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How Medical Diagnosticians Earn their Stripes: Horses, Zebras, and Divergent Thinking

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Abstract

The acquisition of medical expertise is a rigorous endeavor that involves developing a range of cognitive, technical, and interpersonal skills. While clinical knowledge is routinely tested through written and practical examinations in medical school, benchmarking expertise performance for experienced physicians has proven more challenging. The present article considers the acquisition of medical expertise from candidacy through residency and clinical years. Particular attention is given to the skills that distinguish routine Journeymen medical experts who settle for a lower level of automatic skill from adaptive Experts and Masters, as well as the difficulties in defining the metrics required to distinguish these levels. A model of the physician as both a knowledgeable and creative expert is proposed, drawing from multifactorial models of expertise together with the Four Cs model of creativity at each stage of acquisition. Particular emphasis is placed on divergent thinking, a form of creative problem-solving. The benefits of divergent thinking in medicine are discussed in relation to core cognitive functions supporting the acquisition and maintenance of medical skills, differential diagnosis, cognitive heuristics and biases, and the drive for both personal and social innovation. In particular, a novel argument is put forth for the role of divergent thinking and cognitive flexibility as facilitators of expertise acquisition in the medical field. Recommendations are discussed for the integration of divergent thinking training into the medical selection and training practices to support the development of medical expertise.

Keywords

medical expertise, divergent thinking, convergent thinking, differential diagnosis, diagnostic bias, cognitive heuristics, medical training

Introduction

Medical expertise is one of the most essential skills required to sustain a functional society, and the need for medical experts is equally as great. Medicine provides the backbone for social infrastructure, as good health is necessary for a community to maintain standards of daily living (Bhugra, 2014). In this structure, the role of the medical expert is to provide treatment to those who are ill and to promote the health of those who are well. The crucial role served by medical experts has become particularly pertinent in recent years, between the demands of caring for an aging population and the major disruptions faced across all levels of society by the COVID-19 pandemic (Haldane et al., 2021). To this end, societies have a vested interest in the continued training of medical professionals to support the health and development of their communities (Bhugra, 2014).

In defining the scope of medical expertise, it is necessary to establish the ways in which expertise is relevant to medicine, as well as what is meant by “expertise.” Expertise is defined as “peak” or “exceptionally high level of performance on a particular task or within a given domain” (Bourne et al., 2014) and may differ from a clinician’s total years of experience. That is, although expertise is commonly conflated with “years of experience” in the medical field (e.g., Care Quality Commission, 2024), experience alone does not guarantee that an individual is an expert in their practicing domain (Bourne et al., 2014). Specifically, individuals who achieve peak performance are considered experts in their practicing field, whether that extends to the arts, sciences, or other skill-based activities. In medicine, experts include those who work directly with patients, such as physicians and surgeons, as well as medical researchers responsible for the development of new treatment methods, vaccines, and technology (Ericsson, 2015). This article focuses primarily on the role and expertise of the physician or general practitioner and the skills required to practice medicine in clinical settings.

In common with many areas of expertise, particularly in STEM, medicine requires a long period of extensive study, training, and internship to achieve advanced skills (Ericsson, 2007). In the course of this training, an expert-level cognitive understanding of the domain will be acquired, leading to the accumulation of specialized knowledge, an enhanced understanding of the problem-space in diagnostic challenges, and an almost intuitive capacity to carry out tasks fluently and automatically. In other words, trained practitioners will demonstrate “goal-directed, well-organized behavior that is acquired through practice and performed with economy of effort” (Johnson & Proctor, 2016, p. 2).

Nevertheless, despite the similarities outlined above, medical expertise is relatively distinct from many other forms of expertise acquisition in that it initially involves the development of a broad knowledge base and skill set, rather than focusing immediately upon a core skill or competency. Specialization—for example in surgery, pediatrics, psychiatry, forensic pathology, or general medicine—normally follows after an already extensive period of generalist training, essentially procuring a second, narrower, level of expertise on top of the first. Identifying the drivers of medical expertise is therefore challenging and may depend upon the level of qualification reached and the particular specialty selected.

All the same, a number of core medical frameworks worldwide suggest that physicians must develop a range of hard skills (e.g., motor skills, chart reading, memorization of medical knowledge) and soft skills (e.g., empathy, communication, problem-solving) to achieve professional competence (Caddick et al., 2023; Klein, 2006). For example, Table 1 sets out the four core competencies identified in the UK by the General Medical Council (GMC) embracing a wide range of academic, professional, and ethical requirements.

Table 1. Domains of Good Medical Practice (General Medical Council, 2024)

Domain	Description	Associated skills
Knowledge, Skills, and Development	Providing high standards of medical care and keeping medical knowledge up to date	Hard skills, academic competency, problem-solving
Patients, Partnership and Communication	Respect and work together with patients as autonomous individuals	Respect, communication, empathy
Colleagues, Culture, and Safety	Work collaboratively with colleagues and take action if malpractice is observed	Teamwork, conscientiousness, risk management
Trust and Professionalism	Act with integrity and honesty to promote the health of patients and the community	Honesty, vocational motivation, tolerance for ambiguity

An additional feature that distinguishes medicine from many areas of expertise acquisition is that the opportunity to pursue medicine is highly restricted (Giantini Larsen et al., 2021). Medical school is considered a competitive and prestigious endeavor, and typically only those with a high level of academic aptitude are considered eligible. Although many expertise domains, such as music and chess, are associated with barriers to entry including costs and time commitment, the barriers to studying medicine are particularly extensive.

Following recent multifactorial models of expertise (e.g., Friedlander, 2024; Hambrick et al., 2016), medical expertise might be explored through a wide variety of drivers, including training (e.g., acquisition of knowledge and know-how), aptitudes (e.g., intelligence, problem-solving ability, and creativity), personal qualities (e.g., leadership, motivation, communication, and empathy) and opportunity (e.g., financial support, parental aspirations, and access to education). The present discussion focuses particularly on the training (the "knowledgeable expert") and core aptitudes (the "creative expert") involved in the acquisition of medical expertise, and argues that divergent thinking, a form of creative cognition, may be an underexplored skill in the medical profession. Specifically, the article synthesizes existing research on expertise acquisition with literature on the cognitive underpinnings of creativity in a way that has not been previously explored. Specifically, the article synthesizes existing research on expertise acquisition with literature on the cognitive underpinnings of creativity in a way that has not been previously explored. Typical discussions on divergent thinking in medicine focus on the application of specific deductive reasoning strategies in diagnostic settings, rather than divergent thinking as a criterion for the development of expertise. Moreover, the article also highlights ways in which medical education may overemphasize the role of single-solution, convergent thinking exercises, and argues for increased divergent thinking activities in medical selection and training.

