The Future of Expertise: The Need for a Multidisciplinary Approach

Fernand Gobet
University of Liverpool

Correspondence: Fernand Gobet, fernand.gobet@liverpool.ac.uk

Abstract

Much progress has been made in cognitive psychology and neuroscience in understanding the mechanisms underpinning expert behavior. Concurrently, expertise has been extensively studied in several other disciplines; in particular, sociology, philosophy, and artificial intelligence. However, there has been relatively little communication between these disciplines. This is regrettable, as many contradictions between the disciplines have been ignored and many opportunities for cross-fertilization missed. For example, psychology has focused on performance-based expertise and emphasized the remarkable feats displayed by experts, while sociology has directed its attention to the shortcomings of reputation-based experts. It is proposed that unifying forces between disciplines is the way forward for making progress in our understanding of expertise.

Keywords

expertise, computational modeling, deliberate practice, multidisciplinary research, talent, theory development

Introduction

Experts fascinate. Long anticipating the positive psychology movement (e.g., Seligman & Csikszentmihalyi, 2000), researchers have studied the amazing performances of athletes, scientists, and artists as a way to understand human psychology. For example, as early as 1894, Binet studied mental calculators and chess players' remarkable memory. This interest in understanding expertise is motivated by several reasons (Gobet, 2016): to shed light on learning mechanisms; to develop better training methods for coaching experts and more efficient instructional methods in general for schools and the workplace; and to better understand human cognition. In this respect, research into expertise offers a mirror image to neuropsychology: while the latter studies impaired performance to understand normal cognition, the former examines superior performance.

The last decades have seen a substantial amount of research devoted to the study of expertise, which has resulted in a massive literature. In recent years only, the field has witnessed the publication of two handbooks (Ericsson, Hoffman, Kozbelt, & Williams, 2018; Ward, Schraagen, Gore, & Roth, in press), two textbooks (Gobet, 2011, 2016), several edited books (e.g., Hambrick, Campitelli, & Macnamara, 2018; Staszewski, 2013) and several monographs (e.g., Bilalić, 2017; Hoffman, LaDue, Mogil, Roebber, & Trafton, 2017; Selinger, 2011).

Much is known about the psychological mechanisms underpinning expertise and several regularities have been identified in experts' behavior across different domains. There is no space in this brief article for a full review, but a list would start with the role of perception, the omnipresence of chunking, the importance of

innate factors and practice, and the fact that experts are highly selective in their search (see Gobet, 2016, for an extensive discussion). At the same time, there are still many gaps in our understanding of expertise. For example, little is known about the exact nature of the interaction between practice and talent and about the role of emotions in superior performance—with respect to how emotional states affect expert performance in general as well as to how specific kinds of expertise involving emotions, such as acting, are acquired.

Many scientific disciplines have studied expertise, with a dizzying array of different methods. Psychology has tended to use hard-science methodologies such as behavioral experiments, eye-movement recordings, and computer modeling, but has also collected "softer" data with questionnaires and interviews. Neuroscience has used a panoply of techniques including fMRI and EEG. Philosophy primarily uses introspection and critical analysis of classic texts. Sociology tends to employ descriptions and historical analyses. In artificial intelligence, the question of expertise has been important in the fields of expert systems and machine learning. Other scientific disciplines study expertise (e.g., anthropology, ethnography, and economics), but this brief discussion should suffice to illustrate the large variety of techniques used to study expertise.

Definitions and Schools

In these scientific disciplines, the variety of methods is reflected in the different definitions of expertise, which can be summarized in two broad classes (Gobet, 2016). With *performance-based expertise (P-expertise)*, the emphasis is on superior performance, which typically can be replicated in controlled experiments. This is the kind of definition commonly used in psychology and neuroscience. For example, Gobet (2016, p. 5) defines an expert as "somebody who obtains results that are vastly superior to those obtained by the majority of the population." With this definition, examples of experts could be athletes, chess players, or pianists. With *reputation-based expertise (R-expertise)*, expertise is defined using social labels such as

professional certificates, diplomas, PhDs, or simply unofficial recognition. This definition, which is often used in sociology, recognizes that such labels are sometimes given irrespectively of the "experts'" real competences. In some cases, there is reputation but no knowledge: Some vocal commentators in popular media hardly know more than the well-informed person. In other cases, the "experts" have acquired a considerable amount of technical knowledge, but this knowledge is useless for the task at hand: Astrologers base their predictions on pseudo-science (Carlson, 1985), and investors in the stock market cannot predict the future better than chance (Cowles, 1944).

