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Part I

Introduction and Perspectives

1 An Introduction to the Second Edition of *The Cambridge Handbook of Expertise and Expert Performance*: Its Development, Organization, and Content

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The study of expertise and expert performance reached a significant milestone in 2006 when its first handbook was published (Ericsson, Charness, Hoffman, & Feltovich, 2006). In the ten subsequent years, the handbook surpassed 10,000 copies sold, which is pretty impressive for a book of almost 1,000 pages. During this last decade there has been a dramatic increase in articles and books reporting on expertise and expert performance. There are several edited books written about particular domains of expertise, such as sports expertise (Baker & Farrow, 2015) and developing sports expertise (Farrow & Baker, 2013), entrepreneurial expertise (Sarasvathy, 2008), and design expertise (Lawson & Dorst, 2009). Other books have taken more general perspectives on the structure of expertise and its acquisition (Montero, 2016), the social aspects of how expertise is evaluated and experts evaluated (Collins & Evans, 2007), and the relation between skill acquisition and expertise (Johnson & Proctor, 2016). General books on the topics of expertise and expert performance have been published, focusing on professional development (Ericsson, 2009), accelerating the development of expertise (Hoffman et al., 2014), as noted earlier, and expertise in professional decision making (Hoffman, 2007). Another sign of impact is the large number of popular books describing how insights from the study of expertise and expert performance can inform individuals on how to improve their performance. A few examples of such popular books are Colvin (2008), Coyle (2009), Ericsson and Pool (2016), Foer (2011), Gladwell (2008), and Marcus (2012). This new edition of the handbook will update the most active areas of research and provide an up-to-date summary of our knowledge about perspectives, approaches, and methods in the study of expertise and expert performance as well as updated assessments of the knowledge of expertise and expert performance in different domains of expertise. There is also a new section identifying similar mechanisms that mediate expertise and expert performance across different domains, as well as generalizable issues and theoretical frameworks.

Expert, Expertise, and Expert Performance: Dictionary Definitions

Encyclopedias describe an ***Expert*** as "one who is very skillful and well-informed in some special field" (*Webster's New World Dictionary*, 1968, p. 168), or "someone widely recognized as a reliable source of knowledge, technique, or skill whose judgment is accorded authority and status by the public or his or her peers. Experts have prolonged or intense experience through practice and education in a particular field" (Wikipedia). ***Expertise*** then refers to the characteristics, skills, and knowledge that distinguish experts from novices and less experienced people. In some domains there are objective criteria for finding experts, who are consistently able to exhibit superior performance for representative tasks in a domain. For example, chess masters will almost always win chess games against recreational chess players in chess tournaments, medical specialists are far more likely to diagnose a disease correctly than advanced medical students, and professional musicians can perform pieces of music in a manner that is unattainable for less skilled musicians. These types of superior reproducible performances on representative tasks capture the essence of the respective domains, and authors have been encouraged to refer to them as ***Expert Performance*** in this and the original handbook.

It has been known for some time that in some domains it is difficult for non-experts to identify experts, and consequently researchers rely on peer-nominations by professionals in the same domain. However, people recognized by their peers as experts do not always display superior performance on domain-related tasks. Sometimes they are no better than novices even on tasks that are central to the expertise, such as selecting stocks with superior future value, treatment of psychotherapy patients, and forecasts (Ericsson & Lehmann, 1996). There are several domains where experts disagree and make inconsistent recommendations for action, such as recommending selling versus buying the same stock. For example, expert auditors' assessments have been found to differ more from each other than the assessments of less experienced auditors (Bédard, 1991). Furthermore, experts will sometimes acquire differences from novices and other people as a function of their repetitive routines, that is, as a consequence of their extended experience rather than a cause for their superior performance. For example, medical doctors' handwriting is less legible than that of other health professionals (Lyons, Payne, McCabe, & Fielder, 1998). In sum, Shanteau (1988) suggested that "experts" may not need a proven record of performance and can adopt a particular image and project "outwards signs of extreme self-confidence" (p. 211) to get clients to listen to them and continue to offer advice after negative outcomes. After all, the experts are nearly always the best qualified to evaluate their own performance and explain the reasons for any deviant outcomes.