While the article focuses on individual expertise acquisition through a cognitive perspective, it is of course true that medical expertise develops in a collaborative environment between practitioners, colleagues, patients, and technology. That is, a physician's expertise represents not only their individual knowledge and decision-making abilities, but also their development within a shared working environment with other professionals and patients. For example, multidisciplinary team meetings, commonly used in complex cases such as oncology, bring together specialists from diverse fields, including radiologists, oncologists, pathologists, and surgeons. These specialists jointly review patient cases, combining their individual expertise to plan optimal care (Taberna et al., 2020). Future research may benefit from exploring these sociocultural dimensions of expertise acquisition and how divergent thinking can help to support practice in collaborative clinical environments.

Benchmarking Expertise Levels in Medicine

Before embarking on a discussion of the contributors to medical expertise, it is important to define and benchmark expertise in this domain. Expertise in any given domain is considered to exist on a spectrum. At lower levels of the spectrum, individuals may have no knowledge or limited knowledge of the domain. At the upper levels, individuals may be skilled experts or advanced "super experts" in a given field, with other individuals demonstrating skill levels between these ranges. One model to describe the spectrum of expertise suggested by Hoffman (e.g., 2017) describes the stages of expertise from Naïve to Master. A mapping between these stages to the acquisition of medical expertise is proposed in Table 2. Most stated criteria are driven by reputation-based benchmarks (Gobet, 2017), largely resting on the degree of experience, training, certification, and medical seniority achieved in the field. Note that these stages primarily aim to describe the acquisition of medical expertise in the context of formal education and training; in societies without an institutional regulatory structure for medicine, expertise may be recognized in alternative ways.

Table 2. Levels of Medical Expertise, based with interpretation on Hoffman (2017)

Level	Definition	Medical Example
Naïve	An individual who is inexperienced or unknowledgeable about a field or domain	Member of the general population
Novice	A beginner with early introduction to the field or domain	Medical school candidate who has received admission into a medical program
Initiate	A novice with some level of introductory instruction in the field or domain	Medical student undertaking coursework
Apprentice	A learner who has received instruction beyond the introductory level and who traditionally assists an individual at a higher level of expertise	Medical student in residency years or early years as an independent physician
Journeyman	An individual experienced in the field or domain who maintains a high level of performance without the need for external supervision; may remain at this level of expertise for the duration of their career	Independent physician with years of applied clinical experience attending to patients and who no longer requires training or supervision
Expert	A distinguished practitioner who demonstrates a high level of performance and niche specialty knowledge in the field or domain	Advanced senior physician whose skill set and knowledge are sought out for difficult cases
Master	An extremely distinguished expert who sets performance standards for the field or domain	Advanced senior physician who spearheads innovation and/or receives international appraisal for their work

At the lowest level of expertise, individuals who are considered Naïve may include members of the general population with limited medical knowledge and training (Hoffman, 2017). While it is not uncommon for individuals in the general population to possess basic medical competencies, such as the ability to treat minor cuts or burns, most individuals have not undergone formal medical training. Prospective medical school applicants also possess a Naïve level of expertise, although these individuals may have undertaken self-study in general areas of medicine. At the Novice level of expertise, medical school candidates may have received successful admission into a medical program and undertaken an initial induction session without receiving specialized training.

During medical school, students achieve the Initiate level of expertise as they acquire knowledge and training from their taught courses. This is followed by the Apprenticeship period of medical residency in which students receive applied clinical training under the supervision of more senior expert physicians. In some contexts, physicians pursuing further specialisms might also be considered Apprentices in their early years of clinical practice: Hoffman (2017) notes that the Apprenticeship stage may last for up to twelve years. However, the typical medical residency period lasts for two to eight years depending on the area of specialization (NHS, 2024; University of British Columbia, 2024).

At the Journeyman level of expertise, a physician is able to effectively diagnose and treat patients without the need for external supervision. Similar to experts in other fields, many physicians remain at this level of expertise for life, despite further years of clinical practice (Hoffman, 2017). On the other hand, a small number of Journeymen may go on to become Experts who are highly regarded in their field for their niche knowledge of or specialty in working with particular types of cases or in particular domains such as family medicine. An even smaller number of Experts achieve the Master level of expertise, such as Michael DeBakey, who pioneered innovative surgical techniques alongside a successful career as a cardiovascular surgeon (Oransky, 2008).

Benchmarking the level of expertise among fully qualified medical practitioners at the higher levels of expertise is particularly challenging. In contrast to other domains, such as sports performance and musical composition, medicine cannot be measured through relatively tangible outcomes, such as outperforming other athletes or producing a complex musical piece, respectively. Indeed, as “performers of human services” (Tannenbaum, 1997), experts in human medicine have no “product” other than the medical outcomes of those in their care. However, attempts to quantify the quality of care of individual practitioners through metrics have been notoriously fraught with difficulties (McEvoy, 2015; World Health Organization, 2019), whether using surgical outcome data (Soppa et al., 2019) or general measures of clinical performance (Trebble et al., 2015). Factors such as willingness to take on high-risk cases, specialty, and the socioeconomic and demographic characteristics of the population served, are widely recognized confounds.

Characteristics of Medical Physicians and Prospective Medical Candidates

On a practical level, the skills and competencies expected of an expert physician are typically defined into two categories: hard skills and soft skills (Iorio et al., 2022). Hard skills refer to knowledge and technical skills that can be trained and evaluated, including the knowledge acquired during pre-residency years of medical school in areas such as anatomy, physiology, and other taught subjects. These skills might also include abilities such as performing specific motor techniques including suturing, reading charts, measuring medication dosages, completing written reports, other routine clerking tasks, and evaluating and attending to patients. Medical students are not expected to develop competence in these domains prior to admission in a medical program (although basic arithmetic or chart-reading abilities might be evaluated during the medical interview) but would be expected to perform these tasks effectively upon completion of their studies.

In contrast to hard skills, soft skills refer to aptitudes and interpersonal abilities such as problem-solving, communication, and empathy, although it has been argued that the distinction between hard and soft skills as unique skill sets may be counterproductive (Iorio et al., 2022). For example, soft skills are argued to include general and fluid intelligence, critical thinking abilities, and working memory capacity, all of which are needed to support the development of other soft and hard skills (Heckman & Kautz, 2012). In general, soft skills are arguably more difficult to train than hard skills, and medical school applicants are often evaluated for these traits during the medical interview (Wray, 2019). For example, during the interview, candidates may be asked to engage with hypothetical ethical dilemmas to demonstrate understanding of morality and ethics, or to interact with patient actors to evaluate real-world communication abilities. In general, an expert physician is expected to uphold the principles set out in Table 1 in all aspects of patient care, and a prospective medical student who demonstrates the potential to develop, understand, and promote these practices is likely a promising candidate for a medical career.

