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THE PHILOSOPHY OF EXPERTISE IN THE AGE OF MEDICAL INFORMATICS: HOW HEALTHCARE TECHNOLOGY IS TRANSFORMING OUR UNDERSTANDING OF EXPERTISE AND EXPERT KNOWLEDGE?

Abstract. The unprecedented development of medical informatics is constantly transforming the concept of expertise in medical sciences in a way that has far-reaching consequences for both the theory of knowledge and the philosophy of informatics. Deep medicine is based on the assumption that medical diagnosis should take into account the wide array of possible health factors involved in the diagnostic process, such as not only genome analysis alone, but also the metabolome (analysis of all body metabolites important for e.g. drug-drug interactions), microbiome (i.e. analysis of all bodily microorganisms interacting with host cells) or exposome (analysis of all environmental factors triggering potentially harmful cell mutations, such as UV radiation, heavy metals, various carcinogens, etc.). Deep data analysis is of tantamount importance for personalized diagnosis but, at the same time, hardly achievable by a regular human being. However, adequately designed artificial intelligence (e.g. a deep neural network) can undeniably be of great help for finding correlations between symptoms and underlying diseases. Nowadays AI applies to nearly every aspect of medicine, starting from the data analysis of scientific literature, through the diagnostic process, to the act of communication between physicians and their patients. Medical image processing algorithms greatly enhance the chances of successful recognition of melanoma or intestinal polyps. Communication tools designed for physicians use techniques known from social media to provide users with an opportunity to consult the case with colleagues from the same discipline. Natural language processing tools significantly improve doctor-patient communication by the automation of note-taking. Is this enough to support the claim that the non-epistemic competences in medicine are becoming more and more important? Can we attribute expertise only to a person? How is medical informatics changing the way most people usually understand human-computer interactions?

Keywords: philosophy of expertise, expert knowledge, philosophy of medical informatics, computers in medicine.

1. Introductory remarks

Undoubtedly, being a renowned health professional, such as a physician, nurse, midwife, physical therapist or nutritionist, has ceased to be a one-person undertaking. It is rather obvious that, in many cases, treating an ailment or combating a disease requires more than just one expert, not to mention a host of mostly anonymous auxiliary personnel, equally important for the whole endeavor. They, in turn, are heavily dependent on e.g. medical imaging devices and expert medical engineers and technicians, who are responsible for the maintenance of these fine-tuned pieces of life-saving equipment. Patients have certainly grown accustomed to the fact that medical experts are no longer lone self-reliant self-sufficient jacks-of-all-trades but deeply interdependent specialists in a rather narrow field of medicine with an even narrower subspecialty. But this in no way alters the deeply-rooted intuitive concept of a medical expert. This type of medicine is still human-to-human interaction, even though sometimes due to time and financial constraints it may become pretty inhumane.

The introduction of Artificial Intelligence (AI) and Intelligence Augmentation (IA) to medical informatics, and subsequently to general medical practice, has altered the concept of medical expertise in a profoundly qualitative way. With the advent of medical AI, experts are no longer fully autonomous concerning both clinical decisions and information they need in daily practice.

Intuitively people think of experts in terms of the knowledge they have managed to obtain in their chosen discipline, and tend to discern expert from non-expert on the basis of proficiency in acquiring, processing and utilizing a certain subset of human knowledge. But what if the sheer amount of information is so exorbitant that no single person can familiarize themselves with it? Or worse – what if the body of information is highly incomprehensible for a human mind, like when it consists of tens of thousands of statistical correlations between a myriad of parameters? It is hardly possible for the human brain to learn that without a meaningful context, i.e. sensible narration full of well-defined objects and based on direct causation. And what if making sense of symptoms requires an enormous degree of attention to details about the patient's nutrition, family history, coexistent ailments, environmental exposure, and at least several other factors? It could be possibly done by a physician but is so time-consuming that no health provider is going to pay for it.

Recent changes in the concept of medical expertise closely reflect changes occurring in the methodology of medical sciences and are direct

consequences of several micro paradigm shifts that have taken place in 20th-century medicine. These are largely ontological shifts with regard to objects of medical inquiry (mostly but not exclusively disorders and diseases), the nature of causality, and the role of context in medical research. Ontological shifts have in turn epistemological and methodological consequences. The two most important for the present discussion are the concept of medical knowledge and the closely related concept of medical expertise.

