Chapter 1

Analyzing musical prodigiousness using Gagné's Integrative Model of Talent Development

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Introduction

1. Defining (musical) prodigies

For most people the term “prodigy” brings to mind three defining characteristics. The first one is a *process* characteristic: it refers to an extraordinary learning pace in mastering the competencies of a specific occupational field. As Kenneson (1998) aptly noted: “The ability to develop exceedingly quickly is the hallmark of the prodigy, whether the ability expresses itself in the prodigy-prone field of music or elsewhere” (p. 36). This process leads to two closely linked *outcome* characteristics: (a) an outstanding level of competence, akin to expert mastery, in a particular human occupation, and (b) its attainment at a very early age, usually before adolescence. So, prodigies are extremely precocious—pre-teen—high achievers within a specific field of human occupation, in the present case music. Webster's Dictionary (1983) does nothing to attenuate the image of quasi-miraculous achievements. Its main meaning says: “a marvel; a person, thing, or act so extraordinary as to inspire wonder; as, a child *prodigy*” (p. 1436).

This global view agrees with existing scholarly definitions. Here are a few examples. A prodigy is “... a child who, at a very young age (typically younger than 10 years old), performs at an adult professional level in a highly demanding culturally recognized field of endeavor” (Feldman & Morelock, 2010, p. 212). Prodigies are “very young children who demonstrate extraordinary abilities and exceptional talents” (Shavinina, 2009, p. 233). “A prodigy is simply a more extreme version of a gifted child, a child so gifted that he or she performs in some domain at an adult level” (Winner, 1996, pp. 4–5). “A prodigy is able to function at an advanced adult level in some domain before the age of twelve” (Solomon, 2012, p. 405). Note that these definitions do not explicitly acknowledge the process characteristic mentioned above. Moreover, they do not include precisions concerning either the minimum level of expertise required, the maximum age of appearance, or the exact meaning of “culturally recognized field of endeavor”. We will address these ambiguities later in this chapter.

Common usage frequently confounds the concepts of prodigy and genius. In our view, they are very different. We have chosen to endorse Robert S. Albert's landmark definition of genius:

[A genius is] a person who produces, over a long period of time, a large body of work that has a significant influence on many persons for many years; requiring people, as well as the individual in question, to come to terms with a different set of attitudes, ideas, viewpoints, or techniques before all can have “peace of mind”; that is, a sense of resolution and closure.

(Albert, 1983, p. 61)

The principal author, François Gagné, whose theory of talent development forms the basis of this chapter, wrote all the drafts, and authored all twenty-three innovative proposals described on pages 103–104. As second author, Gary E. McPherson facilitated the adaptation of Gagné's theoretical framework to music and to musical prodigies.

This definition shows that former prodigies can attain in adulthood, old age, or even posthumously, the status of genius, but their musical prodigiousness in itself has nothing to do with this technical definition of genius.

2. Chapter organization

We aim in this opening chapter to dissect the phenomenon of musical prodigiousness, looking for answers to a key question: Where does that phenomenal developmental growth originate, and what nourishes it? Are special gifts involved, special temperamental predispositions, or more powerful motivations? Does exceptional investment in time and/or energy play a crucial role, or else a special nurturing environment? In other words, we aim to pinpoint what makes a difference between becoming a musical prodigy as opposed to “just” reaching high musical talent as a young or older adult. Music is a very broad field, including not only performers in a diversity of musical instruments, but also composers, maestros, music teachers, music critics, and many others. Each of these specialties requires different abilities, and implies distinct developmental paths. To avoid undue complexity, we have chosen to focus on the specific subfield where the vast majority of musical prodigies are found, namely music performers in keyboard and string instruments.