Typically, medical knowledge and associated hard skills are acquired through taught coursework and clinical residency, and the acquisition of these skills is routinely assessed through written and practical examinations. On the other hand, soft skills are typically evaluated in the medical school admissions interview but do not continue to be routinely tested throughout a medical curriculum (Lemay et al., 2007).

Acquiring the “Hard” Skills: The Knowledgeable Expert

Given that students entering medical training programs are not expected to possess clinical-relevant “hard” skills, these are the focus of much of the early years of undergraduate training. Achieving expert-level skill in a field can be explained through Fitts and Posner's (1967) model. This model suggests that Novices acquire and hone relevant skills through training, practice, and consolidation, passing through an initially cumbersome, cognitively demanding phase ("Cognitive"), through a semi-compiled "Associative" stage until finally acquiring an Expert level of "Autonomous" operation (Friedlander, 2024).

As noted above, the sheer extent of information to be acquired means that medicine necessitates a long period of extensive study, training, and internship to achieve high-level performance (Ericsson, 2007). Furthermore, without continuous refinement of skills, experts in all domains might plateau at an arrested stage of skill level (Ericsson & Towne, 2010). This is a particular pitfall in medicine, where skills and knowledge might become rapidly outdated without top-up training. In fact, Mylopoulos and Regehr (2007) distinguish between "routine experts" (i.e., Journeymen), who have settled for a lower level of automatic and unreflective medical skill, and "adaptive experts" (i.e., Experts and Masters), who continually reinvest effort into extending their competence and domain knowledge, using new problems as an opportunity for exploration and learning.

Across all scientific fields, Feist (2013) argues that, as individuals become more deeply immersed in their chosen specialty (whether through self-study, interactions with tutors or supervisors, simulations, shadowing, or direct hands-on experience), their cognitive structures become more defined, explicit, and autonomous. Experts in all domains have accumulated a wealth of domain-relevant knowledge through this type of immersion in the field, storing it in efficient structures tailored to their domain, ensuring rapid and secure retrieval: the "skill-by-structure" theory (Lehmann et al., 2018) or "architectonic" understanding of the field (Friedlander, 2024). As part of this process, the precise categorization labels of their field (for example anatomical, physiological, or pharmaceutical terms) will be acquired, resulting in a highly sophisticated lexical system, and associated recall precision, as shown in Table 3.

Table 3. Characteristics of "Knowledgeable Experts" (Friedlander, 2024)

Expert characteristic	Source
Shows high accuracy in reaching appropriate solutions; judgments are reliable and useful.	Hambrick and Hoffman (2016); Sternberg et al. (2011)
Shows highly efficient problem-solving: when time constraints are imposed should solve problems more quickly than Novices.	Sternberg et al. (2011)
Can effectively manage resources under conditions of high stakes, high risk, and high stress.	Hambrick and Hoffman (2016)
Possesses knowledge that is fine-grained, detailed, and highly organized.	Hambrick and Hoffman (2016)
Has a highly interconnected understanding of a domain - information is not scattered but forms a coherent picture.	Sternberg et al. (2011)
Has large, rich schemas containing a great deal of declarative knowledge together with problem-solving strategies relevant to the domain.	Sternberg et al. (2011)
For routine activities and familiar cases, displays signs of "automaticity" and "recognition-primed decision making," where the expert seems to be carrying out a task without significant cognitive load.	Hambrick and Hoffman (2016)
Has refined pattern perception skills and can apprehend meaningful cues, relationships, and patterns that non-experts cannot.	Hambrick and Hoffman (2016)

Possessing an expert-level schema of expectations can also allow Experts to focus on the most visually salient aspects of a problem, leading to perceptual advantages. Eye-tracking studies of Expert clinicians compared to medical students (Initiates/Apprentices) during the interpretation of electrocardiograms, histopathological slides, or digital laparoscopic simulations have shown that Experts were quicker to fixate on key areas of information, detect abnormalities, and to reach a diagnosis (Gegenfurtner et al., 2013; Jaarsma et al., 2014).

The possession of pre-generated cognitive schemas for straightforward tasks also allows medical Experts to draw from tacit knowledge (Polanyi, 1962) to tackle everyday cases, seemingly bypassing conscious deliberation. This approach can be linked with Type 1 intuitive thinking (Abraham, 2018; Caddick et al., 2023) in contrast to Type 2 (slow, controlled, reflective) thinking. This process is driven by pattern-recognition, allowing for the use of heuristics, mental short-cuts that equip the clinician to draw rapidly on prior experience to make immediate and efficient decisions (Caddick et al., 2023). Although prone to multiple cognitive biases—systematic errors in thinking that occur when interpreting and processing information (Croskerry, 2003, 2015)—heuristics are widely acknowledged to be critical in time-pressured situations, and are commonplace across a diverse range of medical fields (Caddick et al., 2023).

Experienced physicians may also apply Naturalistic Decision-Making, which refers to the process by which individuals apply their experience and knowledge to navigate real-world settings (Orasanu, 2001). Specifically, the Naturalistic Decision-Making model is most often used to describe environments with high levels of time pressure and risk such as medicine, military, and aviation, in which the decision maker's general domain knowledge is crucial to understanding the contextual environment, determining relevant information, and planning a course of action (Klein, 2008; Orasanu, 2001). This approach may enable experienced physicians to make rapid, informed decisions in complex situations when quick judgement is needed.

In recent years, medical education has shifted toward competency-based medical education (CBME), an approach that structures training around the acquisition of core medical skills rather than the length of the training (ten Cate, 2017). Learners advance by demonstrating proficiency in each domain, with the focus shifting to that of systematically "ticking off" or verifying each required skill. This is assessed through multiple formats, including direct observation, simulation, and patient outcome measures. While CBME offers advantages in ensuring the acquisition of baseline competencies, its focus on criterion-based standards may inadvertently inhibit the development of higher levels of expertise. Research suggests that reaching higher levels of medical mastery often requires nuanced judgment, adaptability, and metacognitive problem-solving skills that exceed criterion-based competency checks (Hodges, 2015).

Applying the "Soft" Skills: The Creative Expert?

From the discussion so far, one might be forgiven for thinking that medical expertise is vested solely in the reliable application of pre-learned knowledge: a steady, accurate, well-prepared performance demonstrating the logical application of clinical reasoning to a clearly delimited problem. In other words, the role played by a physician "is fairly clear; there are no creative breakthroughs expected" (Tannenbaum, 2000, p. 26). In this view, it might be argued that a physician who is able to correctly diagnose a patient's condition and prescribe a treatment plan is considered a medical expert, achieving the standards needed to promote the health of their patients (Ericsson, 2007).

