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THE ROLE OF INTERESTS IN THE DEVELOPMENT OF EXPERTISE

A Multifactorial Perspective

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People with high levels of expertise in domains such as science, business, law, and music contribute to the prosperity of nations, the competitive advantage of organizations, and the well-being of families and communities. These individuals are often revered by society for their contributions—think of Marie Curie in science, The Beatles in popular music, Tiger Woods in sports, and Ruth Bader Ginsberg in the law. Scientific interest in expertise has a long history in psychology, dating to the earliest days of the field (Galton, 1869). Recent decades have witnessed an explosion of popular interest in research on expertise, as well, through books such as Malcolm Gladwell's (2008) *Outliers: The Story of Success* and Geoff Colvin's (2010) *Talent Is Overrated: What Really Separates World-Class Performers from Everybody Else.*

Not surprisingly, research has made it clear that an important determinant of both within-person and between-person variability in expertise is domain-specific experience: engagement in training and other types of activities within a given domain. Here, we consider the influence of interests on domain-specific experience. The chapter is organized into four major sections. In the first section, we provide a definition of expertise and discuss how expertise is measured in scientific research. In the second section, we briefly review evidence from recent research examining individual differences in expertise, including both domain-general and domain-specific factors. In the third section, we describe a multifactorial model of expertise (Ullén, Hambrick, & Mosing, 2016), and discuss predictions stemming from this model, particularly regarding the role of interests as a primary factor in learning and the development of expertise. In the final section, we offer several future directions for research on the role of interests in expertise over the lifespan.

What Is Expertise?

As a practical matter, people often identify or infer a person's expertise based on titles and credentials, as reflected by advanced degrees, certifications, and licenses. For example, we often assume that a person with an MD is an expert in medicine. And, given the strict laws around practicing medicine, we are generally willing to entrust the treatment of our physical ailments (and thus our lives) to such experts, with little vetting. However, as the old joke about what you call the person who finishes at the bottom of their medical school class (*doctor*) goes, being an MD only raises a patient's confidence that the doctor holds a minimum level of expertise. It certainly does not guarantee that the person is a *good* doctor.

As a scientific matter, expertise can be identified by measuring a person's performance on one or more tasks that capture the essential requirements of a domain (Ericsson & Smith, 1991). Performance can be measured directly (e.g., by having individuals perform laboratory tasks), or it can be measured more indirectly by means of estimation from various proxies for such tasks (e.g., ratings, rankings, grades, awards). For some domains, a single type of task may be sufficient to capture expertise. For example, playing good chess depends on choosing a series of good moves in actual chess games. Therefore, the researcher's obvious choice of a task to measure chess expertise is to give game positions to chess players and ask them to choose what they consider to be the best moves for White or for Black (de Groot, 1946/1978). The quality of each move can then be evaluated by comparing the participant's move using a chess analysis software program, given that current chess engines—such as Komodo, Stockfish, or Houdini—perform much better than even the best human players. One might also have expert chess players rate the moves. As another example, expertise in typing can be measured by giving participants a standardized passage of text to type that is of reasonable difficulty, and then measuring their speed and accuracy (highly skilled typists show both high speed and high accuracy, not one at the exclusion of the other).

For other domains, no single task can be argued to measure expertise, because there are specializations and even sub-specializations. For example, overall musical expertise comprises a wide range of activities, including sight-reading, improvising, composing, arranging, and so on. Similarly, lawyers perform a multitude of tasks, such as writing contracts and briefs, drumming up clients, negotiating settlements, and arguing cases before juries. In these domains, there are many classes of conceptually distinct situations that call on different types of specialized knowledge. Therefore, it is necessary to treat expertise as a multidimensional construct, or else to restrict the focus of research to a particular area of specialization (e.g., sight-reading in music). In some domains, it may even be misleading to use a single task to measure expertise, even if that task would seem to be the most obvious choice for doing so (Hambrick & Hoffman, 2016). For example, many stockbrokers may be no better at predicting the stock market than statistical algorithms (Andersson, 2004). Yet they may be measurably superior in a host of other critical domain-relevant activities, such as executing trades, interpreting economic data, and giving clients advice on how to diversify their investments.

As a final point, it is common in expertise research to classify people into distinct categories based on their level of performance in domain-relevant tasks, even though these categories are ultimately arbitrary labels. One common classification scheme is *beginner, novice, intermediate,* and *expert* (e.g., Chase & Simon, 1973); another is *initiate, apprentice, journeyman,* and *expert* (Hoffmann et al., 2013). These classification schemes can be useful for both research and applied purposes, but most, if not all, forms of expertise are *continuous* in nature (not discrete and univariate). Thus, cut-offs used to create categories representing different skill levels are necessarily arbitrary. That is, although skill level can certainly be distinguished as a practical matter, particularly at the extremes (e.g., beginner vs. expert), these groups do not represent discrete categories of individuals (like people who have brown, blue, or green eyes). Rather, levels of expertise refer to imperfect labels often applied to continuous measures of human performance. Thus, the goal of scientific research on expertise should not be to understand differences between groups of individuals such as "novices" and "experts," but rather to understand factors that contribute to individual differences in expertise across its full range.

