In recent years, heuristics, which are non-analytic, mental shortcuts in reasoning have been viewed as an important cause of diagnostic errors in practice (1). We shall argue in this paper that this view is based on a mistaken idea about the role of heuristics in diagnosis and that, instead, they play a vital role without which diagnosis would not be possible.

The current view about heuristics as a cause of diagnostic errors is based almost solely on the studies of Tversky and Kahneman on judgment under uncertainty (2). In these studies they found that a heuristic leads to a faulty probability judgment due to neglect of an important probability rule. For example, in their well-known engineer-lawyer study (Appendix 1), subjects made a faulty probability judgment about a description belonging to an engineer or a lawyer purely on the basis of the heuristic of resemblance (representativeness) while ignoring base rate. Their findings have been applied to the process of diagnosis to conclude that a heuristic is a cause of diagnostic error as we see in the following example.

In a recent paper (3), the following example is given of a diagnostic error caused by the heuristic of representativeness:

A 65 year old man with bi-temporal headache and aching neck/shoulders in winter is diagnosed with giant cell arteritis rather than influenza due to apparent strong pattern match to arteritis despite greater prevalence of influenza. This diagnosis is considered to be an error as it is a faulty probability judgment due to neglect of base rate.

We suggest this is not how diagnosis would be performed in this patient in practice because a diagnosis (probability judgment) of arteritis would not be made from the presentation alone. Instead, arteritis would only be suspected from the presentation and formulated as a hypothesis which would be verified by tests to see if it is correct or not. Arteritis would be diagnosed in this patient only if the hypothesis is verified to be correct by testing. The role played by the heuristic of resemblance (representativeness) in this patient is only to make us suspect arteritis from the resemblance of this presentation to similar instances in

the past (exemplars) (4) or to an illness script (5) of this disease in our memory and formulate it as a hypothesis.

The manner in which a heuristic is employed to generate a hypothesis during diagnosis in practice is more consistent with the other widely known version of heuristic reasoning based on the work of the mathematician George Polya (6). In this version, heuristic reasoning is a method whose purpose is to discover('heuristic' derived from the Greek word 'heuriskein' which means 'to discover') a plausible and provisional solution to a given problem. It often employs the notion of resemblance or analogy as a heuristic to develop a hypothesis which is a guess or a conjecture that needs to be proven correct by a proof in mathematics or by an experiment in science. In diagnosis, a hypothesis is proven correct usually by a test.

Thus it is Polya's version of heuristic reasoning which plays a key role in generating a hypothesis in diagnosis which is known to be a process of hypothesis generation and verification. (7). Tversky and Kahneman's version of heuristic reasoning des not play any role during diagnosis in practice as we almost never make a probability judgment (diagnosis) from a presentation alone. Specifically there is no provision for hypothesis generation, without which diagnosis is not possible, in their version. Thus this version, in which a probability judgment(diagnosis) is made from a presentation is not applicable to diagnosis in practice which is a process of hypothesis generation and verification.

The wide gulf between Tversky and Kahneman's version of heuristic reasoning and the manner in which this reasoning is employed in diagnosis arises from the fact, we believe, that their version is based on studies about day to day reasoning about probability judgments from given data, while diagnosis, with its hypothesis generation and verification approach, is essentially a scientific process. We have discussed the scientific nature of diagnosis in some detail elsewhere (8). Thus by employing heuristic reasoning to generate a hypothesis during diagnosis, a physician is a scientist at the bedside or in a in a clinic and not a person in the street employing heuristic reasoning to make a probability judgment from given information (presentation).

Therefore in its role in generating a hypothesis, a heuristic is almost never a source of diagnostic error as a hypothesis is only a plausible and provisional explanation which is practically always verified to be correct or not by tests. If a hypothesis is not verified to be correct, it is ruled out so the heuristic generated hypothesis does not cause an error. The main role of heuristic reasoning in diagnosis is creative, to come up with fruitful hypotheses which can be checked by tests. At times, a high level of imaginative heuristic reasoning is instrumental in reaching a correct diagnosis as we see in the following patient discussed in a clinical-pathologic conference (CPC) (9).

The patient is a retired 65 year old grandfather with history of being a retired salesman who presents with dyspnea and bilateral pulmonary infiltrates. In this patient with no obvious risk factors for HIV disease, the discussing physician suspects Pneumocystis pneumonia due to HIV disease, because, as she says,"It is Arthur Miller's play, Death of a Salesman, that suggested to me a risk factor in this retired salesman; he is human and affairs are common". This disease, suspected and formulated as a hypothesis by employing the heuristic of analogy, is proved to be correct by appropriate tests.