An essentialist acontextual and causal concept of disease is certainly still very useful in an operational sense when it comes to diagnosing and treating certain groups of diseases, but at the same time, it is money- and time-consuming, not to mention utterly ineffective, in cases involving a host of others, such as many heart diseases, most types of cancer and a majority of mental disorders, to name just a few examples. The so-called complex diseases are predominantly multi-causal and highly context-dependent, which makes them an ideal research subject of personalized medicine. When a physician is dealing with a complex disease, literally every case is different. And in order to make sense of this complexity, a medical expert needs a lot of data, lots more than they are able to process directly. This is why e.g. personalized oncology offers a lot of promise in treating rare cases of cancer but requires a physician to cooperate with a medical AI in the process of working out an optimal combination of radiotherapy, chemotherapy and interventional surgery.

Philosophical problems generated by the medical informatics can strongly contribute to the discussion about the concept of the informational worldview, especially influencing the debates about the notion of information and automation. According to Stacewicz, the informational worldview (IWV) requires both technological and philosophical awareness. Understanding the function of data processing devices (technological awareness) is just a starting point for the conviction that information processing has some abstract components, independent from the concrete physical realization of data-processing unit (philosophical awareness). Moreover, both technological and philosophical awareness are claimed to have cognitive, axiological and practical components (Stacewicz, 2016). IWV may also support the belief that the concepts of information and automation are a common factor important for both silicone-based and protein-based computation. After all, medical informatics is the area of research involving the interaction between natural, artificial and hybrid computational systems.

The paper is structured along the main concepts distinguishing the classical intuitive approach to expert knowledge from the personalized medicine point of view. The author has no intention to claim that the deeply-rooted

intuitiveness of expert knowledge is just a mere illusion or a systematic bias originating from the inadequate understanding of the cognitive processes of experts. Quite the contrary, the paper aims to raise awareness that modern technology has fundamentally transformed the way most medical experts train their intuition to the point where it is no longer possible to solely rely on the personal intuition. It may be possible that expertise is not just the attribute of the single person but an attribute of a person functioning in the intricate social context, where feedback from other experts, non-experts, and AI is not an exception to the rule but the established norm, a new kind of intuition is formed. It is still personal but cannot be activated by the person alone due to the fact that it requires substantial community feedback.

Each chapter of the paper describes a technological phenomenon that, in author's humble opinion, constitutes a substantial alternation of a classical intuitive approach to expertise in medicine. Firstly, the concept of dispersed expertise is discussed to highlight the fact that crowd-sourcing and social media applications may help to reduce some types of bias, e.g. anchoring or confirmation bias. Secondly, the subject matter of the paper shifts towards the competences delegation and technological advances which may be helpful in the process. Thirdly, the focus point is on the improvement of expert decision due to technologically-based cognitive off-loading strategies. Last but not least, the paper analyzes non-cognitive and semi-cognitive skills of an expert, such as social and interpersonal skills, forming a hypothesis that the development of new technology may deeply influence the ideal set of skills of an expert to the point where knowledge may no longer play the first fiddle. Finally, the field of mental health deserves special mention for the sake of illustrating that pre-analyzed big data really matters and, in some situation, may provide invaluable information about patient's activity outside the clinic. After all, modern medical expertise tries to transgress the clear-cut clinical cases looking to shed light on the intricacies and interdependencies of individual cases.

The purpose of the presented paper is twofold. Firstly, to produce a representative review of scientific literature describing how modern technology alters the concept of expertise and expert knowledge. Such a review is certainly not an exhaustive one but rather aims at emphasizing the most promising trends and tendencies. Secondly, to, at least partially, justify the hypothesis that medical expertise and expert knowledge are no longer conceivable without the concept of context and various interactions between human experts, laypeople and AIs. It is the technological context that re-defines expertise in a way able to bring out new epistemological qualities.

2. Dispersed expertise

The most direct way the rapid development of medical informatics may influence deep alternations of medical expertise is enhanced human-to-human communication. It sounds a bit paradoxical at first, mostly because of the fact that most people associate technological innovation with the de-humanization of a specific realm of life, but this time the direct opposite seems to be true.