When the proposal for the first edition of the handbook was originally prepared, the outline focused more narrowly on the structure and acquisition of highly superior (expert) performance in many different domains (Ericsson, 1996, 2004). In response to the requests of the reviewers of that proposal, the final outline of the handbook covered a broader field that included research on the development of expertise and how highly experienced individuals accumulate knowledge in their respective domains and eventually become socially recognized experts and masters. Consequently, to reflect the scope of the handbook it was entitled *The Cambridge Handbook of Expertise and Expert Performance*. The first edition of the handbook thus included a multitude of conceptions of expertise, including perspectives from education, sociology, and computer science, along with the more numerous perspectives from psychology emphasizing basic abilities, knowledge, and acquired skills. In this second edition there is an even more committed effort to include new perspectives, such as the evolution of expertise over many millennia, the phenomenology of expertise, and even the concept of expertise in non-human animals, such as service dogs and dogs herding sheep. In this introductory chapter, I will briefly introduce some general issues and describe the structure and content of the handbook as it was approved by Cambridge University Press.

Tracing the Development of Our Knowledge of Expertise and Expert Performance

Since the beginning of Western civilization there has been particular interest in the superior knowledge that experts have acquired in their domain of expertise. The body of knowledge that experts accrue in their domain is a particularly important difference between experts and other individuals. Much of this knowledge can be verbally described and shared with others to benefit decision making in the domain and can help educate students and facilitate their progress toward expertise. The special status of the knowledge of experts in their domain of expertise is acknowledged even as far back as the Greek civilization. Socrates said that:

> I observe that when a decision has to be taken at the state assembly about some matter of building, they send for the builders to give their advice about the buildings, and when it concerns shipbuilding they send for the shipwrights, and similarly in every case where they are dealing with a subject which they think can be learned and taught. But if anyone else tries to give advice, who they don't regard as an expert, no matter how handsome or wealthy or well-born he is, they still will have none of him, but jeer at him and create an uproar, until either the would-be speaker is shouted down and gives up of his own accord, or else the police drag him away or put him out on the order of the presidents. (Plato, 1991, pp. 11–12)

Aristotle relied on his own senses as the primary source of scientific knowledge and sought out beekeepers, fishermen, hunters, and herdsmen to get the best and most reliable information for his books on science (Barnes, 2000). He even tried to explain occasional incorrect reports from some of his informants about how offspring of animals were generated. For example, some of them suggested that "the ravens and the ibises unite at the mouth" (Aristotle, 1943, p. 315). But Aristotle notes: "It is odd, however, that our friends do not reason out how the semen manages to pass through the stomach and arrive in the uterus, in view of the fact that the stomach concocts everything that gets into it, as it does the nourishment" (pp. 315 & 317). Similarly, "those who assert that the female fishes conceive as a result of swallowing the male's semen have failed to notice certain points" (p. 311). Aristotle explains that "Another point which helps to deceive these people is this. Fish of this sort take only a very short time over their copulation, with the result that many fishermen never even see it happening, for of course no fishermen ever watches this sort of thing for the sake of pure knowledge" (p. 313). Much of Aristotle's knowledge comes, at least partly, from consensus reports of professionals.