Yet no two patients present with symptoms in exactly the same way, and the skills of a physician must be transferable across a range of diagnostic settings (Shuval et al., 2007) and patient contexts. Ericsson (2007) argues that "adaptive" rather than "routine" experts demonstrate their mastery by going beyond routine competencies, exhibiting flexible, innovative abilities that extend their knowledge rather than simply applying it. Indeed, even the process of drawing up a medical hypothesis to fit a patient's symptoms might be considered a creative rather than purely logical process: as Greenhalgh (2001) comments, "the essence of good clinical decision-making is the use of imaginative storytelling—exploring a range of plausible 'endings'—to contemplate (and discuss with the patient) the clinical, ethical, and human implications of different potential options" (p. 818). In science more generally, the formulation of a hypothesis involves an "adventure of the mind" (Medawar, 1964; as cited in Lippell, 2002), at the intersection of knowledge, holistic and intuitive appraisal, and flexibility of thought. Abraham (2018) also notes that while deductive thinking, based on the logical application of an existing premise, may represent the least creative form of reasoning, inductive reasoning involves reaching uncertain conclusions, based on reasonable hypotheses that take the scientist beyond what is strictly known. Meanwhile, abductive thinking ventures into even more creative territories, generating probabilistic hypotheses that go well beyond the presented information (Abraham, 2018; Friedlander, 2024). Both inductive and abductive thinking are fundamental to the process of diagnostic reasoning.

Notably, in medical school, both the initial medical selection interview and subsequent courses encourage candidates to identify single solutions across a range of assessment measures (Cropley, 2006). In creativity literature, these tasks are referred to as convergent thinking exercises because they involve identifying one correct solution (Runco, 2014). For example, medical students are typically trained in models of evidence-based practice, which set out a standardized approach to medical diagnosis and treatment (Glasziou et al., 2008; Lehane et al., 2019; Mullen & Streiner, 2004). In applying these approaches, students are encouraged to filter and synthesize explicit knowledge together with available research to diagnose patients and prescribe the best possible treatment plan. However, these approaches have also been criticized for their narrow definition of evidence, relying primarily on randomized controlled trials (Cohen et al., 2004). While beneficial in achieving a high standard of quality, such studies are few in number and may not always generate replicable findings (Stupple et al., 2019). Evidence-based approaches have also been criticized for diminishing the importance of patients' unique personal contexts and experiences (Barratt, 2008; Cohen et al., 2004; Tonelli, 2006), and likewise "restricting clinical practice" for physicians by downplaying clinical expertise in favor of strict adherence to standardized protocol (Hisham et al., 2016, p. 7).

In contrast, creative thinking tasks that may help to advance the development of expert performance typically aim to assess an individual's ability to identify more than one solution (divergent thinking, DT). Although an argument for assessing soft skills such as creativity and DT in medical education has been suggested for decades, these skills are often not considered during any stage of medical training (Lippell, 2002; Powis, 1994). In recent years, modern approaches to evidence-based practice have sought an integration of the person-centered and scientific perspectives, promoting rigorous evidence-based practices while also bringing attention to the importance of clinical judgment and the need to treat patients as individuals (Braš et al., 2013; Mezzich et al., 2010; Mullen & Streiner, 2004). This approach honors the creative and scientific foundations of medicine, requiring doctors to think flexibly to determine the optimal treatment for each individual patient.

Creativity and Medicine

In what has been referred to as "a riot of divergent thinking" (Abbasi, 2011, p. 1), an increasing number of medical professionals have advocated for formal training in creative thinking as part of the medical curriculum, arguing that such training may prepare students to better handle uncertainty in diagnostic settings (Sandars & Goh, 2020). However, studies on creativity in medical education generally focus on engaging with creative visual or performing arts, rather than DT and creative cognition (e.g., McKinlay, 2017; Thompson et al., 2010). For example, the University of Bristol introduced a creativity module into the standard undergraduate medical curriculum, in which students were assessed for the production of creative output such as paintings or embroidery (Thompson et al., 2010). However, the course objective was to enhance self-awareness and empathy for patients by participating in self-reflection activities (Thompson et al., 2010), rather than training creative thinking skills to enhance clinical diagnosis. Other approaches conceptualize medicine as an "art form." Kneebone (2011), for example, likens operative surgery to stage or musical performance, with medical professionals "playing their parts" as the operation unfolds in "theater" (p. 94).

Yet creativity, particularly in the form of creative cognition, is also inherent in medical expertise: A physician must think creatively to rapidly conceptualize the problem space when attending to patients, whether in diagnostic contexts or emergency settings. For example, a physician may be required to use unconventional tools to deliver a life-saving treatment, such as using a necktie to apply pressure to a wound (Willems et al., 2013). Similarly, a physician must be able to think creatively to integrate information from various sources and draw comparisons with previously acquired knowledge when diagnosing patients in clinical settings (Cook & Decary, 2020). At the highest levels of expertise, the advancement of medical treatments and technology may represent the output of Master-level creative performance.

In line with this, Kaufman and Beghetto's (2009) Four Cs Model of Creativity describes the expression of creativity throughout life from childhood to adulthood, with an emphasis on the role of creativity in an individual's professional career. In this model, creativity is considered a spectrum that encompasses all forms of creative potential, from grand historical feats, such as the discovery of penicillin, to a child's creative interpretations of their daily life experiences (Csikszentmihalyi, 1997; Kaufman & Beghetto, 2009). The Four Cs Model also broadly overlaps with Hoffman's (2017) levels of expertise (Friedlander, 2024), particularly at the Pro-c and Big-C levels, as shown in Table 4. Both models might be argued to form a pyramid structure, with an expansive base representing the large number of non-Expert, mini-c pursuits and the top representing the small number of eminent Big-C Masters within a particular field or domain.

Table 4. The Four Cs Model of Creativity and the Medical Profession

Level	Description	Expertise Stage	Medical Example
Mini-c	Individual who experiences creative perceptions and interpretations of daily life experiences	Naïve, Novice	Acquiring personally new insights into benefits and drawbacks of various palliative care techniques after listening to a guest speaker
Little-c	Individual who engages in small-scale creative pursuits such as painting or sewing	Initiate, Apprentice	Medical students producing medical artwork including poetry, sculpture, and paintings as part of "compulsory creativity" training (e.g., Thompson et al., 2010)
Pro-c	Individuals who have achieved creative expertise in a specific field and whose work may receive substantial peer recognition	Journeyman, Expert	Experienced surgeon to whom referrals for non-routine operations are often made
Big-C	Renowned individuals whose creative achievements have a wide-reaching historical and sociocultural impact	Master	Barry Marshall (Nobel prize winner for *H. pylori* peptic ulcer discovery); Michael DeBakey (pioneering cardiovascular surgeon)

The 4 Cs Model of Creativity in Medicine

The Four Cs model can be mapped onto the medical profession to describe the ways in which creativity manifests with the acquisition of medical expertise. As noted in Table 4, mini-c creativity refers to the creative interpretation of one's inner thoughts and experiences, such as a young person reflecting on medical ethics after a talk or enjoying the sensation of discovery after making the connection between personal diet and health. Individuals with a high degree of mini-c creativity may exhibit traits such as openness to new experiences, tolerance for uncertainty, curiosity and inquisitiveness, and a generally explorative orientation toward the world (Kaufman & Beghetto, 2009), all of which may be beneficial skills for a future physician.