We will employ as our dissecting tool three developmental models: the *Differentiating Model of Giftedness and Talent* (DMGT), the *Developmental Model for Natural Abilities* (DMNA), and the *Integrative Model of Talent Development* (IMTD), formerly called “expanded model” (Gagné, 2013a). The first author developed the DMGT progressively over the past 30 years (Gagné, 1985) within the field of education, and targeted primarily the educational talent development of bright boys and girls, commonly called “gifted children.” Its reputation progressively exceeded the boundaries of gifted education to encompass, among other fields, musical talent development (e.g. McPherson & Williamon, 2006, 2016) and sports talent development (e.g. Gagné, 2015; Tranckle & Cushion, 2006). The DMNA and IMTD represent recent proposals (Gagné, 2013a, 2015). In the first case, the author aimed to describe the complex developmental process of human natural abilities, commonly—but wrongly—called “innate talent”, from their biological roots to their behavioral expression in childhood and later; that process involves a delicate and still only partially understood interplay between nature and nurture. For its part, the recently created IMTD brought the DMGT and DMNA models together into a unified whole.

In the first two parts of this chapter, we will survey the three analytical models involved in this exploration, focusing on the DMGT in Part I, then on the DMNA and IMTD in Part II. In Parts III to VII, each of the five DMGT components will serve as a focusing framework to examine the nature of musical prodigiousness. This dissection will come together in Part VIII with the key question “Becoming a musical prodigy: Which DMGT facets make a difference?”

I—A brief walk through the DMGT

A—The two key DMGT constructs

1. Giftedness and talent

The DMGT was created to take advantage of the fact that scholars and practitioners almost unanimously acknowledged that the concept of “giftedness” represented two distinct realities: early emerging forms of “giftedness” with strong biological roots, as opposed to fully developed adult forms of “giftedness.” Scholars expressed that distinction through pairs of terms such as potential/realization, aptitude/achievement, or promise/fulfilment. Since two labels, giftedness and talent, were available to describe outstanding abilities, it seemed logical to attach each label to one, and only one, of these two concepts. Thus were born the two basic definitions that constitute the core of the DMGT framework, presented below in their current form.

Giftedness designates the possession and use of untrained and spontaneously expressed outstanding natural abilities or aptitudes (called gifts), in at least one ability domain, to a degree that places an individual at least among the top 10% of age peers.

Talent designates the outstanding mastery of systematically developed competencies (knowledge and skills), in at least one field of human activity, to a degree that places an individual at least among the top 10% of “learning peers” (those having accumulated a similar amount of learning time from either current or past training).

Note how the DMGT clearly separates the concepts of giftedness, potential, aptitude, and natural abilities, on the one hand, from those of talent, performance, achievement, systematically developed abilities, as well as expertise, eminence, and prodigiousness; this is one of the DMGT’s unique qualities. The DMGT will stand—or fall—on the validity of that basic distinction, especially on the acceptance of the giftedness part of this crucial duo of constructs. Note also that we use here the term “ability” as an umbrella construct that covers both “natural” abilities (aptitudes) and “systematically developed” abilities (competencies). No complete consensus exists on the concept of giftedness, although the vast majority of scholars and professionals in various fields of talent development (e.g. music, sports, education) do recognize the existence of what most call “innate talent.” Still, there are some disbelievers; we will address their objections later.

2. Differential assessment of aptitudes and achievements

Even though we call aptitudes a “potential”, assessing their level involves measuring some form of performance. As an example, psychologists use an IQ test to measure intellectual potential. So, as Gagné (2013c) asked relevantly: “How can we hope to distinguish aptitude measures from achievement measures if both rely on some form of performance” (p. 201)? Indeed, the differences are not qualitative; there are no “pure” measures of aptitude on one side, and of achievement on the other. Measures of natural abilities range over a continuum from indices much more typical of natural abilities to clearly accepted achievement measures. Angoff (1988) proposed ten differentiating characteristics between aptitude and achievement measures; they are summarized in Table 1.1. Angoff worded all the descriptions as *quantitative* differences between types of instruments; they simply lean in opposite directions with regard to each criterion. The disparities will stand out easily if we compare well-known examples in each category, for instance Gordon’s (1965/1995) *Music Aptitude Profile (MAP)*, as opposed to any end-of-year exam in musical competence. The specificity (item A) and recency (item B) of contents mentioned in Table 1.1 differ markedly; the abilities assessed with the *MAP* will apply to the learning of any instrument, even voice, whereas any music curriculum focuses on a particular instrument (item C). Similar clear differences will emerge as we continue down Table 1.1.