Much later during the Middle Ages, craftsmen formed guilds to protect themselves from competition. Through arrangements with the mayor and/or monarch they obtained a monopoly on providing particular types of handcraft and services with set quality standards (Epstein, 1991). They passed on their special knowledge of how to produce products, such as lace, barrels, and shoes, to their students (apprentices). Apprentices would typically start at around age 14 and commit to serve and study with their master for around seven years – the length of time varied depending on the complexity of the craft and the age and prior experience of the apprentice (Epstein, 1991). Once an apprentice had served out their contract they were given a letter of recommendation and were free to work with other masters for pay, which often involved traveling to other cities and towns – they were therefore referred to as journeymen. When a journeyman had accumulated enough additional skill and saved enough money he, or occasionally she, would often return to his home town to inherit or purchase a shop with tools and apply to become a master of the guild. In most guilds they required inspection of the journeyman's best work, i.e. master pieces, and in some guilds they administered special tests to assess the level of performance (Epstein, 1991). When people were accepted as masters they were held responsible for the quality of the products from their shop and were thereby allowed to take on the training of apprentices (see the chapter by Amirault & Branson, 2006, in the first edition of the handbook on the progression toward expertise and mastery of a domain).

In a similar manner, the scholars' guild was established in the twelfth and thirteenth centuries as "a *univeristas magistribus et pupillorum*," or "guild of masters and students" (Krause, 1996, p. 9). Influenced by the University of Paris, most universities conducted all instruction in Latin, where the students were initially apprenticed as arts students until they successfully completed the preparatory (undergraduate) program and were admitted to the more advanced programs in medicine, law, or theology. To become a master, the advanced students needed to satisfy "a committee of examiners," then publicly defend a thesis, often in the town square and with local grocers and shoemakers asking questions (Krause, 1996, p. 10). The goal of the universities was to accumulate and explain knowledge and in the process masters organized the existing knowledge (see Amirault & Branson, 2006). With the new organization of existing knowledge of a domain, it was no longer necessary for individuals to discover the relevant knowledge and methods by themselves.

Today's experts can rapidly acquire the knowledge originally discovered and accumulated by preceding expert practitioners by enrolling in courses taught by skilled and knowledgeable teachers using specially prepared textbooks. For example, in the thirteenth century Roger Bacon argued that it would be impossible to master mathematics by the then known methods of learning (self-study) in less than 30 to 40 years (Singer, 1958). Today the roughly equivalent material (calculus) is taught in highly organized and accessible form in every high school.

Sir Francis Bacon is generally viewed as one of the architects of the Enlightenment period of Western civilization and one of the main proponents of the benefits of generating new scientific knowledge. In 1620 he described in his book *Novum Organum* his proposal for collecting and organizing all existing knowledge to help our civilization engage in learning to develop a better world. In it, he appended a listing of all topics of knowledge to be included in *Catalogus Historarium Particularium*. It included a long list of skilled crafts, such as "History of weaving, and of ancillary skills associated with it," "History of dyeing," "History of leather-working, tanning, and of associated ancillary skills" (Rees & Wakely, 2004, p. 483).

The guilds guarded their knowledge and their monopoly of production. It is therefore not surprising that the same forces that eventually resulted in the French Revolution were not directed only at the oppression by the king and the nobility, but also against the monopoly of services provided by the members of the guilds. Influenced by Sir Francis Bacon's call for an encyclopedic compilation of human knowledge, Diderot and D'Alembert worked on assembling all available knowledge in the first *Encyclopédie* (Diderot & D'Alembert, 1966–67), which was published in 1751–80.

Diderot was committed to the creation of comprehensive descriptions of the mechanical arts to make their knowledge available to the public and encourage research and development in all stages of production and all types of skills, such as tanning, carpentry, glassmaking, and ironworking (Pannabecker, 1994) along with descriptions of how to sharpen a feather for writing with ink as shown in Figure 1.1. His goal was to describe all the raw materials and tools that were necessary, along with the methods of production. Diderot and his associate contributors had considerable difficulties gaining access to all the information because of the unwillingness of the guild members to answer their questions. Diderot even considered sending some of his assistants to become apprentices in the respective skills to gain access