The next level, little-c creativity, refers to a form of non-expert, general creativity marked by the pursuit of small-scale creative activities in everyday life (Kaufman & Beghetto, 2009). Such activities might include interests in cooking or drawing, or even specific technical skills including sewing or participating in a robotics team, that might act as a precursor to motor skills later acquired in medical practice (Simonton, 2013). More generally, individuals with a high level of little-c creativity might seek creative solutions to everyday problems, such as finding novel ways to utilize downtime between their classes. At the time of applying to medical school, prospective applicants may express traits and characteristics related to mini-c and little-c creativity, which can later help aid the development of Pro-c creativity in specialized areas of medicine (Amiri et al., 2020). Future research could explore how cognitive architecture developments—such as cognitive load management and adaptability—facilitate the progression from little-c to Pro-c expertise, particularly in light of findings on the impact of dual-process thinking on physicians' cognitive adaptability over time (Caddick et al., 2023). For example, examining whether and how divergent thinking changes throughout medical school might clarify specific factors that contribute to long-term expertise in medical practice.

The third level, professional or Pro-c creativity, refers to the creative expertise achieved by a physician after years of medical education and training (Kaufman & Beghetto, 2009). In medicine, it is estimated that a minimum of ten years of experience is required to achieve Pro-c creative status, in line with other areas of creative expertise (Kaufman & Beghetto, 2009), and which approximately aligns with Hoffman's (2017) suggestion that the Apprenticeship stage of expertise may last for up to twelve years. This form of creativity might be observed in the ability to generate novel and innovative strategies in various medical diagnostic and treatment contexts (Usha, 2009) and fits well with Hoffman's (2017) suggestion that Experts are those who "can deal effectively with rare or 'tough' cases" (p. 445).

However, as noted previously, the expression of Pro-c creativity may differ depending on a physician's area of specialization. While those trained in cardiovascular health may be sought out for consultation on difficult coronary cases, other physicians may be experts in more general domains such as general internal medicine, family medicine, or emergency medicine, with parallel levels of expertise. Experts may also be able to contingency plan more effectively, recognizing when a standard approach is proving ineffective, and reframing the situation to embrace new approaches and solutions to resolve the situation. Indeed, this is argued to be a particular strength of the Master Adaptive Learners (MAL) approach to medical skill acquisition (Cutrer et al., 2017). The MAL model aims to improve adaptability in real-world settings by encouraging learners to prepare for and respond effectively to unexpected clinical challenges. This includes fostering metacognitive skills such as situational awareness, proactive planning, and flexible problem-solving, which are essential for contingency planning in complex medical environments. This contingency-planning ability is especially valued in high-stakes specialties such as emergency medicine, where time and information constraints are common, and strategic flexibility can significantly affect outcomes. Such approaches help Pro-c clinicians to refine their ability to respond dynamically, rather than following rigid protocols that may not fit unique patient cases.

Specifically, physicians often utilize DT when performing medical diagnosis, in an attempt to distinguish between two or more conditions that may potentially explain the same symptoms, a process which is referred to as differential diagnosis (Cook & Decary, 2020). For example, if a patient who is a chronic smoker presents with shoulder pain, a common cause may be impingement due to overuse or a rotator cuff tear (NHS, 2020). However, a much rarer, although possible cause, given the patient's smoking history, may be a Pancoast tumor, in which posterior shoulder pain presents as the most common symptom (Ronan & D'Souza, 2013), even if an overuse injury is statistically more likely. A physician who has achieved Pro-c creative expertise may consider ordering a chest x-ray for the patient given their smoking history, allowing for early cancer detection and intervention, whereas a little-c physician may refer the patient to physiotherapy, leading to delayed diagnosis. In this way, the Pro-c physician is more adaptable to complex cases even when etiology is uncertain, leading to better care outcomes.

Finally, Big-C creativity represents historically notable individuals who have contributed to significant discoveries or advancements in their field with a wide-reaching sociocultural impact (Kaufman & Beghetto, 2009). Big-C individuals might be equated with Master-level experts in Hoffman's (2017) stages of expertise. For example, advancements in anesthesia, antibiotics, chemotherapy, open heart surgery, and vaccine research represent Big-C creative achievements in medicine (Meyers, 2007; Woolliscroft, 2020). Given the rapid development of medical technology in the past century, major medical discoveries and advancements are often made in dedicated lab environments by researchers with limited clinical experience, in contrast to Pro-c medical physicians. However, a small number of individuals achieve both clinical expertise and Big-C contributions, as noted in Table 4. For example, Australian gastroenterologist Barry Marshall discovered the role of *Helicobacter pylori* in causing peptic ulcers, famously proving his theory by infecting and then curing himself with antibiotics (Kyle et al., 2016). Likewise, DeBakey was a pioneering American cardiovascular surgeon who developed innovative surgical techniques including artificial heart pumps, Dacron grafts, and coronary bypass, performing over 60,000 cardiovascular operations in his lifetime (Oransky, 2008). However, this level of creative eminence is rare, despite its impact on society. Most experienced medical professionals achieve stability at the Pro-c level, with Pro-c creativity falling on a continuum between the Journeyman and Expert levels (Friedlander, 2024).

In summary, the role of creativity in medical practice becomes increasingly essential at higher levels of expertise. It might be further argued that the drive for creative innovation and mastery is the primary characteristic that distinguishes Experts and Masters from those who stabilize their careers at the Journeyman level, although some degree of creative cognition is likely required at all levels of expert performance, particularly in diagnostic settings.

Creative Cognition and Divergent Thinking in Medical Practice

As noted previously, DT is a form of creative cognition that involves generating multiple solutions to a problem and is argued in the preceding section to support medical diagnosis at the Pro-c level of expertise. However, this specific skill is often not considered in the selection and training of medical school candidates, with medical education placing almost exclusive emphasis on the teaching and assessment of single-solution convergent thinking outcomes. This section considers the ways in which DT may help to enhance medical education, as well as the benefits of DT in both clinical training and practice.

