Mind & Society (2021) 20:149–154
https://doi.org/10.1007/s11299-020-00262-0

The epistemic uncertainty of COVID-19: failures and successes of heuristics in clinical decision-making

Riccardo Viale[1]

Received: 6 August 2020 / Accepted: 6 October 2020 / Published online: 16 October 2020
© Springer-Verlag GmbH Germany, part of Springer Nature 2020

Abstract
The brief article deals with the following questions: Was the adaptive toolbox of heuristics ecologically rational and specifically accurate in the initial stages of COVID-19, which was characterized by epistemic uncertainty? In other words, in dealing with COVID-19 did the environmental structural variables allow the success of a given heuristic strategy?

Keywords Uncertainty · Heuristics · COVID-19

1) Real-life problems occur within a complex and uncertain environment. These are typically ill-defined problems, that is, the goals are not definite; we do not know what qualifies as an alternative and how many alternatives there are; it is unclear what the consequences might be and how to estimate their probabilities and utilities. This environment may also be called *Large World* (Savage 1954) and it is characterized by uncertainty. *Small Worlds* are, by contrast, theoretically predictable and without surprises and they are characterized by the knowledge of all relevant variables, their consequences and probabilities. Science aims to transform Large World problems into Small World problems (Viale 2020). This is possible only when Large World problems are characterized by epistemic uncertainty and not by fundamental or ontological uncertainty. The first kind of uncertainty occurs when, ideally, empirical research and the collection of data are able to supply statistical figures that characterize relevant variables, their consequences and probabilities. The second kind of uncertainty deals with events that empirical research is not able to represent probabilistically because of complexity or unpredictable surprises. The first kind of uncertainty usually applies to most biomedical research (for example, trials for a new drug) whereas the second

✉ Riccardo Viale
Riccardo.viale@unimib.it

1 University of Milano-Bicocca, Milano, Italy

applies to macro-political, environmental and financial phenomena (for example, the prediction of a financial crisis). COVID-19, like any other infection, is typically characterized by epistemic uncertainty.[1] In a few years biomedical research will be able to define its viral behavior and possible treatments. But the question is: How can we cope with this infection today and what kind of decision-making would be preferable?

2) What kind of decision-making processes are able to match uncertain environmental tasks and solve the problems? This is an empirical question that was addressed some years ago by cognitive scientists like Herbert Simon, Vernon Smith, Richard Selten and particularly, more directly, Gerd Gigerenzer and the Abc group (Gigerenzer, Todd, and the Abc Group, 1999). The adaptive toolbox of formalized heuristics is the result of those empirical investigations. When dealing with a number of problems, simple heuristics proved more accurate than standard statistical methods characterized by the same or more information. This became known as the "less-is-more" effect whereby there exists a point where more is not better, but actually worse. There is an inverse-U-shaped relation between the level of accuracy and the amount of information, computation or time (Gigerenzer and Gassmaier 2011, p. 453). For example, "starting in the late 1990s it was shown for the first time that relying on one good reason (and ignoring the rest) can lead to higher predictive accuracy than achieved by a linear multiple regression" (Gigerenzer and Gassmaier 2011, p. 453). The toolbox is composed of many heuristics that have been successfully tested against statistical algorithms of rationality not in terms of fitting closed samples of data, which would be a simple task, but in the much harder task of prediction. These heuristics have provided both a better description of decision-making and a better prescription of how to decide. Obviously the adaptive success of any given heuristic depends on the specific given environment. In which environments will a given heuristic succeed, and in which will it fail? Todd et al. (2011) identified a number of environmental structure variables:

a) Uncertainty: how well a criterion can be predicted
b) Redundancy: the correlation between cues
c) Sample size: number of observations (relative to number of cues)
d) Variability in weights: the distribution of the cue weights

How do we assess the adaptive success in ecological rationality? Gigerenzer and Gassmaier (2011, p. 457) write:

The study of ecological rationality results in a comparative statement of the kind "strategy X is more accurate (frugal, fast) than Y in environment E"…

Was the adaptive toolbox of heuristics ecologically rational and specifically accurate in the initial stages of COVID-19, which was characterized by epistemic uncertainty? In other words, in dealing with COVID-19 did the environmental structural variables allow the success of a given heuristic strategy?

Let us consider medical decision-making required to deal with the virus in the early days of the epidemic. In this sense I will try to ascertain whether some

[1] It is not characterized by fundamental uncertainty, as maintained by Jani (2020).

environmental structure variables could have allowed for the ecologically rational success of *recognition-based heuristics* and *one reason-based heuristics.*

3) A heuristic is adapted to a specific environmental structure—hence the term *adaptive* toolbox. The match between a heuristic and an environment is the subject matter of the study of ecological rationality.