Is there any hierarchy among these ten characteristics? The labels used in the DMGT (“natural” vs. “systematically developed”) point at both Angoff’s and Gagné’s choice as the overarching differentiator, namely the strength of genetic input in the case of aptitudes as opposed to the crucial role of practice in the case of competencies/talents (see Gagné, 2009, 2013b, for a detailed discussion).

3. The prevalence issue

How many people are gifted and/or talented? As shown in both definitions above, the DMGT proposes a clear answer: “outstanding” means individuals who belong to the top 10% of the relevant reference group in terms of natural ability (for giftedness) or achievement (for talent). This generous choice for the initial threshold is counterbalanced by the recognition of degrees of giftedness or talent. The DMGT’s metric-based (MB) system of levels (Gagné, 1998b) constitutes an intrinsic constituent of the DMGT. It has five hierarchically structured levels, with each successive level including the top 10% of the preceding one; they are labeled *mildly* (top 10%), *moderately*

Table 1.1 Angoff's differentiating characteristics for aptitudes and competencies

Aptitudes (natural abilities)		Competencies (systematically developed abilities)	
Content			
A	More <i>general</i> content	More <i>specific</i> content	
B	" <i>Old formal</i> " learning	<i>Recent</i> acquisitions	
C	More widely <i>generalizable</i>	<i>Narrower</i> transfer to other situations	
Processes			
D	Major <i>genetic</i> substratum	Major <i>practice</i> component	
E	<i>Slow</i> growth	<i>Rapid</i> growth	
F	<i>Resistance</i> to stimulation	<i>Susceptibility</i> to stimulation	
G	<i>Informal</i> learning	More <i>formal</i> learning	
Purpose			
H	<i>Prospective</i> use (predicting future learning)	<i>Retrospective</i> use (assessing amount learned)	
I	Usable for <i>general population</i> evaluation	Limited to <i>systematically exposed individuals</i>	
J	Usable before any formal learning	Requires formal learning to assess	

(top 1%), *highly* (top 1:1,000), *exceptionally* (top 1:10,000), and *extremely* or *profoundly* (top 1:100,000). These levels apply to every domain of giftedness and every field of talent.

The prevalence question is crucial for both theoretical and practical reasons. From a theoretical standpoint, a prevalence estimate represents an important contribution toward a more precise definition of any normative construct (e.g. poverty, tallness, weight, most neurotic syndromes) that targets, as is the case with giftedness and talent, a marginal subgroup within a population. Practically speaking, adopting for instance a threshold of 10% instead of 1%—a *tenfold* difference in estimated prevalence—has a huge impact on selection practices and talent-development policies and services. These reasons no doubt explain why the “How many?” question is the second most common question—after “What do you mean by “gifted (or talented)?”—asked by the media and the general public. Unfortunately, the “How many?” question has no absolute answer; nowhere will we find a magical number that automatically separates those labeled gifted or talented from the rest of the population. The establishment of a proper threshold requires that professionals reach a consensus, just like nutritionists did (National Institute of Health, 1998) when they established the various category thresholds for the body mass index (BMI). Unfortunately, no such consensus has yet been achieved in the various fields of talent development (Gagné, 1998b).

Keeping the above comments in mind, let's move on with our brief tour of the DMGT. As shown in Figure 1.1, it brings together five *components*: gifts (*G*), talents (*T*), and the talent development process (*D*), as well as intrapersonal (*I*) and environmental catalysts (*E*). The first three constitute the core of the DMGT; their interaction summarizes the essence of the DMGT's conception of talent development—the progressive transformation of gifts into talents.

B—The talent development basic trio

1. Gifts (*G*)

The *DMGT* proposes six natural ability domains: four of them belong to the mental realm (intellectual—*GI*, creative—*GC*, social—*GS*, perceptual—*GP*), and the other two to the physical realm

Figure 1.1 Gagné's Differentiating Model of Giftedness and Talent (DMGT).

Reproduced from François Gagné, From genes to talent: the DMGT/CMTD perspective, *Revista de Educación*, 368, p. 19, Figure 1, DOI: 10.4438/1988-592X-RE-2015-368-289 © 2015, Ministry of Education, Culture and Sport. General Technicall Secretariat.