Individual Differences in Expertise

Obviously, not everyone who enters a vocational or avocational domain will reach a high level of performance, even among people who have a strong desire to do so. For example, most people who take up a musical instrument will never become skilled enough to play in a local symphony, much less the Royal Concertgebouw Orchestra in Amsterdam, which is consistently ranked as the world's best symphony orchestra. Likewise, very few people who become an attorney will ever develop the legal expertise necessary to argue a case before the U.S. Supreme Court, and very few people who take up the game of golf will ever make it to a professional tour.

Success in these types of endeavors is, of course, influenced by opportunity. A child whose parents cannot afford to buy him a saxophone and pay for music lessons will probably not become the next Charlie Parker, just as the child whose parents cannot afford to buy her a proper set of golf clubs and pay for golf lessons will probably not become the next Michelle Wie. And legal expertise

is surely not the only factor that determines whether a lawyer gets the chance to argue a case before the Supreme Court. Unfortunately, being in the "right place at the right time" and knowing the "right people" often matters for success. But, beyond differences in opportunity, what are the knowledge, skills, abilities, and other factors (KSAOs) that distinguish people who reach a high level of expertise in complex domains from those who fail to do so? To put it another way, among people with similar opportunity, who rises to the top in business, science, music, sports, and other domains?

Decades of research in industrial-organizational psychology have left no doubt that *general cognitive ability*—the psychological trait captured by IQ tests—is a statistically and practically significant predictor of job training success and subsequent performance (see Schmidt & Hunter, 2004). Especially in the expertise literature, some theorists have argued that this is true only early in training, and that general abilities drop out as a predictor of performance differences at high levels of skill. For example, in their book *Peak: Secrets from the New Science of Expertise,* Ericsson and Pool (2016) claimed that "While people with certain innate characteristics...may have an advantage when first learning a skill, that advantage gets smaller over time, and eventually the amount and quality of practice take on a much larger role in determining how skilled a person becomes" (p. 233).

This hypothesis has been called the *circumvention-of-limits hypothesis* (Hambrick & Meinz, 2011), because the idea is that the acquisition of domain-specific knowledge and skills enables the performer to circumvent (or bypass) performance limitations associated with general abilities (see, e.g., Ericsson & Charness, 1994). As appealing as it is, evidence for this hypothesis is weak. We recently reviewed the available evidence (Hambrick, Burgoyne, & Oswald, 2019), conducting systematic searches for articles in the literatures on expertise (in games, music, science, sports, surgery/medicine, and aviation) and on job performance. On balance, evidence from the expertise literature does not support the hypothesis. To be exact, only 3 of 15 studies were found to show evidence for a diminishing role of cognitive ability with increasing skill, either in terms of significantly different ability-performance correlations across skill groups or Ability × Skill interactions on performance. What might be regarded as the strongest evidence for the hypothesis comes from one of our own meta-analyses (Burgoyne et al., 2016). We found that the correlation between fluid intelligence (as measured by tests of reasoning ability) and chess expertise was significantly higher for less-skilled chess players than for more-skilled players. However, as we noted, this finding must be interpreted cautiously, because the measure of chess skill was highly confounded with age. In general, findings from the expertise literature relevant to the circumvention-of-limitations hypothesis are difficult to interpret because of methodological shortcomings, such as small samples and use of measures with poor or unknown psychometric properties (see Hambrick et al., 2019, for a discussion).

A more consistent picture emerged in the review of evidence from the job performance literature: Even after an extensive amount of job experience, general cognitive ability remains a statistically and practically significant predictor of job performance (see also Reeve & Bonaccio, 2011; Schmidt & Hunter, 2004). Some of the most compelling evidence for this conclusion comes from a re-analysis of data from the Joint-Service Job Performance Measurement/Enlistment (JPM) Standards Project, a large study initiated in 1980 by the U.S. Department of Defense to develop measures of military job performance (see Hambrick et al., 2019; see also Wigdor & Green, 1991).[1] The JPM data set includes 31 jobs and a total sample size of 10,088 military personnel; the measure of general cognitive ability was the Armed Forces Qualifying Test (AFQT) score from the Armed Services Vocational Aptitude Battery, and job performance was measured with hands-on job performance (HOJP) tests for the different jobs. As shown in Figure 13.1, the AFQT-HOJP correlation decreases from the first year to the second, stabilizes, and then, if anything, increases. The overall picture to emerge from this and other large-scale studies (e.g., Schmidt, Hunter, Outerbridge, & Goff, 1988; Farrell & McDaniel, 2001) is that general cognitive ability remains a significant predictor of job performance, even after extensive job experience and even if validity drops initially.