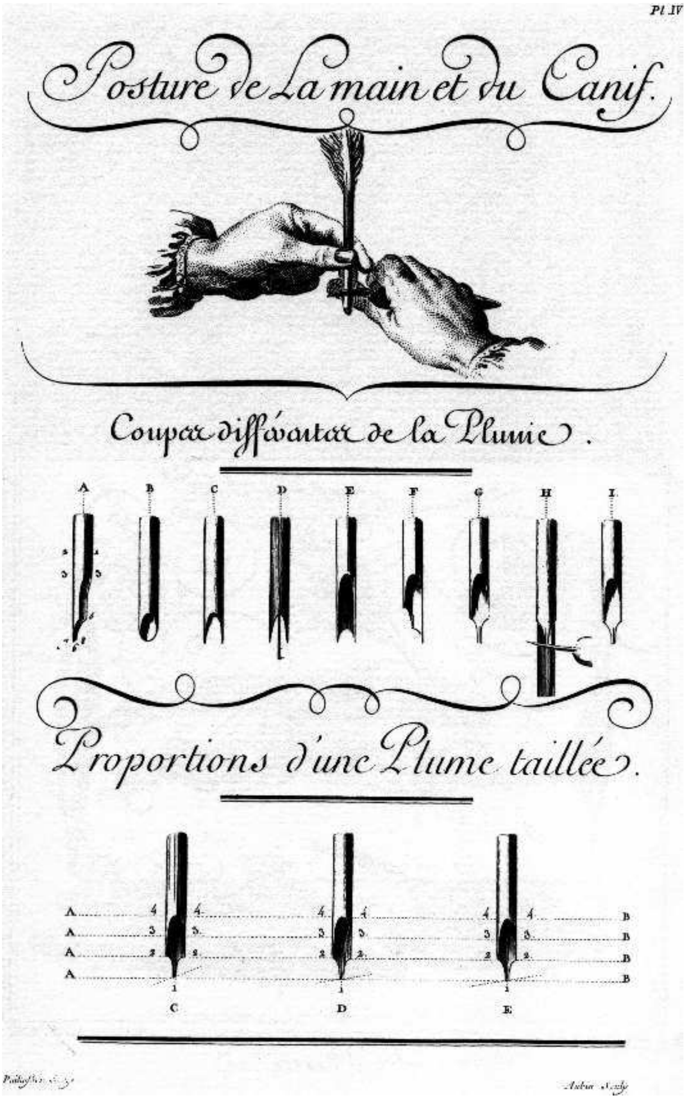

Figure 1.1 An illustration of how to sharpen a goose feather for writing with ink from Plate IV in the entry on "Ecriture" in the 23rd volume of *Encyclopédie ou dictionnare de raisonné des sciences, des arts et des métiers* (Diderot & D'Alembert, 1966–67).

to all the relevant information (Pannabecker, 1994). In spite of all the information and pictures (diagrams of tools, workspaces, procedures, etc. as illustrated in Figure 1.2 showing one of several plates of the process of printing) provided in the *Encyclopédie*, Diderot was under no illusion that the provided information would by itself allow anyone to become a craftsman in any of the described arts and wrote: "It is handicraft that makes the artist, and it is not in Books that one can learn to manipulate" (Pannabecker, 1994, p. 52). In fact, Diderot did not even address the higher levels of cognitive activity, "such as intuitive knowledge, experimentation, perceptual skills,