Overworked doctors simply love uncomplicated cases, i.e. cases that can be easily diagnosed, rapidly treated, and marked as done during a single visit. When a physician hasn't had a first-hand experience with a certain disorder, there is a high risk their diagnosis will be imprecise or plainly wrong. In a very interesting study researchers compared the first diagnosis of 286 patients with their second and usually final diagnosis. It is rather worrisome that both diagnoses were the same in only 12% of cases. In another 66% of cases the diagnosis needed a serious redefinition and in 22% of cases the final diagnosis was distinctly different from the first one (Van Such et al., 2017). But what to do when the constellation of symptoms is deeply puzzling and cannot be effortlessly ascribed to a known disorder? What if the worst-case scenario really happens and a physician is forced either to make an educated guess (sometimes even a blind guess) or ask for a second opinion? The classical notion of expertise involves a strongly assumed conviction that an expert is nearly fully self-reliant and needs peer assistance only when facing a conundrum of the utmost complexity – the assumption that encourages the physician to guess instead of asking for a second opinion to avoid losing face. Moreover, even in cases when medical experts are willing to ask for a second opinion, they may be severely limited because of the geographical location they are currently in. Not to mention cases when they are not really sure with whom they should consult their cases and asking at random about a mind-boggling patient doesn't seem like a good strategy.

However, there is an easy solution that could potentially greatly facilitate the likelihood of getting a second or even a hundredth opinion in a very short time and without even knowing the person helping us with the diagnosis. There are many applications for medical personnel that greatly enhance communication between experts (Andrews et al., 2017). They are so-called crowdsourcing apps and their strongest point lies in the collective knowledge of their users. Applications like this offer a simple but very powerful solution in case of doubts about the proper diagnosis. If you know the solution it costs only a few seconds to a minute of precious time to respond,

but if you don't it can take many hours until you work it out. A dermatologist confronted with a suspicious-looking but unknown skin discoloration or lesion can post a picture of the skin area and patiently wait for another dermatologist from around the world to respond and share their thoughts about it. It is very likely that at least one of many registered experts has confronted it before and is able to offer a reliable opinion about it. This way of communicating is definitely easier than sending an email or picture message because it doesn't require the user to know a knowledgeable person willing to help. After all, how could they possibly know who of their colleagues have experienced a similar case and who have not? Posting it makes it publicly available and accessible to anybody willing to help.

There are even initiatives involving the recruitment of the general public to help with the diagnostic process. But what is the point of that, if they are not expert physicians? Well, laypeople usually have more time for research than a typical medical practitioner. In the medical world, it is not uncommon to hear of a patient who has pinpointed their illness far better than the medical experts they have been referred to. Why? Because in the time of open-access internet medical publications and search engines, anybody possessing a minimal knowledge can google their symptoms and compare their friend's case to hundreds or thousands of similar cases described in posts on a variety of internet fora. Literally anybody can navigate through medical journals and find something meaningful by just reading abstracts or even titles of published papers. Doctors surely know better what to look for but, at the same time, they rarely have the advantage of time. According to a recent study, 397 cases of mysterious illnesses were completed. These patients previously visited a median of 5 physicians, incurred a median of US\$10,000 in medical expenses, and had symptoms for a median of 2.6 years (Meyer et al., 2016). There is even an initiative to encourage medical researchers to add two types of abstracts to their papers – one addressed to experts and one aimed at a lay audience willing to just scratch the surface and use it for their personal research.

The very idea of recruiting laypeople for scientific research seems to be quite prolific in many other areas of expertise, such as astrophysics or bioinformatics. In some cases, laypeople can help scientists even without making a considerable effort, like in the case of the popular multiplayer game Foldit, where solving a puzzle for sheer enjoyment is helping scientists to discover stable patterns of protein folding (Cooper et al., 2010).

Undoubtedly, any burst of boundless enthusiasm for crowdsourcing medical apps is definitely premature because of the urgent need for a thorough and extensive evaluation of the potential risks associated with it. How-

ever, if the promise of their creators proves to be even partially true, it could revolutionize the way we think of medical experts and expertise in general. Crowdsourcing medical apps may mark a transition from person-centered expertise, subject to all the biological and psychological limitations of an individual human, to dispersed expertise which is a property of an interconnected system involving both people (experts and laypeople alike) and assisting computer programs.