Of course, this is not to say that general cognitive ability (or any other general ability) is the only important factor in acquiring expertise. Even a very smart person must engage in some form of training to acquire expertise, as no one is *literally* born an expert (or even a novice). (We humans may not enter the world as blank slates, but we are certainly not innately endowed with the type of specialized knowledge that is necessary for success in domains such as science, business, music, and the law.) Ideally, training is adapted to fit to the level of the person's skill, beginning simple. Then, as basic skills are mastered, training builds in complexity. For example, a music student learns scales and arpeggios before attempting to sight-read complex pieces of music.

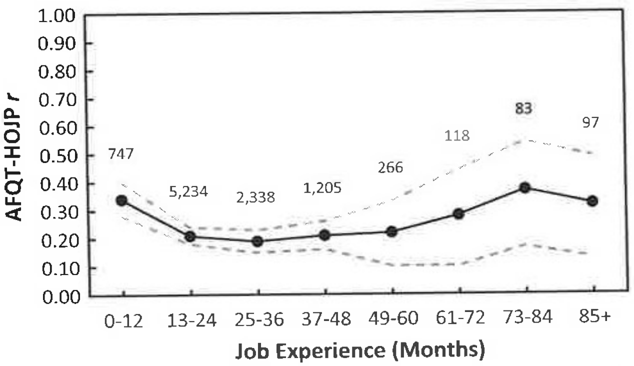

FIGURE 13.1 Correlations (with 95% confidence intervals) between AFQT scores and Hands-on Job Performance (HOJP) scores at 8 job experience intervals. Dashed lines are 95% confidence intervals; adjacent values are sample sizes. Data from Joint-Service Job Performance Measurement/Enlistment (JPM) Standards Project (N = 10,088). Adapted with permission of Oxford from Hambrick, Burgoyne, and Oswald (in press).

In technical terms, the training process contributes to *intra-individual variability* (change)—that is, improvement in performance over time. Even prodigies, who progress at an unusually rapid rate of domain-specific skill acquisition, must engage in extensive training to develop skill. For example, having learned the moves of chess at age 5, Magnus Carlsen started playing chess seriously at age 8 but did not become a grandmaster until age 13 (Gobet & Ereku, 2014), and then took another 6 years to reach number one in the Fédération Internationale des Échecs rankings. Notwithstanding reports from the North Korean government's state-run news media that the late Kim Jong-il shot a world-record demolishing 38-under par his first time playing golf (Longman, 2011), and bowled a perfect 300 on his first trip to Pyongyang Lanes despite drinking a pint of beer between each roll (Vasquez, 2012), there are no instant experts. Expertise is acquired gradually.

The more controversial question about expertise is not the need for training—everyone needs it to develop expertise—but the extent to which individual differences in training history can explain individual differences in expertise. Of particular interest has been the role of what Ericsson and colleagues (Ericsson, Krampe, & Tesch-Römer, 1993) termed *deliberate practice* in explaining individual differences in expertise. In a study made famous by Malcolm Gladwell in his bestselling book *Outliers: The Story of Success* (2008), these researchers asked violin students of varying levels of accomplishment to estimate the amount of time they had devoted to deliberate practice for each year since beginning their musical career. By young adulthood, the "best" group had accumulated an average of around 10,000 hours of deliberate practice. This was similar to the average for a group of professional musicians, and about 2,500 hours more than the average for the "good" group and 5,000 hours more than the average for the least accomplished group.

Applying their findings to several domains, Ericsson et al. concluded that "individual differences in ultimate performance can largely be accounted for by differential amounts of past and current levels of practice" (Ericsson et al., 1993, p. 392). To empirically test this claim, Macnamara, Hambrick, and Oswald (2014) conducted a meta-analysis of 88 relevant studies (157 effect sizes, with a cumulative sample size of $N > 11,000$) that quantitatively summarized correlations that were reported between activities interpretable as deliberate practice and performance. The results of the meta-analysis were summarized across five broad domains: games, music, sports, education, and professions. Across domains, deliberate practice accounted for an average of 14% of the variance in expertise. Furthermore, moderator analyses revealed that deliberate practice tended to be more predictive of expertise in some domains than in others.

For example, variance in expertise explained by deliberate practice was 24% for games, 23% for music, and 20% for sports, but only 5% for education and 1% for professions (for a correction to the original values, see Macnamara et al., 2018). Thus, regardless of domain, deliberate practice accounted for considerably less than half of the variance, and thus did not *largely account for* individual differences in expertise. In a meta-analysis on music, Platz, Kopiez, Lehmann, and Wolf (2014) similarly found that deliberate practice accounted for 37% of the variance in musical expertise, after accounting for measurement error.