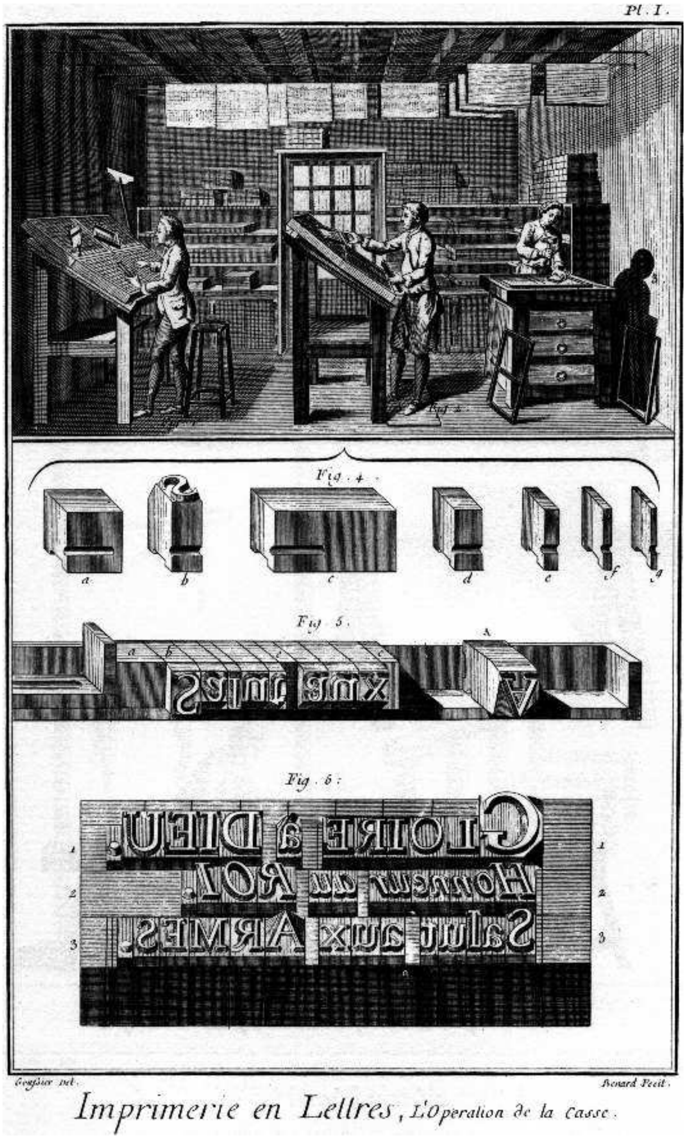

Figure 1.2 An illustration of the workspace of a printer with some of his type elements from Plate I in the entry on "Imprimerie" in the 28th volume of *Encyclopédie ou dictionnare de raisonné des sciences, des arts et des métiers* (Diderot & D'Alembert, 1966–67).

problem-solving, or the analysis of conflicting or alternative technical approaches" (Pannabecker, 1994, p. 52).

A couple of years after the French Revolution the monopoly of the guilds was eliminated (Fitzsimmons, 2003) including the restrictions on the practice of medicine and law. After the American Revolution and the creation of the United States of America laws were initially created to require that doctors and lawyers be highly trained based on the apprenticeship model, but pressure to eliminate elitist tendencies led to the repeal of those laws. From 1840 to the end of the nineteenth century there was no requirement for certification to practice medicine and law in the USA (Krause, 1996). However, with time both France and the USA realized the need to restrict vital medical and legal services to qualified professionals and developed procedures for training and certification.

Over the last couple of centuries there have been several major changes in the relation between master and apprentice. For example, before the middle of the nineteenth century children of poor families would often be taken on by teachers in exchange for a contractual claim for part of the future dancers', singers', or musicians' earnings as an adult (Rosselli, 1991). Since then the state has gotten more involved in the training of their expert performers, even outside the traditional areas of academia and professional training in medicine, law, business, and engineering. In the late nineteenth century public institutions, such as the Royal Academy of Music, were established to promote the development of very high levels of skill in music to allow native students to compete with better trained immigrants (Rohr, 2001). In a similar manner during the latter part of the twentieth century, many countries invested in schools and academies for the development of highly skilled athletes for improved success in competitions during the Olympic Games and World Championships (Bloomfield, 2004).

More generally, over the last century there have been economic developments with public broadcasts of competitions and performances that generate sufficient revenue for a number of domains of expertise, such as sports and chess, to support professional full-time performers as well as coaches, trainers, and teachers. In these new domains, along with the traditional professions, current and past expert performers continue to be the primary teachers at advanced levels (masters) and their professional associations have the responsibility for certifying acceptable performance and the permission to practice. Thus they have the clout to influence training in professional schools, such as law, medical, nursing, and business schools – "testing is the tail that wags the dog" (Feltovich, personal communication). The accumulation of knowledge about the structure and acquisition of expertise in a given domain as well as knowledge about instruction and training of future professionals have, until quite recently, occurred almost exclusively within each domain, with little cross-fertilization of domains in terms of teaching, learning methods, and skill training techniques.