Cognitive Correlates of DT

On a cognitive level, DT is related to soft skills that help to support intellectual functioning and problem-solving abilities. DT itself represents an individual's combined capacity across three cognitive domains: fluency, the ability to think of many ideas; flexibility, the ability to think of many thematic categories of ideas; and originality, the creativeness of one's ideas (Runco, 2011). These domains are inherently related to cognitive capacities such as executive functioning and fluid intelligence (Nusbaum & Silvia, 2011; Palmiero et al., 2022), and may potentially be selected for, by proxy, in medical entrance tests through the requirement for candidates to have excellent academic qualifications.

The first associated cognitive capacity mentioned above, executive functioning, refers to a set of mental functions used to organize and implement goal-directed behavior, including working memory, inhibitory control, and cognitive flexibility (McCabe et al., 2010; Palmiero et al., 2022). Both DT and executive functioning also relate to measures of fluid intelligence (Nusbaum & Silvia, 2011; van Aken et al., 2016), a form of problem-solving that involves processing and integrating various sources of information (Zaval et al., 2015), and "thinking on one's feet" (Friedlander & Fine, 2016) or "reflection-in-action" (Moulton et al., 2007).

In a latent modeling assessment of the relationship between DT, executive functioning, and fluid intelligence, Nusbaum & Silvia (2011) found that the impact of fluid intelligence on DT is mediated by executive functioning switching abilities, suggesting that this capacity helps to support creative ideation and flexible thinking. Taken together, DT, executive functioning, and fluid intelligence may help to enhance academic performance in medical school as well as practical outcomes in applied medicine. Moreover, cognitive flexibility has also been found to have protective benefits against burnout among physicians and is associated with higher levels of empathy and resilience (Houser et al., 2018), which can also help to improve outcomes in clinical practice.

DT in Differential Diagnosis: The Peapod Model

In addition to supporting cognitive functioning, DT is also involved in diagnosis and in countering diagnostic bias. As noted above, differential diagnosis is the process by which a physician considers multiple explanations for a set of symptoms before identifying the most probable cause (Cook & Decary, 2020). DT is integral to this process, supporting the identification of various common and uncommon conditions (Lunney, 1992). After identifying a range of possible conditions, a physician systematically narrows down these possibilities into fewer options using convergent thinking (CT), the process of identifying a single correct solution (DeYoung et al., 2008). As information is evaluated, and relevant testing or treatment options employed in accordance with evidence-based protocol, the gradual reduction in the number of possibilities leads to the identification of a single diagnosis (Cook & Decary, 2020). Alternatively, test results may prompt additional questions that require further application of DT before repeating the CT selection process.

In psychological terms, the oscillation between divergent and convergent thinking is known as the Peapod Model (Yilmaz & Daly, 2014: see Figure 1), which follows a similar structure to guidance on implementing evidence-based diagnostic strategies (Johnson, 2008). In this model, an individual begins by identifying a broad number of solutions to a problem (DT), narrows down these solutions to a smaller number of possibilities by evaluating and interpreting relevant information (CT), broadens the possibilities again as further questions arise (DT), and finally identifies the single most probable diagnosis (CT). The interaction between divergent and convergent thinking in the Peapod Model is shown in Figure 1. This form of oscillating thinking is also applied in engineering, software development, performing arts, and other areas of design (Yilmaz & Daly, 2015). Cross (2021) also refers to the design engineering process as an integration of convergent and divergent attentional strategies to achieve a final convergent outcome or solution. Along similar lines, the UK Design Council (2024) describes the process of design engineering as non-linear "double diamond" approach (discover, define, develop, deliver) to facilitate product generation.

The Peapod Model is most useful in conditions without time pressures, allowing practitioners to integrate clinical expertise with deliberate honing techniques. Nevertheless, while "Type 2" thinking may play a more significant role in typical diagnostic environments, "Type 1" judgments may be necessary in complex emergency situations. Under such time constraints, clinicians may adopt a Naturalistic Decision-Making approach (Orasanu, 2001), in which they apply domain-general knowledge to make prompt and immediate clinical decisions, as discussed previously.

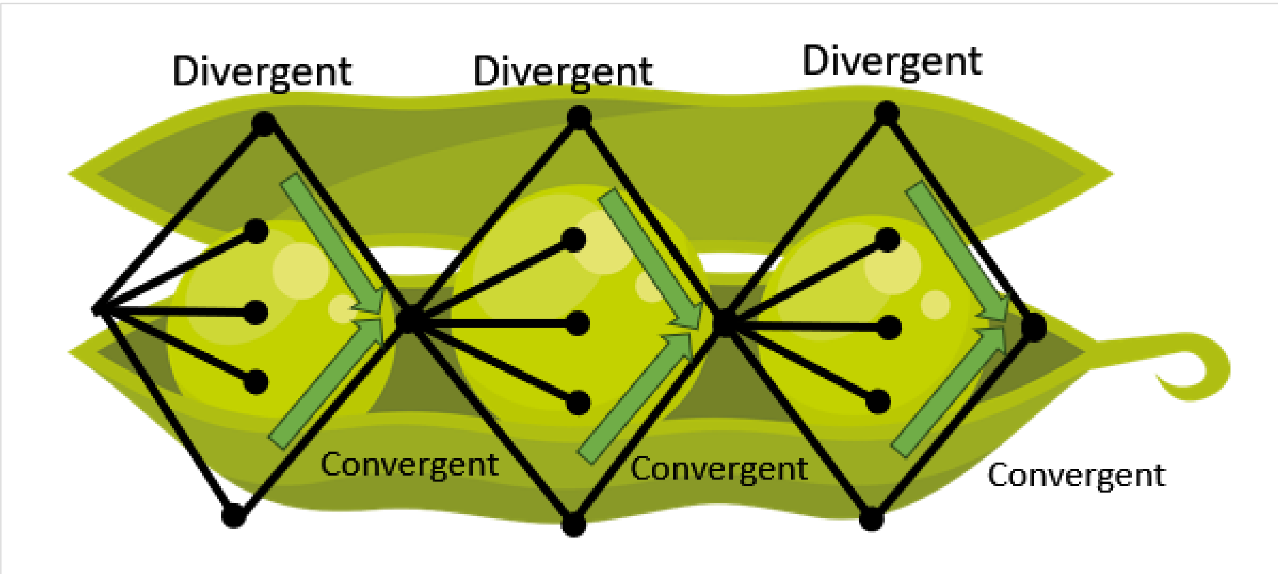

Figure 1. A Peapod Model of creative ideation (Yilmaz & Daly, 2014)

DT and Cognitive Bias

The expertise paradox, whereby possessing too much domain knowledge can lead to blinkered and stereotypical thinking, has been widely noted across a number of domains (Chi, 2006). Automaticity and intuitive thinking can also lead to common pitfalls: Chi (2006) includes among these a susceptibility to a wide range of biases, insufficient attention to the particulars of a situation, and over-confidence. In medicine, DT can aid a physician in countering these biases. For example, DT may help to avoid early fixation on a particular diagnosis (anchoring bias) or the tendency to assume a common or frequently occurring cause (the availability heuristic: Croskerry, 2013; O'Sullivan & Schofield, 2018). The integration of divergent and convergent thinking processes helps to support a balanced diagnosis while minimizing the effects of cognitive bias, yet DT is typically not included in taught instructional and assessment content in medical school.