Subsequently, Macnamara, Moreau, and Hambrick (2016) focused on the domain of sports, to assess the role of potential moderators of the relationship between deliberate practice and expertise. The study investigated whether this relationship might be moderated by whether the sport was a *closed-skill* sport (i.e., relatively predictable, such as running) versus an *open-skill* sport (i.e., less predictable, such as field hockey). The idea was that practice might be easier to design around closed-skill sports, meaning that practice would have a more standardized regimen, a more targeted effect, and thus have stronger correlations with performance. Conversely, open-skill sports might require skills that cannot be readily trained due to the complexity of the game requiring highly situation-contingent behaviors that are, relatively speaking, more difficult to practice and train for.

Moderation was not found for open- versus closed-skill sports, but was found for the skill level of the participants. Specifically, deliberate practice accounted for more variance in studies that sampled both elite and non-elite athletes (27%) than in studies that sampled only elite athletes (<1%). This finding could reflect a diminishing importance of training at high levels of skill. That is, among elite performers, it could be that abilities (talent) are the main distinguishing factor. To some degree, this finding could also reflect restriction of range among the elite athletes, although there was still a range of performance levels represented at the elite level (national- to international-level athletes).

Overall, evidence indicates that deliberate practice is an important piece of the expertise puzzle, just not as important as Ericsson and colleagues originally argued it is. That is, while deliberate practice appears to contribute substantially to individual differences in expertise, it leaves an even larger amount unexplained and potentially explainable by other factors. Ericsson and colleagues have further claimed that a minimum amount of deliberate practice (10 years, or 10,000 hours) is required to reach an elite level of performance. For example, writing in the *Harvard Business Review*, Ericsson, Prietula, and Cokely (2007) explained, "It will take you at least a decade to achieve expertise, and you will need to invest that time wisely, by engaging in 'deliberate' practice" (p. 116), adding: "Our research shows that even the most gifted performers need a minimum of ten years (or 10,000 hours) of intense training before they win international competitions" (p. 119).

This claim (the 10-year rule) may serve as a useful reminder to the layperson that expertise is acquired gradually, but as a testable proposition, it appears to be false. For example, as already mentioned, the Norwegian chess great Magnus Carlsen reached grandmaster status less than 6 years after he began playing chess seriously (and less than 9 years after learning the moves; Gobet & Ereku, 2014). And, in a study of chess players, Gobet and Campitelli (2007) found that the amount of deliberate practice that participants required to reach master status ranged from 3,016 to 23,608, and some players had not reached this level of skill despite more than 20,000 hours of deliberate practice. Ericsson (2006) allowed that "people are able to reach world-class levels in fewer than ten years in activities that lack a history of organized international competition" (p. 692), but as one of the world's oldest games, chess is clearly not such an activity. To be sure, there is *some* minimum amount of training that a person must engage in to become an elite performer, for reasons already discussed. However, that minimum does not appear to be 10 years (or 10,000 hours). Even in domains with a long history of organized international competition, it is considerably less for some performers.

In sum, key predictions stemming from Ericsson and colleagues' deliberate practice view are not well supported by empirical evidence. In the face of challenge, Ericsson has mounted a vigorous defense of his view. However, this defense has been undermined by repeated contradictions, inconsistences, and material errors in Ericsson's arguments (for further discussion, see Hambrick et al., 2014; Macnamara, Hambrick, & Moreau, 2016; Hambrick, Burgoyne, Macnamara, & Ullén, 2018). As a case in point, in an unpublished commentary, Ericsson (2014a; see also Ericsson, 2014b) criticized Macnamara et al. (2014) for deviating from his definition of deliberate practice, even though he has defined the term in conflicting ways, without acknowledging and explaining the shifts in the definition. For example, on the critical point of who designs deliberate practice, Ericsson has argued that a teacher ***must be involved:*** "In distinction from leisurely or normal job-related experience, Ericsson *et al.* defined *deliberate practice* as a very specific activity designed for an individual by a skilled teacher explicitly to improve performance" (Krampe & Ericsson, 1996, p. 333); that a teacher is ***typically involved:*** "When individuals engage in a practice activity (typically designed by their teachers), with full concentration on improving some aspect of their performance, we call that activity deliberate practice" (Ericsson, 2007, p. 14); and that a teacher ***need not be involved:*** "Ericsson et al. (1993) proposed the term deliberate practice to refer to those training activities that were designed solely for the purpose of improving individuals' performance by a teacher or the performers themselves" (Ericsson, 1998, p. 84).[2] Obviously, defining a theoretical term in conflicting ways is problematic, because it allows the theorist (and others) to flexibly select or reject evidence depending on whether it supports his theory.

