, which we quote below, is Einstein's somewhat enigmatic remark from his marvelous essay, 'Physics and Reality' (10):

"The relation is not analogous to that of soup to beef but rather of wardrobe number to overcoat".

Einstein makes this remark to emphasize that sense experiences do not serve as evidence (soup) for a concept (beef), but as a clue (wardrobe number) to a concept (overcoat).

We suggest this remark is equally applicable to the relationship between a presentation and a disease suspected from it during diagnosis in practice.

We believe a presentation serves as a clue (wardrobe number) to a suspected disease (overcoat) and not as evidence (soup) for a suspected disease (beef).

It is because a presentation is looked upon as a clue that we are able to diagnose a disease accurately in practice regardless of its presentation (prior probability).

Also, we do not employ the Bayesian method in practice because we are required to consider prior probability (presentation) as prior evidence in it which is likely to lead to diagnostic errors in patients with low prior probabilities (atypical presentations).

The fourth and final piece, quoted below, is his remark made during lectures on Relativity Theory at Princeton in 1921 (11):

“ this universe of ideas is just as little independent of the nature of our experiences as clothes are of the form of the human body “.

We interpret this remark to indicate that it is essential for a scientific theory to be consistent with our experience (observed facts and experimental results).

According to this remark, the Bayesian theory of diagnosis is incorrect scientifically as it leads to results which are inconsistent with our experience as we point out below with an example:

In a 40 year old healthy woman with highly uncharacteristic chest pain who is found to have acute ST elevation EKG changes, acute myocardial infarction (acute MI) is diagnosed to be indeterminate from the posterior probability of 50 percent which is generated by combining the prior probability of 7 percent and likelihood ratio of 13 (for acute ST elevation EKG changes) (12) (Appendix 1).

But this Bayesian diagnosis is inconsistent with our experience of acute ST elevation EKG changes leading to accurate diagnosis of acute MI in 85 percent (8 to 9 out of 10) patients (13).

Therefore due to lack of this consistency, the Bayesian method cannot be considered correct.

It is of interest that the discussing physician in the clinical problem solving exercise, in which this patient is presented, does not make the Bayesian diagnosis.

Instead, he correctly diagnoses acute MI definitively in this patient based on his experience (13).

In conclusion, we find the writings of Einstein to be highly relevant to study of diagnosis.

First of all, he gives us courage to analyze the well established Bayesian theory of diagnosis by pointing out 'it is not an idle game'.

Then he shows us the right method of analyzing the correct method of diagnosis which is by examining how physicians diagnose in practice.

He also points out the correct relationship between a presentation and a suspected disease.

And finally, he points out the mark of a correct theory of diagnosis, which is that it should be consistent with our experience.

#### Appendix 1

Prior probability of 7 percent = Prior odds of 1/13

In odds form of Bayes' theorem,

Posterior odds = Prior odds x Likelihood ratio

Therefore,

Posterior odds =  $1/13 \times 13$  = Posterior probability of 50 percent

#### References

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