(muscular–GM, motor control–GR). As shown in Figure 1.1, each of these domains or *subcomponents* comprises more specific *facets*. Natural abilities are not innate; they do develop, especially during childhood, through maturational processes and informal exercise (see Part II-B). Yet, that development and level of expression are partially controlled by the individual's genetic endowment. We observe major individual differences in natural abilities in the daily lives of all children, both at home and at school. For instance, think of the intellectual abilities needed to learn to read, speak a foreign language, or understand new mathematical concepts; the creative abilities needed to solve different kinds of problems and produce original work in the visual and performing arts, literature, technology, and science; the physical abilities involved in sports, performing music, and sculpture; the social abilities essential in interactions with classmates, teachers, and parents. Gifts can be observed more easily and directly in young children because environmental influences and systematic learning have not yet exerted their moderating influence in a significant way. However, they still show themselves in older children, and even in adults, through the facility and speed with which individuals acquire new competencies in any field of human activity. Said differently, ease and speed of learning are the trademarks of giftedness; they contribute strongly to the learners' pace of progress, with extremely rapid learning pace being, as mentioned earlier, the crucial developmental characteristic of prodigies.

2. Talents (T)

Within the DMGT framework, talents progressively emerge from the transformation of these outstanding natural abilities or gifts into the well-trained and systematically developed competencies characteristic of a particular field of human activity. On the potential–performance continuum, talents belong to the performance pole, and thus represent the *outcome* of the talent development process. Talent fields can be extremely diverse. Figure 1.1 shows nine talent subcomponents. Six of

them correspond to the American College Testing's World-of-Work classification of occupations (ACT, 2008). It has its source in John Holland's RIASEC classification of work-related personality types: Realistic, Investigative, Artistic, Social, Enterprising, and Conventional (see Anastasi & Urbina, 1997, Chapter 14). Three additional subcomponents complement the RIASEC taxonomy: pre-occupational academic (K-12) subjects, games, and sports. Thanks to a variety of exercises, exams, or competitions, we can assess talents more easily—with more reliability and validity—than aptitudes. But the simplicity of such assessments hides a real interpretive complexity, since their results always reflect the combined and interactive action of all four causal components: aptitudes, developmental processes, and both sets of catalysts.

3. Developmental process (D)

Natural abilities or aptitudes serve as the “raw materials” or constituent elements of talents; they act through the talent development process. Talent development is formally defined as “the systematic pursuit by *talentees*, over a significant and continuous period of time, of a structured program of activities leading to a specific excellence goal” (Gagné, 2015, p. 20). The neologism *talentee* describes anyone actively involved in a systematic talent development program, whatever the field. The D component has three subcomponents (see Figure 1.1): activities (DA), investment (DI), and progress (DP), each subdivided again into multiple facets. Talent development begins when a child or adult gains access (DAA), through an identification or selection process, to a systematic program of activities. These activities include a specific content (DAC), the curriculum, offered within a specific learning environment (DAF or format). That learning environment may be either unstructured (autodidactic learning) or structured (e.g. school, music conservatory, sport organization). The investment (DI) subcomponent quantifies the intensity of the talent development process in terms of time (DIT), psychological energy (DIE), or finances (DIF). Finally, the progress (DP) of talentees from initial access to peak performance can be broken down into a series of stages (DPS) (e.g. novice, proficient, advanced, expert). Its main quantitative representation is pace (DPP), or how fast—compared with learning peers—talentees are progressing toward their predefined excellence goal. The long-term developmental course of talentees will be marked by a few crucial turning points (DPT) (e.g. being spotted by a teacher or a coach, receiving an important scholarship, accidents, death of a family member or close friend).

C—The “supporting cast”

Two large sets of catalysts, respectively labeled *intrapersonal* and *environmental* (see Figure 1.1) affect the talent development process, either positively or negatively.