Ericsson (2014a) also rejected studies that Macnamara and colleagues (2014) included in their meta-analysis for not meeting his criteria for deliberate practice that he previously used to explicitly argue for the importance of deliberate practice. Most perplexing, Ericsson even rejected some of his own studies, seeming to undermine the case he has made for the importance of deliberate practice. For example, he rejected his study of darts expertise (Duffy, Baluch, & Ericsson, 2004; see Ericsson's, 2014b, Table 2) because there is no record of a teacher/coach supervising all or most of practice, but in the article itself, based on the finding of skill group differences (i.e., amateur vs. professional) in measures labeled "deliberate practice" (see Duffy et al., Table 3, p. 240), he and his colleagues concluded: "This finding supports one of the main tenets of Ericsson et al.'s (1993) theory whereby expertise is acquired through a vast number of hours spent engaging in activities purely designed to improve performance, i.e., deliberate practice" (Duffy et al., p. 243). As another example, referring to another one of his own studies (Tuffiash, Roring, & Ericsson, 2007), Ericsson et al. (2009) noted that there are activities that meet the criteria for deliberate practice in the game of SCRABBLE: "Several researchers have reported a consistent association between the amount and quality of solitary activities meeting the criteria of deliberate practice and performance in different domains of expertise, such as...Scrabble (Tuffiash et al., 2007)" (p. 9). More recently, however, Moxley, Ericsson, and Tuffiash (2017) claimed that a person *cannot engage in deliberate practice in SCRABBLE:* "[T]he domain of SCRABBLE is a recently developed domain, and it lacks professional coaches and a large body of written knowledge about training. SCRABBLE players, therefore, must decide for themselves which types of training activities that they think are effective for improving their performance. Consequently, SCRABBLE players cannot engage in deliberate practice, but only purposeful practice and other types of practice" (p. 4). By all appearances, the "criteria of deliberate practice" have changed.

It is, of course, perfectly appropriate to revise a theory as evidence accumulates. This is a normal, and essential, part of the scientific process. However, it should go without saying that the revisions must be explicitly acknowledged and justified. A theorist must be willing to admit that his theory is wrong—or, at least, not quite right! Otherwise, a theory can be endlessly tweaked in response to challenge. Then, to use Ferguson and Heene's (2012) term, it becomes an *undead theory:* like the vampire or zombie that is deceased but behaves as if it is alive, a theory that is "ideologically popular but [has] little basis in fact" (p. 555) and "continues in use, having resisted attempts at falsification, ignored disconfirmatory data, negated failed replications...or having simply maintained itself in a fluid state with shifting implicit assumptions such that falsification is not possible" (p. 556).

The issues with deliberate practice theory aside, it is now relatively clear that deliberate practice (however operationally defined) is an important contributor to individual differences in expertise. That is, deliberate practice does not appear to be as important as Ericsson and colleagues originally argued, but it still accounts for a practically, statistically, and theoretically meaningful amount of the inter-individual variability in expertise—even if deliberate practice is confounded with aptitude. With that established, we now turn to the core of this chapter and examine interests as a key motivator for selecting a domain of expertise and then engaging in deliberate practice and other forms of domain-specific experience.

The Role of Interests in Expertise

Given evidence that training history contributes meaningfully to individual differences in expertise, it is important to ask what contributes to people's willingness to engage in training activities in the first place. Deciding to train is an important first step (e.g., deciding to enroll in college, or to pursue IT certification), but people vary greatly in how much they will then commit to the hard work that is required to reach a high level of expertise. For example, among children enrolled in piano lessons, some will practice diligently, whereas others will only practice before a lesson, if at all, before giving up.

Motivation is the fuel that drives sustained training, so before discussing interests as a form of motivation, we consider motivation more broadly. A high level of motivation is manifested in a willingness to engage in the activity (i.e., direction), to engage in that activity often (i.e., frequency), and to do so with a high level of focus (i.e., intensity). What are the factors that predispose a person to decide to spend thousands of hours training in some vocational or avocational domain, particularly when feedback may be ambiguous or discouraging to many, and particularly when success, however defined, is itself ambiguous or far from certain? For example, who among a classroom of high school students will be so taken with physics that they will go on to earn a PhD in the subject, and generate discoveries worthy of a Nobel Prize? Who among a group of music students will spend all of their free time in the practice room and earn a scholarship to Julliard? And who among a group of new attorneys at a large law firm will make partner? Interests reflect a form of motivation that presumably plays a key role in the formation of many types of expertise. In a free society, people often will invest a great amount of time and energy learning, practicing, and performing in a given domain, with domain-related interests forming, developing, and changing along the way. It is in this context that expertise in domains such as science, business, medicine, law, and any other profession is born.