It is not immediately apparent what is generalizable across such diverse domains of expertise as music, sport, medicine, and chess. What could possibly be shared by the skills of playing difficult pieces by Chopin, running a mile in less than four minutes, and playing chess at a high level? The premise for a field studying expertise and expert performance is that there are sufficient similarities in the theoretical principles mediating the phenomena and the methods for studying them in different domains that it would be possible to propose a general theory of expertise and expert performance. All of these domains of expertise have been created by humans and thus the accumulated knowledge and skills are likely to reflect similarities in structure reflecting human biological and psychological factors as well as cultural factors. This raises many challenging problems for methodologies seeking to describe the organization of knowledge and to identify the mechanisms mediating expert performance that generalize across domains.

Once we know how experts organize their knowledge and their performance, is it possible to improve the efficiency of learning to reach higher levels of expert performance in these domains? It should also be possible to determine why different individuals improve their performance at different rates and why different people reach very different levels of final achievement. Would a deeper understanding of the development and its mediating mechanisms make it possible to select individuals with unusual potential and to design better developmental environments to increase the proportion of performers who reach the highest levels? Would it even be possible to facilitate the development of those rare individuals who make major creative contributions to their respective domains?

Conceptions of Generalizable Aspects of Expertise

Several different theoretical frameworks have focused on broad issues on attaining expert performance that generalize across different domains of expertise.

Individual Differences in Mental Capacities

A widely accepted theoretical concept argues that general innate mental capacities mediate the attainment of exceptional performance in most domains of expertise. In his famous book, *Hereditary Genius*, Galton (1869/1979) proposed that across a wide range of domains of intellectual activity the same innate factors are required to attain outstanding achievement and designation as a genius. He analyzed eminent individuals in many domains in Great Britain and found that these eminent individuals were very often the offspring of a small number of families – with much higher frequency than could be expected by chance. The descendants from these families were much more likely to make eminent contributions in very diverse domains of activity, such as becoming famous politicians, scientists, judges, musicians, painters, and authors. This observation led Galton to suggest that there must be a heritable potential that allows some people to reach an exceptional level in any one of many different domains. After reviewing the evidence that height and body size were heritable Galton (1869/1979) argued: "Now, if this be the case with stature, then it will be true as regards every other physical feature – as circumference of head, size of brain, weight of gray matter, number of brain fibers, &c.; and thence, by a step on which no physiologist will hesitate, as regards *mental capacity*" (pp. 31–32, emphasis added).

Galton clearly acknowledged the need for training to reach high levels of performance in any domain. However, he argued that improvements are rapid only in the *beginning* of training and that subsequent increases become increasingly smaller, until "maximal performance becomes a rigidly determinate quantity" (p. 15). Galton developed a number of different mental tests of individual differences in mental capacity. Although he never related these measures to objective performance of experts on particular real-world tasks, his views led to the common practice of using psychometric tests for admitting students into professional schools and academies for arts and sports with severely limited availability of slots. These tests of basic ability and talent were believed to identify the students with the capacity for reaching the highest levels.

In the twentieth century scientists began testing large groups of experts to measure their powers of mental speed, memory, and intelligence with psychometric tests. When the experts' performances were compared to control groups of comparable education there was no evidence supporting Galton's hypothesis of a general superiority for experts, because the demonstrated superiority of experts was found to be specific to certain aspects related to the particular domain of expertise. For example, the superiority of the chess expert's memory was constrained to regular chess positions and did not generalize to other types of materials (Djakow, Petrowski, & Rudik, 1927). Not even IQ could distinguish the best among chess players (Doll & Mayr, 1987) nor the most successful and creative among artists and scientists (Taylor, 1975).

In an article in the *Annual Review of Psychology*, Ericsson and Lehmann (1996) found that (1) measures of basic mental capacities are not valid predictors of attainment of expert performance in