3. Delegated competences

How much of a medical expert's time is actually fully devoted to activities requiring expert knowledge and which are not just another mundane task, which could be done by a non-expert or a computer? The first thing that usually comes to mind is paperwork. It is plainly obvious that physicians waste a lot of precious time on filling in countless forms and taking handwritten notes, which, despite their best intentions, are often indecipherable even for themselves. And even if they are computer-literate enough to take notes using computer programs, it usually takes so much time that all that is left are two or three minutes for examination and doctor-patient interaction. In most developed countries the average duration of a medical consultation is between 15 (Argentina) and 8 (Great Britain) minutes, with some notable exceptions on both ends of the spectrum, such as Sweden (20 minutes) or China (a hardly imaginable 2 minutes) (Rodríguez Torres et al., 2018). This is certainly too short to make good notes, perform an extensive examination and even initially bond with the patient.

Nowadays, being an actual expert in general, or a medical expert in particular, involves more and more delegation skills. The lightning-fast advances in all aspects of human knowledge make total self-reliance an obsolete if not downright odd concept. Interestingly, delegating has become a skill in its own right, while knowing what can be delegated and to whom requires both knowledge and intuition, i.e. it is a field of expertise in itself. So why not delegate note-taking and save innumerable office hours for direct conversation with the patient? Delegating it to a person could prove to be fatal. Not only because the presence of another person in the room may disrupt the atmosphere of privacy during a consultation, but also it generates additional costs to be covered. Contrary to people, natural language processing programs take notes automatically and process them to improve readability and reduce redundancy at the same time (van Wyk & van Ryneveld, 2018). Those notes need only minor revision requiring a fraction of the time needed

for unaided note-taking, not to mention an advantage which is easily overlooked: such programs force the physician to be very precise in both asking and answering questions, leaving no room for wordiness, incomprehensible mumbling or just plain verbal impoliteness.

4. Cognitive offloading

But the cognitive offloading of medical experts can be also performed even more directly than in the case of automated note-taking. The advances in the blossoming field of digital image processing make it possible to offer some substantial assistance in offloading overworked dermatologists and radiologists.

Undeniably, the strongest point of a radiologist is pattern recognition, i.e. something modern neural networks excel at. A single X-ray can be an invaluable tool in determining the right diagnosis but only when enough attention is paid to the details. A chest X-ray can reveal a potentially cancerous mass, a nodule, pleural effusion, pneumothorax, cardiomegaly, pneumonia and dozens of other medical problems. And if an average radiologist examines about 20 thousand X-rays each year, it is no wonder that they can extract invaluable information from minuscule details in no time. After all, good intuitive judgment is one of the crucial characteristics of an expert and thought by many to be distinctively human. Many people when asked about the crucial differences between a computer and a human would certainly claim that it is not declarative knowledge but intuition that is more distinctive for a human being. But intuition must also be learned and can be learned both by the human mind and, in an ever-increasing number of cases, by an artificial neural network. The initial results are so promising that many physicians are asking bluntly whether radiologists have any future prospects at all or when radiologists will be replaced by neural networks? (Langlotz, 2019)

The feverish excitement about the future of computer vision in radiology is powered mainly by the increasing performance of diagnostic systems that, in the field of radiology, are claimed to have achieved competences comparable to a human expert. Even in the very moderately optimistic version of the technological future, computers will maybe not entirely replace radiologists but surely offer them substantial feedback to either support their human judgment or prevent people from making simple mistakes caused by cognitive overload, time constraints, sleep deprivation or a multitude of cognitive biases, such as confirmation bias or representation bias. It is suggested that

the interpretation of chest X-rays by a deep convolutional neural network is accurate in about 95 percent of cases (Halligan & Plumb, 2019) – a result rarely achievable by a human radiologist, especially working on a night shift and under enormous time pressure.

In a similar manner, various computer algorithms can be used for early screening of skin cancer. Using a smartphone app to decide whether the skin lesion is serious enough to pay a visit to the dermatologist's office could possibly revolutionize the prevention of melanoma, basal cell carcinoma and many other less serious skin cancers. But prevention is only one of many possible applications of neural networks in dermatology. Computer algorithms could also prove to be an equal partner in the diagnostic process. A recent review of the deep neural network's performance in the field of dermatology demonstrated that neural networks have achieved a human-level performance in several diagnostic categories and even outperform humans in the classification of non-standard variants of skin cancer, i.e. those where the simple diagnostic heuristic ABCDE (**a**symmetry, **i**rrregular **b**order, **c**olor, **d**iameter, and **e**vidence of growth) is of limited practical use (Esteve et al., 2017).