1. Intrapersonal catalysts (I)

The I component has five subcomponents grouped into two main dimensions, namely stable traits (physical–IF, mental–IP), and goal management processes (self-awareness–IW, motivation–IM, and volition–IV). The IF subcomponent includes physical characteristics that *do not* act as building blocks for natural abilities (see Part II-B), but can impact, sometimes critically, the talent development process, for instance a person's general physical health, a pianist's finger span that affects choice of repertoire (Parncutt & Troup, 2002; Wagner, 1988), or specific handicaps. Within the mental or personality (IP) category, we find an almost infinite list of descriptive qualities. The concept of temperament (IPT facet) refers to behavioral predispositions with a strong hereditary component, whereas the term personality encompasses a large diversity of positive or negative acquired styles of behavior (Rothbart, 2012). The most widely

accepted structure for personality attributes is called the Five-Factor Model (FFM). These factors are respectively labeled *Openness to experience* (O), *Conscientiousness* (C), *Extraversion* (E), *Agreeableness* vs. *Antagonism* (A), and *Neuroticism* vs. *Emotional stability* (N); they can easily be remembered through the acronym OCEAN. Research has shown that each factor has strong biological roots (McCrae, 2009).

The term “motivation” usually brings to mind both the idea of *what* motivates us (IM), and *how intensely* motivated or determined (IV) we are; that is, how much effort we will invest to reach a particular goal. Within the framework of their *Action Control Theory*, two German scholars (see Corno, 1993; Kuhl & Beckman, 1985) proposed differentiating the goal-seeking process into distinct goal-setting activities, which would receive the label motivation (IM), and goal-attainment activities, which they labeled “volition” or willpower (IV). Talented will first examine their values and their needs, as well as determine their interests or be swept by a sudden *coup de foudre* or passion; these will serve to identify (IM) the specific talent goal they will be aiming for. The loftier that goal, the more efforts talented will need to reach it (IV). Long-term goals placed at a very high level require intense dedication, as well as daily acts of willpower to maintain practice through obstacles, boredom, and occasional failure.

2. Environmental catalysts (E)

In Figure 1.1 the E component is shown partially covered by the I component. This partial overlap signals the crucial filtering role of the I component with regard to environmental influences. The narrow downward arrow at the left indicates some limited direct E influences on the developmental process (e.g. social pressures, rules, or laws). But most environmental stimuli have to pass through the sieve of an individual’s needs, interests, or personality traits; talented continually pick and choose which stimuli will receive their attention. The E component comprises three distinct subcomponents. The first one (EM) includes a diversity of *social* influences, from demographic ones (e.g. climate, rural vs. urban living) to political, financial, or cultural ones. The second subcomponent (EI) focuses on the *psychological* influence of significant persons in the talented’s immediate environment. It includes of course parents and siblings (EIF), but also the larger family, teachers and trainers (EIT), peers (EIP), mentors, and even public figures adopted as role models by talented. The third subcomponent (ER) covers all forms of *educational* resources and programs. The two traditional facets of enrichment and administrative provisions directly parallel the “content” and “format” facets of the DA subcomponent described earlier. Here we adopt a broader outlook rather than examine special services from the perspective of a given talented’s talent development course. Enrichment refers to specific talent development curricula or instructional strategies; its best-known example is called enrichment in density or curriculum compacting (Reis, Burns, & Renzulli, 1992). Official curricula such as national or regional music syllabuses found in many countries belong to that category. In gifted education, professionals commonly subdivide administrative provisions into two main practices: (a) ability grouping (part-time or full-time), and (b) accelerative enrichment (e.g. early entrance to school, grade skipping).

3. Note on the chance factor (C)

Chance used to play the role of a fifth causal factor associated with the environment (e.g. the chance of being born in a particular family; the chance of the school in which the child is enrolled developing a program for talented students). But, strictly speaking it is *not* a causal factor. Just like the type of influence (positive vs. negative), chance characterizes the *predictability* (controllable vs. uncontrollable) of elements belonging to the four other components (G, D, I, or E). Chance’s

crucial involvement is well summarized by Atkinson's (1978) belief that all human accomplishments can be ascribed to:

two crucial rolls of the dice over which no individual exerts any personal control. These are the accidents of birth and background. One roll of the dice determines an individual's heredity; the other, his formative environment.