As a psychological construct, interest can be thought of simply as a preference for engaging in some activity. Interests may be specific or general, although expertise eventually develops in specific domains, meaning that specific interests are usually the researchers' concern with regard to particular domains (e.g., music) and sub-domains (e.g., piano). Although specific interests are the primary focus of expertise research, general interests reflect preferences for engagement in broader classes of domains, and are therefore important to consider when considering how seeds of expertise get planted in the first place.

For example, it could be that a person who becomes highly skilled in oil painting could have also become highly skilled in metal sculpture under different circumstances, because both fall within the general domain of artistic interests.

Holland (1959, 1997) described general interest domains in his theory of vocational personalities and work environments. Specifically, as reviewed in the introductory chapter of this volume, he distinguished among six vocational interests: Realistic (R), Investigative (I), Artistic (A), Social (S), Enterprising (E), and Conventional (C). These interests may reflect different drives toward expertise. For example, the drive to hike El Capitan without a rope, as the rock climber Alex Honnold was first to do, seems to differ radically from the drive to become the Sage of Omaha, as Warren Buffet has been called for his financial investment strategies. From the RIASEC viewpoint, this makes good sense, because hiking is a Realistic task, and financial investment is Conventional (with some adjacent Enterprising interest).

RIASEC is as much a theory of environments (e.g., work, careers) as it is a theory of people, where over time, people tend to seek out activities congruent with their interests. The person-job fit literature in organizational psychology (e.g., Cable & Edwards, 2004; Kristof, 1996) capitalizes on this idea, addressing supplementary fit and complementary fit. With supplementary fit, the person and environment match on a similar profile of characteristics; for example, a job might require that a person have a high level of communication and teamwork skills, and employees that are hired possess this profile of requisite skills. Complementary fit, by contrast, represents the nature of transactional or reciprocal relationships between the person and the environment. For example, an organization might provide a good salary and benefits in exchange for an employee providing the aforementioned communication and teamwork skills (i.e., both parties are getting what they want through this exchange). Note that these two types of fit seem to mirror conditions that foster intrinsic and extrinsic motivation, respectively, and as noted earlier, motivation is the fuel for cultivating interests. Using the previous examples of fit, an environment that supports and rewards communication skills and teamwork allows employees with those skills to invest and refine them further. Or more generally speaking, once supplementary and complementary fit begin to be established in a person, and collectively in a team or organization, that can contribute to greater investment in interests over time. As interests strengthen, become refined, or otherwise change over time (Hoff, Briley, Wee, & Rounds, 2018), so might the domains of expertise in which one engages; or, if the domain is already fixed (e.g., one is already committed to a salesperson job and its sales objectives), then changing and refining one's interests might still occur in order to make task engagement and problem-solving more satisfying to oneself and effective for the organization. (For a theory of interests and interest refinement within a dynamic environment with cognitive and affective inputs, see the Four-Phase Model of Interest Development by Hidi and Renninger [this volume].)

The Multifactorial Gene-Environment Interaction Model of Expertise

Ullén et al's (2016) Multifactorial Gene-Environment Interaction Model (MGIM) provides a theoretical framework for thinking about the role of interests in the development of expertise. The model rests on three core assumptions. The first assumption is that expertise (i.e., domain-relevant performance) arises from the influences of domain-general traits (e.g., intelligence, personality) and the domain-specific characteristics (i.e., knowledge and skills) that arise from these traits. The second assumption is that these factors may have both direct and indirect influences on expertise. For example, domain-general traits may predict domain-specific characteristics, which in turn predict expertise. However, domain-general traits may also have direct effects on expertise. Finally, the model assumes that environmental and genetic influences operate throughout the model to produce individual differences in these factors. That is, consistent with a large body of evidence demonstrating that essentially all individual-difference characteristics are influenced by both genetic and environmental factors and their interplay (Plomin, DeFries, & Loehlin, 1977), the model makes no assumption that any individual-difference variable is purely environmental or purely genetic. Consistent with Turkheimer's (2000) *first law of behavioural genetics,* all individual-difference factors within the model are assumed to reflect both environmental and genetic influences.

As can be seen in Figure 13.2, training is one primary way that interests may operate to influence expertise. Specifically, people who have higher levels of interest tend to be more highly motivated and invest more of their time and effort in training on a consistent basis, eventually leading to greater expertise. There is empirical evidence to support these speculations. For example, in a study of 190 national spelling bee contestants, Duckworth, Kirby, Tsukayama, Berstein, and Ericsson (2011) found that *grit*—defined as perseverance and passion for long-term goals—predicted deliberate practice ($\beta = .30$, $p < .001$). In turn, deliberate practice predicted spelling performance ($\beta = .31$, $p < .001$). Thus, the type of people in the real world who decide to engage in deliberate practice was as important as deliberate practice itself. As another example, Miksza and Tan (2015) found that in a sample of 241 collegiate music students, grit was strongly and positively correlated with practice in terms of minutes per day ($r = .40$, $p < .001$). Although musical expertise was not measured in this study, Macnamara et al. (2014) estimated that the average correlation between deliberate practice and music expertise was .48, again suggesting that deliberate practice is an important mediator between individual differences (here, grit) and expert performance.