Sometimes the working strategy may even be based on the web searches of potential patients. In one study researchers have assumed that people's online activities can yield clues about their emerging health conditions. Anonymized web query logs of patients looking for diseases matching their symptoms before and after they were diagnosed brought surprising results. In about 5% to 15% of cases, it was possible to link patterns of queries in search logs with a later diagnosis of pancreatic adenocarcinoma (Paparrizos et al., 2016).

The above-mentioned examples of computer-assisted medical diagnostics undeniably shed new light on the rapidly evolving concept of medical expertise. Contrary to some popular beliefs fueled by mass media, AI will surely not replace medical experts in the immediate future but is certainly going to deeply transform most medical professions. AI easily outperforms humans in well-defined tasks (Buch et al., 2018) but is not very helpful when it comes to the creative side of medicine. Digital image processing is an invaluable resource in the hands of an experienced clinician whenever it is used as an additional and not the sole diagnostic tool.

Neither knowledge nor experience is nowadays an exclusive characteristic of a medical expert. Neural networks are honing their diagnostic skills using tens of millions of scans (i.e. at least two orders of magnitude more than the typical physician has seen in their whole medical career) and have access to databases containing an amount of medical information beyond

the reach of even the best human experts. And still, the total replacement of medical experts by computers seems to be very unlikely. Why?

First of all, expertise is not only about knowledge. World-class physicians are surely knowledgeable experts, but perhaps more importantly, they possess the gift of extrapolation and know how to make an educated guess on the basis of very limited data. They are able to connect distant areas of medical knowledge to create a full picture of the disease. Unlike the praised neural networks, a human expert is more of a generalist than a specialist, i.e. they are able to use insights outside their area of expertise. The second reason involves emotional intelligence and communication skills. After all, computers are still not terribly good at communicating with people.

5. Social skills

As mentioned before, the distinction between what to do (goal setting) and how exactly to do it (the pursuit of the objectives) is of utmost importance for the concept of expertise. Even if a neural network has superior diagnostic competences and could outperform every physician both qualitatively and quantitatively, there is still a lingering question about the above-mentioned distinction. In other words, neural networks can be used to confirm or revisit the diagnosis of a human or maybe provide some clue as to whether one should seek the advice of an expert physician, but are still not competent enough to diagnose something completely unknown. However, it is very reasonable to expect that in the near future cloud-based diagnostics systems similar to IBM Watson Analytics will also outperform humans in general diagnostics, i.e. using patient data to diagnose an illness without any prior knowledge about its specific nature, such as myocardial fibrillation or melanoma. Does this mean the end of human medical experts? Certainly not.

Among many other easy- or difficult-to-automate competences are the social skills of an expert. The way the physician communicates an illness to their patients, or even apparently meaningless small talk, are both important parts of the human side of medicine. Medicine is not only about correct diagnosis and effective treatment but also about comforting, supporting and giving hope, i.e. social skills, which are many times more difficult to automate than the diagnostics. After all, communication with patients requires a lot of empathy, highly developed emotional intelligence and mindreading skills to name just the most important skills. It also means that cognitively offloaded physicians of the future could have more time for social

interaction and communication with the patient – something most modern physicians can only dream of (Topol, 2019, pp. 283–310). The probability of such an optimistic scenario is rather hard to assess right now but only 3.8% of the respondents of a Global Physician Survey think that future technology would make their job completely obsolete (Doraiswamy et al., 2020).

6. Mental Health Revisited

Most mental disorders are extremely complex in terms of causal explanation, i.e. they have high phenotypic variability, partially vague diagnostic criteria and a significant overlap ratio. Exploring individual differences of mental disorders requires taking into account both genetic and non-genetic variation, not to mention the multitude of interactions between the two. Mutation-selection balance is just one topic, which, in most cases, needs to be supplemented by mutation-drift balance and at least some dose of balancing selection. Unsurprisingly, most mutations have neither directly beneficial nor outwardly deleterious phenotypic consequences, but remain, so to speak, dormant, potentially able to be transformed either way by a future mutation event. It makes no two cases exactly alike and always leaves an unexplored area of additional factors contributing to a disorder in only some individuals. Balancing selection is an equally important concept encompassing factors such as heterozygote advantage (i.e. cases where a particular mutation in a homozygote is deleterious but, at the same time, clearly beneficial for a heterozygote), sexually antagonistic selection and various forms of spatially variable selection, temporally variable selection and frequency-dependent selection. Additionally, there is a lot of non-genetic variation resulting from various manifestations of evolutionary conflicts, such as sexual conflict, parent-offspring conflict or even pathogen-host conflict. Last but not least, the importance of variation coming from different ecological and social niches is also worth mentioning (Del Giudice, 2018, pp. 68–95).