According to Gigerenzer (2019), *recognition* is a core cognitive capacity that the recognition heuristic exploits to make inferences under limited knowledge. In the case of the choice between two alternatives, the heuristic is: *If one of two objects is recognized and the other is not, then infer that the recognized object has the higher value with respect to the criterion*. This heuristic is ecologically rational in situations with high recognition validity. It makes a bold prediction that no other theory has made: the existence of less-is-more effects. The goal is to make inferences about a criterion that is not directly accessible to the decision-maker, based on recognition retrieved from memory. For two alternatives, the heuristic is defined as (Goldstein and Gigerenzer 2009):" … If one of two alternatives is recognized and the other is not, then infer that the recognized alternative has the higher value with respect to the criterion". The higher the recognition validity α for a given criterion, the more ecologically rational it is to rely on this heuristic and the more likely people will rely on it. For instance, people who know less about a topic may make systematically more accurate predictions in comparison with others who know more. This occurs when the recognition validity > knowledge validity; the conditions are specified in Gigerenzer and Gassamaier (2011) The recognition heuristic can be generalized to choice between more than two alternatives, where it describes the creation of consideration sets (Gigerenzer 2019).

Whereas recognition and fluency heuristics base decisions on recognition information, other heuristics like one-reason-based ones, rely on *recall*. One class looks for only one "clever" cue and bases its decision on that cue alone. The other involves sequential search through cues, and while it may search for more than one cue, it still bases its decision on one cue only. Examples include lexicographic rules, and elimination-by-aspect (Tversky 1972). The take-the-best heuristic is a model of how people infer which of two alternatives has a higher value on a criterion, based on binary cue values retrieved from memory. The ecological rationality of take-the-best has been studied in various situations. Taken together, these results suggest two structures of environments that take-the-best can exploit: high cue redundancy and high variability in cue weights (Gigerenzer and Gaissmaier 2011).

4) At the beginning of the COVID-19 pandemic, the situation was characterized by epistemic uncertainty resulting from ignorance of the virus's mechanisms of action, pathogenicity, immune response of the body, duration of the disease and duration of immunization, etc. At first, symptoms like fever, coughing, headache and pulmonary complications led to the conclusion that it was some form of seasonal flu. In Hubei, China, in November 2019 those who questioned this hypothesis

> and theorized that this was a new viral infection were invariably silenced. Later, in February 2020 in Italy, despite the epidemic underway in the province of Hubei (where by now the coronavirus infection had been recognized and assigned the acronym COVID-19) medical operators in healthcare environments continued to diagnose the flu to patients presenting these flu-like symptoms. Similarly, other European countries also underestimated the virus after the outbreak of the infection in Italy. In all these situations, which were characterized by uncertainty and ignorance of the real infectious situation, health decisions were made not in an analytical way but rather through the intuitive heuristic recognition of the flu pattern in the symptoms and the season in which they occurred. Indeed, until February 2020 even the WHO struggled to acknowledge the seriousness and specificity of the situation and the pandemic nature of the contagion because recognition mechanisms leaned towards less dangerous alternatives, like SARS and MERS.

This first phase of ignorance about the mechanisms of the disease that was starting to spread was followed by the next, in which the existence of COVID-19 was finally acknowledged, the virus isolated, tests were run to identify patients who had contracted the infection, and the fight to find effective treatments and save lives began. In this situation, when epistemic uncertainty remained significant but less so than before, the symptomatology of lung disorders was regarded as highly redundant and of higher value than other conditions (high variability). The dramatic clinical evidence of respiratory failure and the emergence of pulmonary thickening in CT scans in the case of COVID-19 infections were cues that lead one-reason decision-making based on the recall of interstitial pneumonia as the cause of the severe respiratory failure generated by COVID-19. On the basis of this diagnosis, the therapy that was initially developed mainly consisted of respiratory assistance. But reality, unfortunately, was quite different (Boraschi 2020). When the body first encounters a virus or a bacterium, the immune system ramps up and begins to fight the invader. The foot soldiers in this fight are molecules called cytokines that set off a cascade of signals to cells to marshal a response. Usually, the stronger this immune response, the stronger the chance of vanquishing the infection. But in some cases —and one is COVID-19—the immune system keeps raging long after the virus is no longer a threat. It continues to release cytokines that keep the body on an exhausting full alert. In their misguided bid to keep the body safe, these cytokines attack multiple organs including the lungs, liver and kidneys, and may eventually lead to death. In these people, it is the body's response, rather than the virus, that ultimately causes harm. There are many variations on the phenomenon, and they go by many names: systemic inflammatory response syndrome, cytokine release syndrome, macrophage activation syndrome, hemophagocytic lymphohistiocytosis. Broadly speaking, they are all marked by an unbridled surge in immune molecules, and may all result in the fatal shutdown of multiple organs. How and Why? The cytokine storm damages in particular the endothelium of the blood vessels of the various organs, specifically the lungs, causing thromboembolism and widespread intravascular coagulation, again especially in the lungs. In other words, COVID-19 damages the blood vessels and the cardiovascular system, and venous microthrombosis in the lungs causes respiratory failure, not interstitial pneumonia (Wang et al. 2020; Tang et al. 2020).[2] Consequently, the therapy must include platelet antiaggregators against microthrombi as well as antirheumatic and corticosteroids against cytokines. And yet, a hasty heuristic focused on interstitial pneumonia initially reduced the therapeutic possibilities and resulted in thousands of deaths that could have been prevented.