Another way to think about how interests influence performance through training is based on Vallerand et al.'s (2003) Dualistic Model of Passion. Within this model, *harmonious passion* (HP) refers to an internalization of an activity

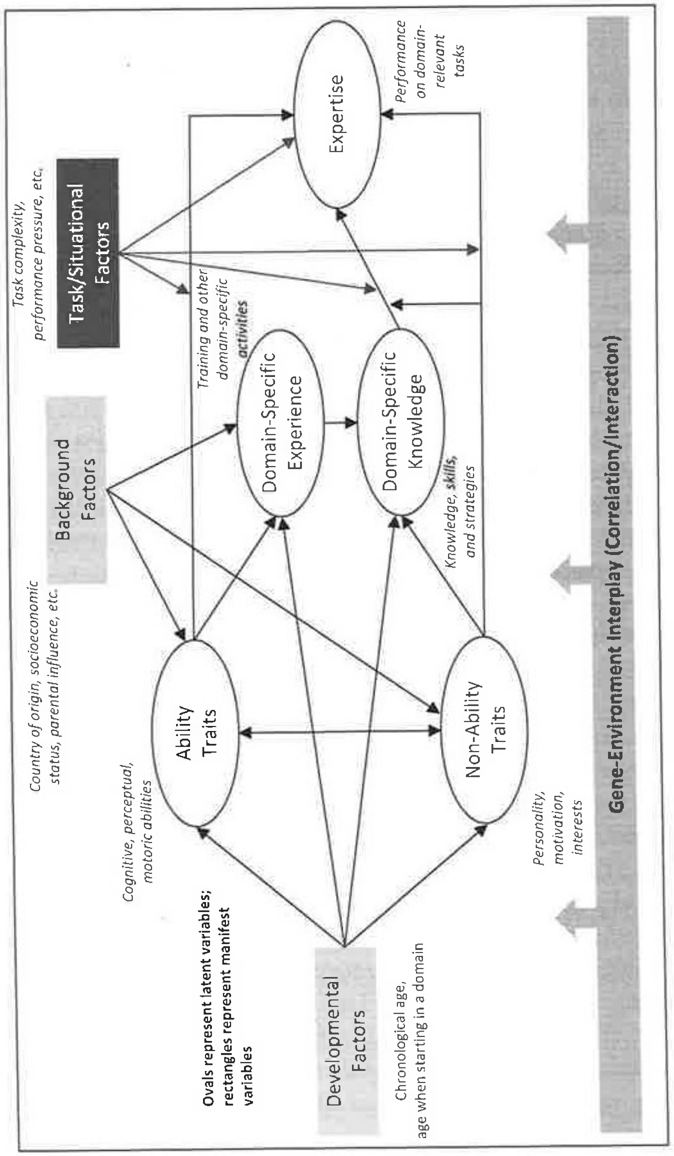

FIGURE 13.2 Instantiation of Multifactorial Gene-Environment Interaction Model (MGIM) of expertise (Ullén, Hambrick, & Mosing, 2016). Adapted with permission of Routledge from Hambrick, Campitelli, and Macnamara (2017).

into a person's identity, which motivates engagement in that activity and leads to positive affect. By contrast, *obsessive passion* (OP) refers to a controlled internalization of an activity into one's identity, such that one feels compelled to perform the activity despite conflicts with other aspects of one's life (Vallerand et al., 2003). HP and OP have been shown to jointly predict training time and perseverance under adverse conditions. In one study, Vallerand and colleagues examined the impact of HP and OP on cycling, despite unfavorable winter conditions found in Montréal. (During the winter, temperatures drop to an average of 8° F in Montreal, and slippery roads make cycling dangerous.) Only 30% of participants continued cycling through the winter, but those who persevered had higher levels of OP for cycling than those who did not. In another study, of water-polo and synchronized swimming athletes, Vallerand and colleagues (Vallerand et al., 2008) found that HP and OP correlated significantly with deliberate practice (rs of .30 and .32, $ps < .01$, respectively). Deliberate practice, which in this study referred to training activities performed independent of coaching or supervision, in turn correlated significantly with coach-evaluated performance ($r = .33$, $p < .01$).