(Atkinson, 1978, p. 221)

These two impacts alone give a powerful role to chance in sowing the foundations of a person's talent development possibilities. Because of its redefined role, the "chance" factor should no longer appear in a visual representation of the DMGT. Yet, because of its popularity among DMGT advocates, it was given some visibility in the background of the components it influences (see Figure 1.1).

D—Talent development as a dynamic process

Readers should keep in mind two crucial points concerning the theoretical scope of the DMGT. First of all, it does not pretend to be anything more than a *talent development model*. As we have said repeatedly, the DMGT's target outcome is talent, strictly talent. Of course, within a holistic perspective (e.g. Ambrose, 2012) a person's global development involves much more than just an outstanding mastery of work- or leisure-related competencies; for instance, it may include acquiring a well-rounded personality, developing strong values, caring for others, and so forth. But, as important as these parallel goals are, they cannot be included as outcomes within the limited scope of the DMGT. Second, the DMGT maintains a *macroscopic perspective*; it ignores daily or weekly events that have only small or temporary effects on the talent development process. For instance, as heartbreaking as a disappointing concert performance or audition by a young musician can be, we will bypass it if there are no lasting impacts on that musician's professional progress.

1. Basic developmental dynamics

Space considerations limit our discussion of this subject to just a few general comments.

1. A dynamic view of talent development automatically implies constant interactions between various elements—essentially facets—within the DMGT. These interactions will manifest themselves in two main ways: (a) *between* components (e.g. parental behavior [EIF] influencing a talentee's motivations [IM]; the talentees' brisk pace of progress [DPP] acting on their commitment [IM–IV] to pursue their education and/or training; their parents' commitment [EIF] to maintain their support); (b) *within* components (e.g. interactions between parents [EIF] and teachers [EIT] with regard to a young musician's program of activities; the impact of pace of progress [DPP] on curriculum [DAC] modifications). There can be literally hundreds of such interactive modalities. They come to the forefront or recede into the background as the developmental process evolves with time.
2. The most central dynamic process is the active involvement of natural abilities as building blocks of systematically developed skills. Their role is metaphorically similar to the pleiotropic action of many genes (Dawkins, 2010); a given G facet may act as the building block for a large diversity of competencies. For example, abilities belonging to the motor control (GR) subcomponent can be modeled into the particular skills of a pianist, a painter, or a video game player. Similarly, cognitive processes (GI) can be modeled into the scientific reasoning of a chemist, the memorization and game analysis of a chess player, or the strategic planning of an athlete.

3. Because talent emerges from the dynamic interaction between *all* causal facets identified in the preceding sections, each of them may vary in the intensity of its causal influence from one person to the next, across developmental periods, or between fields of talent. For example, pianists or violinists do not need outstanding creativity (GC) to master a specific musical piece; similarly, computer programmers have little use for special physical abilities, just those any human being needs to go through a typical day.
4. Because all four causal components (G, D, I, E) contribute to the developmental process, any particular facet need not always express itself beyond the top 10% threshold; this is especially the case for natural abilities. In other words, talent may emerge *without* gifted-level natural abilities, as long as other components compensate to ensure that the minimum top 10% threshold of achievement is reached. Of course, as we shall see later in this chapter, higher levels of talent will require correspondingly higher levels of input from relevant natural abilities.
5. The previous comments lead to one major observation: individual differences on any valid measure of competencies reflect the *combined impact of all significant causal influences* active at the time that measure was obtained. Consequently, we must always guard ourselves against oversimplified explanations of observed achievements. Most of us have our pet “causes” to explain the emergence of talent. For instance, look at the following example: “Without a violoncello [*sic*], instruction and family support, Yo-Yo Ma could not become an outstanding cello player” (Guenther, 2011, p. 63). Such examples, proposed most of the time to highlight some environmental influence, bring to mind three closely linked reactions. First, we should not talk about causal variables in an either/or, present/absent manner; most causal variables appear in quantitative form, in a more/less format. Second, we could replace the first few words in many ways: “without exceptional natural abilities for music, Yo-Yo Ma ...”, or “without a passion for music and for that particular instrument, Yo-Yo Ma ...”, or “without thousands of hours of deliberate practice, Yo-Yo Ma ...”, or “without the strong willpower needed to maintain that heavy practice schedule, Yo-Yo Ma ...”. Second, we could point out that among the thousands of young boys and girls who, every year, start cello lessons, most quit within a year or two, and just a few ever reach professional status. In brief, there is much more to becoming a Yo-Yo Ma than just enjoying a propitious environment that offers the cello, the instruction, and the family support!