In fact, the use of DT in medical education may be actively discouraged in some contexts. Most medical students are introduced to the famous maxim, "when you hear hoofbeats, think horses, not zebras" during their studies, which refers to the understanding that a patient's symptoms are more likely due to a common illness, rather than an uncommon one (Dickinson, 2016, p. 620). On one hand, there is truth to this statement, but it may also lead to premature fixation on early diagnostic hypotheses and discourage DT problem-solving strategies, which may be needed when dealing with difficult cases.

DT and Type 2 Thinking

The processes underlying differential diagnosis are also referred to as Type 1 and Type 2 thinking in the Dual Process Model of medical reasoning (Jones, 2017). The intuitive Type 1 form of thinking, also referred to as non-analytical reasoning, represents a physician's immediate intuitive response or gut feeling about a particular diagnosis, which can sometimes be susceptible to cognitive biases such as those mentioned above (Groves et al., 2003). The second, Type 2 form of thinking, also referred to as analytical reasoning, involves the use of deliberative reasoning strategies and hypothesis testing to determine the most likely diagnosis (Tay et al., 2016). Type 2 thinking is characterized by a balance of DT (i.e., identifying many solutions, including both rare and common diagnoses) and convergent thinking (i.e., narrowing in on the most probable diagnosis through testing, inference, and other available evidence), as described in the Peapod Model (Yilmaz & Daly, 2014).

Notably, in a study on diagnostic strategies in experienced and junior physicians, Djulbegovic et al. (2014) found that experienced physicians who utilized Type 1 thinking made fewer mistakes in logical-inferential clinical-style reasoning problems, in comparison to junior physicians and trainees, consistent with evidence on the importance of expert naturalistic decision-making in clinical environments (Orasanu, 2001). The authors also found that maximizing (i.e., the willingness to utilize alternative search strategies) was negatively correlated with age, and that experienced physicians were more likely to engage in "intuitive-experiential" thinking (Type 1 thinking; p. 628) compared with trainees, who were more likely to rely on analytical reasoning strategies (Type 2 thinking). However, the tendency to inhibit an immediate intuitive response was also associated with better task performance. Satisficing (i.e., the tendency to select an option that satisfies the minimum requirements) was also negatively correlated with age (Djulbegovic et al., 2014). These mixed findings have been interpreted to suggest that physicians' willingness to spend time identifying a diagnosis decreases with experience, but that expert physicians have also internalized the "mindware" supporting diagnosis on an intuitive level (Djulbegovic et al., 2014, p. 627), leading to better reasoning outcomes for the Pro-c physician.

Nevertheless, the inferential reasoning test used in this study may have had limited ecological validity given that the clinical scenarios used were manipulated to test syllogistic problem-solving, a somewhat artificial test challenge. These tasks sometimes employ false premises, contradicting actual medical knowledge and requiring the solver to suppress prior expertise to comply with the test requirements. For example, participants were presented with a question aligned with the "Modus Ponens" syllogism: "Assume the following is true: If a patient has a high fever, then the patient has malaria. Given that the following premise is also true: Ms. Boyle has a high fever. Is it necessary that: Ms. Boyle has malaria?" (Djulbegovic et al., 2014, p. 631). This is an unbelievable but logically correct statement.

Given what is known about the characteristics of Experts in a wide range of domains (Table 5, next page), it is in fact plausible that flexible and divergent thinking are cornerstone skills for both experienced practitioners and newcomers to the field alike, assuming that the quality of the challenge is sufficient to prompt reflection. For example, Caddick and colleagues (2023) observe that the tendency of physicians to use Type 2 reflective thinking is tempered by situational requirements such as time pressure. Similarly, Kulasegaram and colleagues (2013) note widespread evidence that, while medical experts typically rely on Type 1 thinking, experienced surgeons, for example, will switch from a rapid mode of operation to a slow and deliberate style in cases that present unexpected abnormalities. In other words, expert surgeons will "slow down when they should" (Moulton et al., 2007), and "know when to look it up" (Eva & Regehr, 2007). Training physicians to recognize when each approach is optimal may be the key challenge, but this is under-researched (Caddick et al., 2023).

Paradoxically, medical education typically places heavy emphasis on the teaching and assessment of convergent thinking without considering the value of cultivating DT skills in early training years, with most structured examinations involving multiple-choice and short-answer questions that assess students' abilities to identify single correct solutions (Lippell, 2002), as noted previously. Exercises that encourage DT may help to improve diagnostic abilities in residency and clinical years.

Recent years have seen the introduction of problem-based learning (Rotgans, 2012) and critical thinking (Croskerry, 2018) curricula in medicine, which may go some way to addressing these issues, although explicit DT training remains a rarity. Work by Ness (2011, 2012, 2015) suggests that such curricula might assist public health students in “enhancing observation, using analogies, changing point of view, juggling opposites, broadening perspective, reversal, reorganization and combination” (Ness, 2015, p. S114) leading to an improved ability to break the frame of habitual thought patterns.

Table 5. Characteristics of Experts Involving Type 2 Divergent Thinking (Friedlander, 2024)

Expert characteristic	Source
Can recognize aspects of a problem that make it novel or unusual and will bring special strategies to bear to solve “tough cases.”	Hambrick and Hoffman (2016)
Forms rich mental models of cases or situations to support sense-making and anticipatory thinking.	Hambrick and Hoffman (2016)
May spend proportionately more time determining how to represent a problem than in searching for/executing a problem strategy. Particularly the case for atypical problems.	Sternberg et al. (2011)
Uses a large repertoire of strategies for reasoning about tasks and conducting them.	Hambrick and Hoffman (2016)
Can create procedures and conceptual distinctions, sometimes on the fly as new challenges appear.	Hambrick and Hoffman (2016)
Knows that their knowledge is constantly changing and continually contingent.	Hambrick and Hoffman (2016)

DT and the “Good Doctor”

Beyond diagnosis, the personal characteristics typically demonstrated by those skilled in DT parallel a number of core competencies outlined in Table 1. For example, DT may involve exercising conscious cognitive shifting strategies to consider personal biases and alternative perspectives (DeYoung et al., 2008; Ness, 2012), potentially helping to promote more effective communication with colleagues as well as person-centered approaches to patient interaction. For a medical school applicant, characteristics of those who exhibit mini-c and little-c creativity may also promote the traits expected of an expert physician. For example, qualities such as psychological openness and tolerance for ambiguity are considered hallmark features of mini-c creativity (Kaufman & Beghetto, 2009; McCrae, 1987; Zenasni et al., 2011) and may help physicians to confront uncertainty in all stages of diagnosis and treatment. A high tolerance for ambiguity has been linked to better complex decision-making in medical contexts, enabling physicians to integrate scientific evidence with applied practical outcomes (Knight & Mattick, 2006). For medical students, high ambiguity tolerance is also related to leadership qualities (Sherrill, 2001) and ethical decision-making (Geller, 2013). Similarly, a high degree of psychological openness has been shown to significantly predict successful examination outcomes in the final year of medical school (Lievens et al., 2002).