A single visit to a psychiatrist's office is not representative and very susceptible to the framing effect and other cognitive biases. But even continuous evaluation is made in an artificial environment due to the fact that the physician has little or no knowledge of patient behavior outside the clinic or his/her office. For obvious reasons, self-reports are often subject to various forms of bias, such as hindsight bias, where patients tend to perceive events that have already occurred as more predictable than they were before the events took place. Patients formulate *ad hoc* hypotheses about

their past behavior and, as a result, may not be a very reliable source of information about their own social lives. Even if they were, they could overlook some minor but clinically important details. For the above-mentioned reason, successful diagnosis should be founded upon a large data set, which, in turn, can be obtained only through constant monitoring of the patient's behavior. Social media could prove to be an effective data-gathering tool, if used efficiently.

In some cases, simply providing more detailed data can enormously facilitate diagnosis. Digital phenotyping of mental disorders is a strategy based on extensive analysis of patient-generated data. Constant monitoring and computer-measurable criteria make it a promising approach whenever traditional therapies fail due to limited data. A recent study of digital voice phenotyping revealed interesting connections between voice parameters and diagnostic criteria of major depressive disorder (Or et al., 2017). By using audio and video data provided by smartphones, scientists could scrutinize various aspects of speech (prosody, volume, vowel space, word choice, length of phrases and coherence), voice (its valence, tone, pitch and intonation), hand movement (reaction time, attention, hand-eye coordination), facial expression (emotion, tics, smile length, eye movements, eye contact) and innumerable additional parameters, such as: heart rate variability, skin temperature, blood pressure, breathing pattern, posture, etc. (Topol, 2019, pp. 165–182). A similar strategy was previously applied to predict psychosis onset and proved moderately promising (Bedi et al., 2015).

Digital phenotyping and big data could be, at least partially, a remedy for the low replicability of diagnoses concerning some quite heterogeneous mental disorders, such as schizophrenia spectrum disorder (SSD). Schizophrenia diagnostic tools are widely claimed to be rather inaccurate and highly susceptible to confirmation and anchoring bias. In a recent study where mental health clinicians were asked to assess the prevalence and supposed reasons for inaccuracies in schizophrenia diagnosis, nearly 53% of the respondents reported encountering instances of schizophrenia being diagnosed even if the clinical presentation did not match standardized diagnostic criteria. Even more worrisome is the fact that as much as 73% of senior psychiatrists admitted diagnosing schizophrenia in patients contrary to the opinions of their junior colleagues, and 15% of them declared it to be a frequent occurrence (Tzur Bitan et al., 2018). Having the patient's digital phenotype created on the basis of their mental health history, social media activity monitoring and sometimes invaluable self-reports may eliminate some guessing and stereotyping in the diagnostic process.

How useful digital phenotypes could be was partially demonstrated by a pioneering attempt to classify depression subtypes. Magnetic resonance imaging scans of nearly 1200 patients, 40% of whom were previously diagnosed with some form of major depressive disorder (MDD), contributed their data for a large-scale machine-learning experiment. AI analyzed signal fluctuations from 258 distinct brain regions and, to the awe of many researchers, revealed the existence of four unique depression subtypes. Two depression biotypes (subtypes 1 and 3) were demonstrated to arise due to the abnormal electrical activity of some neuron groups and assumed to be treatable by transcranial magnetic stimulation (TMS), which, indeed helped nearly 70% of the patients with those two biotypes (Schnyer et al., 2017). Before the application of machine-learning and the big data approach, the aforementioned biotypes were diagnostically merged into one arbitrarily delineated block encompassing different units requiring unique therapeutic tools.