2. What makes a difference?

Although all four causal components are always active, it does not mean that they exert equal influence. We saw above how true it was at the individual level, with each talentee following a unique path toward excellence. But what can we say about average influences? Are some causal factors generally recognized as more powerful predictors of outstanding achievements? Which among them appear to make more of a difference in reaching excellence? All professionals involved in any type of talent development consider this search for the key “ingredients” of talent as the Holy Grail of their professional efforts. And, as stated at the beginning of this chapter, it will become our key question in Part VIII of this chapter. Gagné (2004) examined that complex question in the context of academic talent development. His literature review brought him to propose a G–I–D–E decreasing hierarchy: gifts first, followed by intrapersonal catalysts (especially IM and IV), followed by the D component (especially DI), with E catalysts judged to play a somewhat more modest role. It will be interesting to see which special observations made throughout this chapter will influence our proposed answer to that question in the case of musical prodigiousness.

II—Introducing the DMNA and IMTD

The DMGT can be seen as a dynamic map of the numerous causal influences facilitating or blocking the growth of competencies in general, including their outstanding manifestations as talents. Among this large set of influences, natural abilities play, as we have seen above, a significant causal role. If we define these natural abilities as having significant biological roots, it becomes necessary to position these roots somewhere within the DMGT. But the DMGT was designed strictly as a framework for behavioral variables. These reflections led to four consecutive theoretical developments: (a) identifying the main categories and levels for the biological underpinnings of the main DMGT components; (b) integrating these biological basements within the existing DMGT framework; (c) determining the dynamic interactions between these biological bases and other influences responsible for the development of natural abilities, thus creating the *Developmental Model for Natural Abilities* (DMNA); and (d) creating the *Integrative Model of Talent Development* (IMTD) as a natural integration of the two existing models. Let us look more closely at this evolution.

A—Biological underpinnings of talent development

Recurring questions from scholars and practitioners, as well as personal observations, highlighted the absence in the DMGT of specific references to recognized nonbehavioral influences on the growth of natural abilities (e.g. neurophysiological activity, gene activity, anatomical characteristics) or the structure of intrapersonal catalysts (e.g. neurotransmitter action, genetic foundations of personality traits). The recent exceptional growth of the neurosciences, thanks in large part to neuroimaging techniques, was also showing how brain structures and processes were directly correlated with individual differences in cognitive, social, or physical abilities, interests, and other major behavioral functions (Geake, 2009). In its current form, the DMGT left no specific room to include these distal sources of talent emergence. So, how could we transform it to properly integrate these significant sources of causal influence?

For quite a long time science has taken for granted some form of hierarchical organization of explanations, moving progressively from behavioral phenomena, *down* to physiology, microbiology, chemistry, and then physics. For instance, Plomin, DeFries, Craig, and McGuffin (2003) describe functional genomics as “a bottom-up strategy in which the gene product is identified by its DNA sequence and the function of the gene product is traced through cells and then cell systems and eventually the brain” (p. 14). The expression “bottom-up” makes clear that such biological *underpinnings* would occupy basement levels under the strictly behavioral DMGT framework, thus creating a 3D representation. The large number of levels of analysis suggested more than one basement; but how many should there be? Strictly speaking, identifying the proper number of levels was not crucial; it was also highly probable that experts in these fields would argue *ad infinitum* about the “right” number of such explanatory levels. A brief examination of the literature suggested a comfortable solution of three underground levels. Consequently, if we use a “house” metaphor, we have the DMGT occupying the ground floor (see Figure 1.2), with three distinct basements underneath.