Talking about "disciplines" might give the wrong impression that each discipline is homogeneous. Nothing could be further from the truth. For example, in psychology, numerous approaches or "schools" can be identified, which often differ in important ways; among the main approaches, one might mention those based on cognitive psychology, genetics, giftedness, psychometrics, and decision making, to mention just a few. The same variety can be found in other disciplines.

Transversal Themes

Given the diverse methods and definitions used in the different disciplines, and given the varied approaches within each field of study, it stands to reason that there will be many differences in the way these disciplines study expertise. I have proposed to use eight themes (Gobet, 2016) to compare the way disciplines tackle expertise (see Table 1).

Table 1. Eight transversal themes cutting across scientific disciplines (Gobet, 2016)

Definition/Identification of Expertise
Rationality
Knowledge
Search
Generativity
Diachronicity
Nature vs. Nurture
Environment and Society

Examining scientific disciplines through these lenses turns out to be illuminating. Let us briefly consider the theme of rationality, as an example. A first observation is that this concept has many different definitions. For example, in cognitive science, Newell (1982) argues that an agent is rational to the extent that it fully uses its knowledge to reach its goals. In economics, where the assumption of (full) rationality is central, an agent is rational if its choices maximize utility. In recent years, a similar assumption has also been made in several theories in psychology (e.g., theories based on Bayesian inference). Among the many definitions put forward in philosophy, Montero and Evans (2011) propose that agents are rational if they can always justify their decisions.

The study of expertise is very informative about rationality: If the best humans in a domain do not behave rationally, then it is very difficult indeed to argue that humans in general are rational. In psychology, expertise research concludes that humans are far from being fully rational: Experts make minor and occasionally even major mistakes in domains such as chess, medicine, and sports. This point has been in particular documented in research carried out in the judgment and decision-making tradition (e.g., Dawes, 1994). This conclusion is of course consonant with the concept of bounded rationality (Simon, 1982), according to which a decision maker's rational choice is limited by cognitive constraints, in particular limitations in knowledge and computational resources, such as limited capacity of short-term memory and slow learning rates. But then, how can individuals become experts in spite of their bounded rationality? The answer is knowledge. By acquiring vast amounts of perceptual, declarative, and procedural knowledge, experts manage to automate many processes and rapidly identify the key features of a problem (Campitelli & Gobet, 2010; Simon & Chase, 1973).

In philosophy, there have been many discussions about experts' rationality. For example, Dreyfus and Dreyfus (1986) argue that experts are *arational,* in the sense that the

concept of rationality does not apply to them, as they act intuitively, without making decisions. By contrast, Montero and Evans (2011) contend that experts are fully rational, in the sense mentioned above that they can fully justify their actions. The theme of rationality is relatively less important in other disciplines such as education and sociology.

The Necessity for a Multidisciplinary Science of Expertise

Research into expertise has been successful in examining several questions within each discipline. It has been much less successful in reaching a broad multidisciplinary understanding of expertise. This is in great part due to the traditional boundaries between fields of study which impede communication. However, the lack of conversation within individual disciplines is also part of the problem. When there is little positive and productive interaction within each discipline—think of the acrimonious debate about deliberate practice and talent in psychology, as exemplified by the July-August 2014 issue of the journal *Intelligence* devoted to the acquisition of expertise—it is hardly surprising that there is little dialogue between disciplines.

A consequence of this lack of communication between fields is that too much important information is ignored, which can lead to serious mistakes. A striking example is provided by Dreyfus and Dreyfus's book *Mind over Machine* (1986) and numerous subsequent publications, in which the authors describe their five-stage theory of expertise. They argue that experts do not carry out search nor use analytical thinking. Rather, they act in a pure intuitive way.