Concluding Remarks

Taken together, research suggests that DT may help to facilitate the development of medical expertise, both in terms of the cognitive processes involved in diagnosis and the personal qualities associated with highly divergent thinkers, particularly for those at the highest levels of expert performance. Medical school generally focuses on developing the skill set of the Journeyman expert, taking students through training and internship to graduate with a functional level of knowledge and technical competence needed for practice as an independent physician. Students may learn to apply DT techniques in undertaking differential diagnosis, but assessment outcomes are typically scored for the production of the correct diagnosis drawing from evidence-based strategies (Glasziou et al., 2008), rather than the cognitive processes involved in determining a solution (Lippell, 2002). Thus, with the strong emphasis on the teaching and testing of convergent thinking knowledge, medical education may leave some student Apprentices to remain at the level of Journeyman or “routine experts” (Mylopoulos & Regehr, 2007) for the duration of their career. Those who stagnate at this stage settle for a lower level of knowledge and skill, exercising strict evidence-based approaches derived from acquired knowledge and training. On one hand, the demand for medical expertise is so great that the skill set harnessed by the routine medical expert is typically sufficient for most clinical purposes, as the vast majority of patients present with relatively common conditions that can be identified through routine systematic processes (Dickinson, 2016). The routine expert maintains this level of competence without the enhanced need for DT and flexible thinking.

However, the limitations of the routine expert’s knowledge may pose challenges to diagnosing and treating more complex clinical cases, or cases in which heuristic biases (Croskerry, 2015) or stereotypical thinking (Chi, 2006) may be present. That is, routine experts may rely on acquired automatic knowledge and procedures without seeking continuous refinement of their skills and knowledge. Similarly, these individuals may be more susceptible to biases in clinical situations, including both diagnostic biases—such as anchoring, fixation, and other heuristics that may interfere with interpreting symptoms (Croskerry, 2013, 2015)—as well as biases related to the age, gender, race, and other socio-demographic characteristics of their patients. For example, chronic pain is more likely to be dismissed in women than in men (Samulowitz et al., 2018), and women typically require more visits to a doctor than men to receive the same diagnosis for a range of conditions (Kole & Faurisson, 2009). Similarly, African American patients are less likely to receive pain medicine compared to white patients, perpetuating racial disparities in treatment (Meghani et al., 2012). The prevalence of diagnostic bias is a widely pervasive issue that can cost patients years of their lives. The use of flexible thinking strategies such as enhancing observation or deliberately challenging automatic associations (Ness, 2015) may help to improve diagnostic outcomes, yet these strategies may not be actively employed by those who remain at the routine or Journeyman level of expertise.

In contrast, the “adaptive expert” (Mylopoulos & Regehr, 2007) who achieves an Expert or Master level of medical expertise takes the knowledge of the routine expert further, applying DT strategies to consider alternatives when an outcome is not immediately clear (Ness, 2015), whether in diagnosis or in devising a treatment plan. In this way, the adaptive expert is better able to identify uncommon conditions as well as to engage with patients using a holistic approach, integrating evidence-based with person-centered care to consider each patient in an individual context. That is, rather than attending strictly to the automatic or mechanistic approach practiced by Journeymen, the adaptive expert develops an intuitive pattern recognition system (Djulbegovic et al., 2014), integrating knowledge and schematic associations with clinical experience and flexible thinking when treating patients.

Adaptive experts also exhibit a continuous drive to maintain and update their medical skills with advances in research and technology, ensuring that expertise remains in a constant state of growth without stagnating at a lower level of skill development (Ericsson & Towne, 2010). For the most eminent Master experts who achieve Big-C creative discoveries, the intuitive knowledge base also allows for the seemingly serendipitous discovery of treatment methods such as penicillin (Copeland, 2018). Here, Master-level expertise provides experts with the cognitive framework capable of making connections and inferences between patterns through "opportunistic assimilation" (Seifert et al., 1995, p. 86), enhancing medical innovation and discovery.

On the other hand, expertise can also bring about inflexibility and entrenchment. Indeed, functional fixedness, the act of over-relying on previous experience, thus hindering any attempt to handle a new situation innovatively (Chrysikou et al., 2016), is an issue in the medical field (Watkins, 2020). To counter this, it could be argued that DT enables physicians to think more widely, allowing them to break away from rigid convergent thinking to consider other options. For example, Barry Marshall's work on peptic ulcers, discussed previously, challenged years of ingrained medical wisdom. While he was awarded the Nobel Prize in 2005 for his acclaimed discovery, he was reported in 1998 as saying "everyone was against me, but I knew I was right" (Beattie-Moss, 2008). Given the speed of technological advancement, DT can thus be a useful tool for physicians, allowing them to adapt their diagnostic and therapeutic skills when new technologies emerge.

To this end, enhanced emphasis on instructional content in medical school that aims to exercise DT and cognitive flexibility may prepare students to become adaptive experts in later years of practice, rather than plateauing at the level of routine experts. In an immediate educational context, DT training helps to strengthen abilities in differential diagnosis, enabling students to recognize the possibility of uncommon diagnoses in applying the steps of the Peapod Model (Yilmaz & Daly, 2014). Beyond the classroom, an advanced understanding of DT may also help Apprentices to counter diagnostic biases and improve clinical outcomes for patients, particularly those from medically disadvantaged populations, as well as to promote continuous refinement of their medical skills and knowledge. To this end, excellent medicine can therefore be argued to fall at the intersection of expert perception, knowledge, and reflective creativity. It represents the ability to notice patterns, perhaps spotting something "not quite right," to reflect flexibly about the presentation of the case, and to apply knowledge appropriately and sensitively according to the patient's personal circumstances. DT abilities are key to this intuitively holistic approach to medicine, enabling the successful recognition and treatment of both common and rare "zebra" conditions. Armed with this approach, doctors emerging from training might truly "earn their stripes" as diagnostic physicians.

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