Tversky and Kahneman mention that heuristics often deteriorate into cognitive biases such as anchoring, confirmation bias etc., which are systematic errors in reasoning (2). This may be true in their studies about day to day reasoning, but does not appear to occur in diagnosis, we believe, in which the sole role of a heuristic is to generate a hypothesis which is always evaluated by tests. We agree, cognitive biases are a source of diagnostic errors in practice (1), but do not think they arise from heuristics. Some cognitive biases have been known for a long time as impediments to arriving at truth in an investigation. For example, they were well-known to Sir Francis Bacon, one of the founders of the scientific method, almost 400 years back, who called them Idols of the Mind (10). His description of the confirmation bias (Appendix 2) (11) rivals any modern description of this bias.

We propose, based on the above discussion that heuristics and cognitive biases, should not be lumped together as a source of diagnostic errors, for heuristics play an essential role in generating a hypothesis without which diagnosis would not be

possible. It is cognitive biases alone, we believe, which lead to diagnostic errors in practice.

Appendix 1

In this study, subjects were shown brief personality descriptions of several individuals, allegedly sampled at random from a group of 100 professionals-engineers and lawyers. The subjects were asked to assess for each description the probability that it belonged to an engineer rather than to a lawyer. In one experimental condition, subjects were told that the group from which the description had been drawn consisted of 70 engineers and 30 lawyers. In another condition, subjects were told that the group consisted of 30 engineers and 70 lawyers. In both conditions, subjects produced essentially the same probability judgments. Apparently subjects evaluated the probability that a particular description belonged to an engineer rather than to a lawyer by the degree to which this description was representative of the two stereotypes, with little or no regard for the prior probabilities (base rates) of the categories.

Appendix 2

The human understanding when it has once adopted an opinion (either as being the received opinion or being agreeable to itself) draws all things else to support and to agree with it. And though there be a greater number and weight of instances to be found on the other side, yet these it neglects and despises, or else by some distinction sets aside and rejects, in order that by this great and pernicious predetermination the authority of its former conclusions remain inviolate. And therefore it was a good answer that was made by one who, when they showed him hanging in a temple a picture of those who had paid their vows as having escaped shipwreck, and would have him say whether he did not now acknowledge the power of the gods-"Aye" asked he again, "but where are they painted that were drowned after their vows?' And such is the way of all superstition, whether in astrology, dreams, omens, divine judgments, or the like; wherein men, having a delight in such vanities, mark the events where they are

fulfilled, but where they fail, though this happen much oftener, neglect and pass them by. But with far more subtlety does this mischief insinuate into philosophy and the sciences, in which the first conclusion colors and brings into conformity with itself all that comes after, though far sounder and better. Besides, independently of that delight and vanity which I have described, it is the peculiar and perpetual error of the human intellect to be more moved and excited by affirmatives than by negatives; whereas it ought properly to hold itself indifferently toward both alike. Indeed, in the establishment of any true axiom, the negative instance is the more forcible of the two.

References

1. Balogh EP, Miller BT, Ball JR. eds. Improving Diagnosis in Health Care. Washington DC. National Academies Press; 2015.
2. Tversky A, Kahneman D. Judgment under uncertainty: Heuristics and Biases. Science 1974; 185: 1124-1131.
3. Bernishek LE, Weaver SJ, Newman-Toker DE. The cognitive psychology of diagnostic errors. Scientific American Neurology. Jan 2015, DOI 102310/7900.6288, 1-21, p11.
4. Brooks LR, Norman GR, Allen SW. Role of specific similarity in a medical diagnostic task. J Exp Psychol Gen 1991; 120: 278-287.
5. Schmidt HG, Norman GR, Boshuizen HP. A cognitive perspective on medical expertise: theory and implications. Acad Med 1990; 65: 611-621.
6. Polya G. How to solve it: A new Aspect of Mathematical Method. Princeton NJ. Princeton University Press 1971.
7. Brush JE, Sherbino J, Norman GR. How expert clinicians intuitively recognize a medical diagnosis. Am J Med 2017; 130: 629-634.
8. Jain BP. The scientific nature of diagnosis. Diagnosis 2017; 4: 17-19.
9. Finn KM, Ginns LC, Robbins GK, Wu CC, Branda JA. Case records of the Massachusetts General Hospital (Case 20-2014). A 65 year old man with dyspnea and progressively worsening lung disease. N Engl J Med 2014; 370: 2521-2530.

10.10.Klein J. Francis Bacon. The Stanford Encyclopedia of Philosophy (Winter 2016 Edition), Zalta EN ed, URL= < https: ll plato.stanford.edu/archives/win2016/entries/francis.bacon/>

11.Bacon F, Jardine L. The New Organon. New York: Cmbridge University Press, 2000. Aphorism XLVI.