The argument is plausible in principle, but is in fact inconsistent with empirical data. Dreyfus and Dreyfus wholly ignore the considerable body of evidence first collected by De Groot on chess (1946/1978) but later replicated and expanded by other researchers showing that experts do in fact carry out considerable amounts of search when necessary. It is an interesting task for historians of science of future generations to explain how such a theory,

which is at variance with empirical data and indeed common sense, had such an impact in the social sciences and beyond.

The fragmentation of scientific knowledge about expertise has several additional consequences. First, some research is duplicated, which leads to a waste of resources, inasmuch as this research is not properly cumulated. From a statistical view point, this is tantamount to sampling with replacement—not an efficient approach. Second, as information is not propagated properly across the nodes of the knowledge nexus, there is a tendency to direct most resources toward relatively few questions. For example, psychology has focused much effort on the question of deliberate practice, and philosophy has devoted a considerable amount of resource to the question of knowing-how vs. knowing-that, incidentally mostly ignoring the research in psychology about declarative/procedural knowledge and implicit/explicit knowledge. There is no arguing that these questions are unimportant, but the point is that many other important questions have been neglected.

The solution to these issues consists in fostering multi-disciplinary research and cross-fertilization between scientific disciplines. (In the following, I will treat pluri-, inter-, multi-, trans-, and cross- disciplinary research as synonymous.) The idea is obviously to create mutual empowerment where the strengths of each discipline are brought together in order to create a gestalt-like entity which is more than the sum of its parts, as has been recently exemplified in undertakings such as the Human Genome Project. In addition to this ambitious aim, another important contribution of multi-disciplinary research is to show how models of expertise developed in a specific discipline (e.g., psychology) relate to data collected in another discipline (e.g., neuroscience). A concrete example is offered by Guida, Gobet, Tardieu, and Nicolas (2012), who showed how the psychological theories of template theory (Gobet & Simon, 1996c) and long-term working memory (Ericsson & Kintsch, 1995) make correct predictions about brain-imaging data and thus illuminate mechanisms occurring at the

neural level. Identifying the links between mechanisms occurring at different levels of analysis is obviously an important goal of scientific research (e. g., Simon, 1962).

The contributions that diverse disciplines can make to the study of expertise merit some comments. Psychology and neuroscience have a strong experimental tradition and can contribute considerable skills in designing experiments and analysing data. Sociology brings a focus on social issues and expertise in qualitative analysis and analysis of large cohort data. Artificial intelligence provides concepts and algorithms enabling the development of formal and therefore precise theories, which can perform the behavior under study—with obvious possible implications in the case of expertise. Philosophy excels in analyzing concepts and theories, and it can also contribute to powerful formalisms such as those based on logic.

It is my belief that a multi-disciplinary approach offers the only way to reach a full understanding of expertise, not only theoretically but also with respect to practical applications (e.g., for experts' training and more generally education). Researchers from various disciplines will have to relinquish, at least temporarily, the coziness of their disciplines in order to enter a dialogue with colleagues from other fields. In the extreme case, a new field may be created. At this stage, it is not possible to predict what the outcome of such an enterprise would be, as no research on expertise has so far been truly interdisciplinary. However, it is certain that it will highlight parallels but also differences between the individual disciplines, and that it will pinpoint contradictions between theories.

The Importance of Using Formal Methods

Due to the complexity of expertise, it is almost certain that formal modeling (both mathematical and computational) will play an important role. This complexity is produced by several factors, including at the very least the following: cognitive mechanisms occurring in parallel; necessity to adopt different levels of analysis

(e.g., micro-mechanisms with working memory, macro-mechanisms with planning); necessity to consider different time scales (from milliseconds to years); and necessity to factor in the environment in which experts develop and perform (e.g., Gobet, 2016; Gobet, Lloyd-Kelly, & Lane, 2018). The importance of the environment can be seen by the fact that experts in different fields meet vastly different demands, from knowledge in science to endurance or speed in sports to emotions in the arts. In addition, the mechanisms underpinning expertise include feedback loops, interact in nonlinear ways and often evolve as a function of time.