What lesson do we learn from these events? In conditions of epistemic uncertainty, when the environmental task is highly complex as is the case with COVID-19, the use of recognition and one-reason decision-making does not always lead to ecologically rational results. This is mainly because without a more careful analysis of cues, it is difficult to recognize or recall the highest redundancy and variability that rationally justify the use of heuristics. Recognizing the disease or recalling a reason to set a clinical and therapeutic course for treatment, in an intuitive and non-analytical way, entails the risk of focusing on marginal or erroneous aspects of the phenomenon. In these cases of ignorance, uncertainty and complexity, less-is-more does not apply. The preferential choice of pneumonia as the cue on which to base the clinical decision was incorrect because it was not redundant (it could not be linked to other inflammatory symptoms at the cardiac, hepatic, renal and intestinal levels) and it did not fulfill high variability (it was not the cue with the highest value among all the symptoms). Moreover, respiratory failure was generally due not to interstitial pneumonia, but to microthrombosis in the lungs. In the case of COVID-19, the most redundant and highly variable cue is widespread intravascular coagulation caused by the cytokine storm, a fact that allows ecologically rational and broad-spectrum decisions to be made on patient treatment without focusing on the pulmonary condition only. It is redundant because it is connected to most symptoms in the lungs, heart, liver, kidney and intestines. It fulfills high variability because its symptomatological value is much higher than all the other symptoms (Wang et al. 2020; Tang et al. 2020)

Lastly, let us consider the response of governments to COVID-19. In some cases the recognition heuristic has been decisive in attributing the initial phases of the disease to a seasonal flu. Donald Trump andJair Bolsonaro have been, up to very recently, insisting on this misguided attribution, and this weakened the public health responses of the two countries and allowed the infection to spread.[3] In other countries, like South Korea, the recognition heuristics led the government to classify the disease as similar to MERS, with which COVID-19 shares the same coronavirus class, and to take immediate and effective measures to contain the epidemic. In this case, the recognition heuristics has proven to be ecologically rational.

[2] Reference to this evidence: https://onlinelibrary.wiley.com/journal/15387836/covid19.

[3] Other behavioral phenomena can explain the ecologically irrational decisions of leader as Trump: optimistic bias for the future; illusion of control of risk variables; wishful thinking that the reality will be as he prefers it must be; status quo bias not to change the current government plans and programmes; present day bias and time discounting because the minor current economic losses from lockdown have more value that the bigger future economic losses without lockdown (not to consider the deaths).

Complaints with ethical standards

Conflict of interest The authors declares tha they have no conflict of interest.

References

Boraschi P (2020) COVID-19 Pulmonary Involvement: Is Really an Interstitial Pneumonia? Acad Radiol. https://doi.org/10.1016/j.acra.2020.04.010

Gigerenzer G (2019) How to Explain Behaviour? Top Cognit Sci. https://doi.org/10.1111/tops.12480

Gigerenzer, G., P.M. Todd, and the ABC Research Group (1999) Simple Heuristics that make us smart. Oxford University Press, New York

Gigerenzer G, Gassamaier W (2011) <<Heuristic Decision making>>. Annual Rev Psychol 62:451–482

Goldstein DG, Gigerenzer G (2009) Fast and frugal forecasting. Int J Forecast 24:760–772

Jani A (2020) Preparing for COVID-19's aftermath: simple steps to address social determinants of health". J Royal Soc Med. https://doi.org/10.1177/0141076820921655

Savage LJ (1954) The Foundations of Statistics. Dover, New York

Todd, PM, Gigerenzer, G., and ABC Res, Group (2011) Ecological Rationality: Intelligence in the World. Oxford University Press, New York

Tversky A (1972) Elimination by aspects: a theory of choice. Pschol Rev 79:281–299

Tang N, Li D, Wang X, Sun Z (2020) Abnormal coagulation parameters are associated with poor prognosis in patients with novel coronavirus pneumonia. J Thrombosis and Haemostasis. https://doi.org/10.1111/jth.14768

Viale R (2020) Handbook on Bounded Rationality. Routledge, London

Wang BS, Xiaoying Gu, Guan L, Wei Y, Li H, Xudong Wu, Jiuyang Xu, Shengjin Tu, Zhang Yi, Chen H, Cao B (2020) Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet 395:1054–1062. https://doi.org/10.1016/S0140-6736(20)30566-3

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.