Thus, across multiple empirical studies, a particular model of mediation is strongly supported: interest in a domain positively predicts engagement in training in that domain, which in turn positively predicts expertise. Note that interest and engagement themselves may be fuelled not only by the situational features, but by personality traits such as conscientiousness and grit. Furthermore, some research has discovered that conscientiousness and interest can compensate for one another across individuals (Trautwein et al., 2015). As a specific example of a compensatory relationship that may occur in the development of expertise, a person high in interest but low in conscientiousness may engage in more playful activities in the domain (forgoing "serious" practice). By contrast, a person high in conscientiousness but low in interest may engage in practice over the short term, but may ultimately experience burnout because they feel they should practice even though they lack interest in doing so. One can also reasonably speculate that compensation occurs *within* individuals over time as well. For example, sometimes playing the violin feels deeply interesting in certain moments of task engagement; yet in other moments, it can feel like sheer drudgery to practice. Anyone who is considered an expert has likely had both experiences in their pursuit of expertise.

Finally, it is possible that interests may also have effects on domain-relevant performance, independent of domain-specific knowledge. For example, a person with a high level of interest in a task may maintain greater task focus than a person with a lower level of interest, and consequently be less prone to mind-wandering (Unsworth & McMillan, 2013) and more likely to become immersed in the task and experience a "flow" state (Csikszentmihalyi, 1990).

Summary and Conclusions

We believe that adopting a multifactorial perspective involving a wide range of relevant personal characteristics and situational factors will push scientific understanding of the origins of expertise to new heights. This includes a better understanding of the role of interests as a key motivating factor for developing expertise. Traditionally, research on expertise has focused on what for all but a few people are hobbies, such as games, music, and sports. However, the insights gained through multifactorial research on expertise are equally applicable to the workplace, and efforts to bridge the gap between research in workplace performance and expertise will enhance understanding of both.

We already know that those who possess high levels of knowledge and interest in a given domain as children will likely continue into adult careers that fall within that same domain (Austin & Hanisch, 1990; Makel, Kell, Lubinski, Putallaz, & Benbow, 2016). A multifactorial perspective should incorporate interests, and also follow up on the personal, social, and situational factors that together can facilitate or limit interests and aspirations, and therefore subsequent development of expertise. Examples include feedback on one's task performance (e.g., timely, veridical, or normative feedback); family, peer, and teacher support (vs. discouragement or conflict); perceived and actual discrimination (e.g., by race, gender, or disability); and mental and physical health. Meta-analysis has investigated some of these factors within a larger developmental framework focused on academic achievement and success (Brown et al., 2018), and this framework could inspire a similar approach in the continued study of the development of expertise.

Teachers, mentors, and coaches have a whole host of intervention strategies to improve performance in others. They motivate and engage interests, and they attempt to tailor training to the specific needs of individuals, both of which can certainly be seen in the case of athletic training (e.g., Mann, Lamberts, & Lambert, 2014). An important goal for research on expertise is to conduct high-quality longitudinal research that can usefully inform the design and tailoring of these interventions that will improve a person's engagement with tasks and situations relevant to education, work, hobbies, and life, and thus ultimately accelerate the acquisition of knowledge, skill, and expertise. New technologies not only make more intensive data collection possible, to inform such research; these technologies may bring the interventions within reach of more people, including low-SES, underrepresented minorities, the disabled, and those living in rural settings, ultimately bringing expertise within the reach of more people than is currently the case. We may see more experts in our future as a function of technology and big data—so long as both are well-informed by psychological research and theories in areas such as interests, motivation, knowledge and ability, training and practice, and expertise.

Finally, it is critical to note that interests *shape* the process of developing expertise; they do not *dictate* that process. Cultivating interests, learning, and expertise throughout the lifespan surely benefits from both short-term interventions and longer-term nurturing environments (e.g., intensive mentoring, or college). However, those settings also allow for important-yet-unanticipated interests, learning experiences, and new insights into oneself to emerge (see the Happenstance Learning Theory of Krumboltz, 2009). In these beneficial settings, we agree with Louis Pasteur (1854) who famously said that luck favors the prepared mind. However, luck will also favor those who are more open to experience (von Stumm, 2018; Woo, Keith, Su, Saef, & Parrigon, 2017) and can identify and create expertise-building situations that present themselves.

Notes

1. We are grateful to Dr. Jane M. Arabian (Assistant Director, Accession Policy Office of the Under Secretary of Defense, The Pentagon, Washington, D.C.) for granting us permission to use the data, and to Dr. Rodney McCloy (Principal Scientist, Human Resources Research Organization, Louisville, KY) for sending us the data, with helpful notes.
2. What is Ericsson's current definition of deliberate practice? It depends on where you look. On his website, he defines deliberate practice as "activities designed, typically by a teacher, for the sole purpose of effectively improving specific aspects of an individual's performance" (see archived webpage here). However, in *Peak: Secrets from the New Science of Expertise*, he states that "deliberate practice requires a teacher who can provide practice activities designed to help a student improve his or her performance" (Ericsson & Pool, 2016, p. 98).

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