When the task is to develop precise and testable scientific theories, the most efficient way to deal with this complexity is to use computational modeling, which offers several advantages over other formal and non-formal approaches, at the very least including the following: rigorous specification of theories, testable predictions, sufficiency of theories (i.e., ability to carry out the behavior under study) and possibility to understand the interactions between several variables (Gobet, in press; Gobet et al., 2018; Lane & Gobet, 2012; Newell & Simon, 1972). Another advantage is that computational modeling makes it possible to study the role of the environment, sometimes together with more mathematical techniques (De Groot & Gobet, 1996; Simon & Gilmartin, 1973). A good example of this is offered by research into the acquisition of first language, which can be seen as a kind of expertise. For example, Freudenthal, Pine and Gobet (2009) showed that small differences in the characteristics of child-directed speech in German, Dutch, and English led to subtle but clear differences in children's speech, such as the fact that in Dutch and German root infinitives tend to refer to actions more than static situations.

Importantly, computational modeling can make new predictions that lead to theoretical re-evaluations. For example, the CHREST model developed by Gobet and Simon (1996a) predicted that, contrary to the received wisdom at the time, experts should be superior to non-

experts not only with domain-specific meaningful material, but also with domain-specific random material. This prediction was originally supported by a re-analysis of the experiments carried out with chess (Gobet & Simon, 1996b) and more recently with a meta-analysis that examined memory recall in all relevant domains of expertise (Sala & Gobet, 2017).

Some Hurdles

While the prospects of a multidisciplinary research on expertise are appealing, it should be acknowledged that this kind of research is not easy to carry out. Organizational structures, specialist terminologies, traditions, loyalties, and mental sets due to training mean that scientists often eschew such collaborative work. In addition, even if multidisciplinary collaboration is initiated, the problems of communication between different disciplines are considerable (Luhmann, 1995; Okada & Simon, 1997). Miscommunication is not always blatant and can be insidious. Even when participants believe that they understand a specific term (e.g., "rationality"), it frequently turns out that different members use that term with different meanings and epistemological connotations. In practice, it is often the case that at least one member of the multidisciplinary group should be an expert in several fields. But the danger, then, is that this person will assume leadership and impose the theoretical and methodological assumptions of her or his original field.

Conclusion

Starting from the observation that many different disciplines study expertise, this article has argued that the current state of research into expertise is problematic as knowledge is currently fragmented and communication between disciplines is poor. The way forward for the field of expertise is to join forces and carry out multi-disciplinary research. This is probably a difficult endeavor, but it is potentially a very fruitful one. While the process is likely to be uncomfortable and even painful, it

offers the prospect of interesting insights, more understanding within each discipline, and the development of a general theory of expertise.

Author's Declaration

The author declares that there are no personal or financial conflicts of interest regarding the research in this article.

References

Bilalić, M. (2017). *The neuroscience of expertise*. Cambridge: Cambridge University Press.

Binet, A. (1894). *Psychologie des grands calculateurs et joueurs d'échecs*. Paris: Hachette. [Reedited by Slatkine Ressources, Paris, 1981.]

Campitelli, G., & Gobet, F. (2010). Herbert Simon's decision-making approach: Investigation of cognitive processes in experts. *Review of General Psychology, 14*, 354-364.

Carlson, S. (1985). A double-blind test of astrology. *Nature, 318*, 419–425.

Cowles, A. (1944). Stock market forecasting. *Econometrica, 12*, 206-214.

Dawes, R. M. (1994). *House of cards: Psychology and psychotherapy built on myth*. New York: Free Press.

De Groot, A. D. (1978). *Thought and choice in chess (first Dutch edition in 1946)*. The Hague: Mouton Publishers.

De Groot, A. D., & Gobet, F. (1996). *Perception and memory in chess*. Assen: Van Gorcum.

Dreyfus, H. L., & Dreyfus, S. E. (1986). *Mind over machine: The power of human intuition and expertise in the era of the computer*. New York: Free Press.

Ericsson, K. A., Hoffman, R. R., Kozbelt, A., & Williams, A. M. (Eds.). (2018). *The Cambridge handbook of expertise and expert performance (2nd Ed.)*. New York: Cambridge University Press.

Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review, 102*, 211-245.