Worth mentioning also are reports about the possibility of utilizing AI as part of behavioral therapy or for suicide and depression prevention. It may sound a little bit paradoxical but there is some promising but rather inconclusive evidence that talking with a computer bot could potentially be a viable option for people with both exogenous depression and some forms of major depressive disorder (MDD). It is a popular and rarely questioned belief that talking with a real empathic human being is of great therapeutic value, especially when the other person is a trained therapist. However, there is also a different side of human nature. The so-called social brain, i.e. the connections between the dorsolateral prefrontal cortex (DLPFC), orbitofrontal cortex (OFC), anterior cingulate cortex (ACC), amygdala and superior temporal sulcus (STS), responsible for recognizing and evaluating other people's mental states, such as intentions, desires and beliefs, usually impedes total openness toward other human beings and creates a less genuine but more socially appropriate version of the patient's inner life. From an evolutionary perspective, pretending to be a slightly different person than in reality is a natural defense mechanism which human beings apply when encountering a stranger or a person who cannot be trusted. The social brain utilizes fast and frugal heuristics to assess other people in social situations and that, in turn, strongly contributes to the inherently judgmental nature of our species. Deep inside, patients are aware that even a certified therapist cannot be fully trusted due to the fact that no matter how they try, they cannot escape subconsciously passing judgment on the patient. Being aware that we are not having a conversation with a real person but with a bot could paradoxically improve

openness and sincerity in an unforced way. Freely expressed thoughts and beliefs could also increase the patient's self-awareness and willingness to disclose deeply held negative thoughts, and relieve social anxiety before the subsequent step, such as a visit to a real psychiatrist's office (Lucas et al., 2014).

7. Conclusion

The unprecedented development of medical informatics is a good starting point for the revision of the concept of expertise. Nowadays, being an expert involves both epistemic and non-epistemic competences forming an intricate net of mutual dependencies. Among epistemic skills, factual and procedural knowledge are neither the only nor the most important competences. Equally crucial are the abilities to delegate some activities to both human and computer agents and to cooperate in a large group of experts representing various fields of expertise. Generally, this concept can be described as dispersed expertise. Non-epistemic skills consist of emotional intelligence, mindreading and effective communication – all of which define expertise in its social context.

The rapid development of AI in medicine could deeply redefine the typical diagnostic process. Closed unidirectional information flow from the physician to the patient, where most of the time the patient is just a passive observer, could be substituted by an open multidirectional information system, where both the physician and the patient, together with the patient-relevant data on social media, are active participants supervised by the AI. Big data tools enabling multisource information about the patient support the human-computer-interaction-based dispersed expert system, transgressing the typical limitations of a human-based health care. Narrow analysis of complex cases usually limited to just one medical specialty can be reformed into social-media-based case conferences of many specialists from all over the globe, where each one need not contribute more than a few minutes of their precious time. Transparent data presentation and fully AI pre-analyzed medical records are able to significantly limit the waste of time associated with the analysis of incomplete patient records. Severe time limitations and availability bias could become less important if all the data were pre-analyzed, compared with the global case database and edited to remove unnecessary repetitions, ambiguities, and some forms of human bias.

Nevertheless, just like every other tool, medical AI solves many dilemmas but simultaneously creates some problems of its own. Just like peo-

ple, AI is susceptible to the representativeness heuristic, and its effectiveness strongly depends on the quality of data provided for analysis. It is simply useless without adequate data-gathering tools and free-access databases. Proper data interpretation is also of crucial importance due to the fact that there is no such thing as raw data. Data must be pre-selected and assessed for material errors, i.e. cases where data were improperly gathered or simply falsified. Just like every product on the market, an AI expert system could potentially fall prey to vested interests of software manufacturers, the pharmaceutical industry, various medical lobbies or insurance companies. To develop its full potential, it needs proper legal regulations governing the access to patients' data and preventing the use of those data for anything other than the diagnostic and therapeutic process. Psychological aspects are also crucial. How should we deal with the excessive (patients) and insufficient (physicians) trust in AI in medicine? How can we prevent overenthusiastic patients from ignoring their doctor's advice when it contradicts the preliminary diagnosis of a computer bot? And how do we convince health experts to accept the fact that most of the time artificial neural networks are black-box systems, unable to explain how they come to the final conclusion? These are only some of the issues to be addressed in the immediate future (Matuchansky, 2019).

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