Freudenthal, D., Pine, J. M., & Gobet, F. (2009). Simulating the referential properties of Dutch, German and English Root Infinitives in MOSAIC. *Language Learning and Development, 5*, 1-29.

Gobet, F. (2011). *Psychologie du talent et de l'expertise [The psychology of talent and expertise]*. Bruxelles: De Boeck.

Gobet, F. (2016). *Understanding expertise: A multidisciplinary approach*. London: Palgrave.

Gobet, F. (in press). The classic expertise approach and its evolution. In P. Ward, J. M. Schraagen, J. Gore, & E. Roth (Eds.), *Oxford handbook of expertise: Research and application*. Oxford: Oxford University Press.

Gobet, F., Lloyd-Kelly, M., & Lane, P. C. R. (2018). Computational models of expertise. In D. Z. Hambrick, G. Campitelli, & B. N. Macnamara (Eds.), *The science of expertise* (pp. 347-364). New York: Psychology Press.

Gobet, F., & Simon, H. A. (1996a). Recall of random and distorted positions. Implications for the theory of expertise. *Memory & cognition, 24*, 493-503.

Gobet, F., & Simon, H. A. (1996b). Recall of rapidly presented random chess positions is a function of skill. *Psychonomic Bulletin & Review, 3*, 159-163.

Gobet, F., & Simon, H. A. (1996c). Templates in chess memory: A mechanism for recalling several boards. *Cognitive Psychology, 31*, 1-40.

Guida, A., Gobet, F., Tardieu, H., & Nicolas, S. (2012). How chunks, long-term working memory and templates offer a cognitive explanation for neuroimaging data on expertise acquisition: A two-stage framework. *Brain and cognition, 79*, 221-244.

Hambrick, D. Z., Campitelli, G., & Macnamara, B. N. (2018). *The science of expertise*. New York: Psychology Press.

Hoffman, R. R., LaDue, D. S., Mogil, H. M., Roebber, P. J., & Trafton, J. G. (2017). *Minding the weather: How expert forecasters think*. Cambridge, MA: The MIT Press.

Lane, P. C. R., & Gobet, F. (2012). A theory-driven testing methodology for developing scientific software. *Journal of Experimental and Theoretical Artificial Intelligence, 24*, 421-456.

Luhmann, N. (1995). *Social systems*. Stanford, CA: Stanford University Press.

Montero, B., & Evans, C. D. A. (2011). Intuitions without concepts lose the game: Mindedness in the art of chess. *Phenomenology and the Cognitive Sciences, 10*, 175-194.

Newell, A. (1982). The knowledge level. *Artificial Intelligence, 18*, 87-127.

Newell, A., & Simon, H. A. (1972). *Human problem solving*. Englewood Cliffs, NJ: Prentice-Hall.

Okada, T., & Simon, H. A. (1997). Collaborative discovery in a scientific domain. *Cognitive Science, 21*, 109-146.

Sala, G., & Gobet, F. (2017). Experts' memory superiority for domain-specific random material generalizes across fields of expertise: A meta-analysis. *Memory & cognition, 45*, 183–193.

Seligman, M. E. P., & Csikszentmihalyi, M. (2000). Positive psychology: An introduction. *American Psychologist, 55*, 5-14.

Selinger, E. (2011). *Expertise: Philosophical reflections*. Birkerød, DK: Automatic Press.

Simon, H. A. (1962). The architecture of complexity. *Proceedings of the American Philosophical Society, 106*, 467-482.

Simon, H. A. (1982). *Models of bounded rationality: Behavioral economics and business organization*. Cambridge, MA: The MIT Press.

Simon, H. A., & Chase, W. G. (1973). Skill in chess. *American Scientist, 61*, 393-403.

Simon, H. A., & Gilmartin, K. J. (1973). A simulation of memory for chess positions. *Cognitive Psychology, 5*, 29-46.

Staszewski, J. (Ed.) (2013). *Expertise and skill acquisition: The impact of William G. Chase*. New York: Psychology Press.

Ward, P., Schraagen, J. M., Gore, J., & Roth, E. (Eds.). (in press). *The Oxford handbook of expertise: Research and application*. Oxford: Oxford University Press.