The bottom basement has been reserved for genotypic foundations (e.g. gene identification, mutations, gene expression, epigenetic phenomena, protein production, and so forth); we can roughly label that third basement the *chemical* level. The second basement, the *physiological* level, is essentially devoted to microbiological and physiological processes. This second basement moves us from genotypic to phenotypic phenomena; but their hidden nature, at least to the naked eye, justifies labeling them *endophenotypes*; they correspond to “physical traits—phenotypes—that are not externally visible but are measurable. Endophenotypes can reveal the biological bases of a disorder better

Figure 1.2 The DMGT's biological underpinnings.

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than behavioral symptoms because they represent a fundamental physical trait that is more closely tied to its source in a gene variant” (Nurnberger & Bierut, 2007, pp. 48–9). Similarly, Gottesman and Gould (2003) explain that, in the case of phenomena having multi-gene origins, endophenotypes provide “a means for identifying the ‘downstream’ traits or facets of clinical phenotypes, as well as the ‘upstream’ consequences of genes” (p. 637). Finally, the basement closest to the ground level includes *anatomical* or morphological characteristics that have been shown to impact abilities or intrapersonal catalysts. Most of these characteristics are observable *exophenotypes*, either directly (e.g. tallness in basketball, physical template in gymnastics) or indirectly (e.g. brain size through neuroimaging, white and grey matter distribution, muscle type through biopsy). Both endophenotypes and morphological traits are part of the complex hierarchical causal chain joining genes to physical abilities, and ultimately to systematically developed skills. No detailed cartography has yet been proposed in the DMGT for these biological underpinnings beyond the above trilogy of levels.

B—A Developmental Model for Natural Abilities (DMNA)

Beyond its main role as a dynamic framework to explain the birth and growth of natural abilities, the creation of the DMNA provided an excellent opportunity to perform three important “corrective surgeries” that had been causes for the first author’s constant personal frustration: (a) correct the wrong image of natural abilities given by common expressions such as “innate talent” or “God-given gifts”, (b) respond to scholars who were questioning the relevance of the concept of giftedness, and (c) correct the misunderstanding transmitted by well-meaning users of the DMGT who opposed gifts and talents as innate versus acquired. That simplistic bipolar view is wrong: gifts are not innate—they develop during the course of childhood, and sometimes continue to do so during adulthood. This developmental view of “natural” abilities has to fight its way through a host of common language expressions that maintain the ambiguity, like “she is a born musician,” or “it’s God’s gift”, or “this is not

something you learn; either you have it or you don't!" So, if all these uses of the label "innate" are incorrect, what does "innateness" really mean?

1. The proper meaning of "innate"

When we say that little Mary is a "born" pianist, we are certainly not implying that she began playing the piano in the nursery, nor that she was able to play a concerto within weeks of beginning her piano lessons. Describing her talent as innate only makes sense metaphorically. It will convey the idea that Mary progressed rapidly and seemingly effortlessly through her music curriculum, at a much more rapid pace than that of her learning peers. The same applies to any natural ability. Intellectually precocious children do not suddenly manifest an exceptional vocabulary or impressive reasoning processes; they develop these cognitive abilities by going through the same developmental stages as any other child. The difference resides essentially in the ease and speed with which they advance through these successive stages. The term "precocious" says it all: they reach a given level of knowledge and reasoning *before* the vast majority of their learning peers. And the higher their intellectual giftedness, the earlier these successive stages will be mastered.

Terminological clarification Researchers in behavioral genetics have defined the term "innate" in a very specific way. At the behavioral level, it implies "hard-wired, fixed action patterns of a species that are impervious to experience. Genetic influence on abilities and other complex traits does not denote the hard-wired deterministic effect of a single gene but rather probabilistic propensities of many genes in multiple-gene systems" (Plomin, 1998, p. 421; see also Elman et al., 1996). So, when we use it to qualify the DMGT's natural abilities, we convey two false interpretations: (a) that the observed individual differences are immutable, and (b) that they are present at birth or, if not, appear suddenly with very little training. Because of its restricted meaning, very few scientists use the term "innate" to describe any type of natural ability. Consequently, the term "innate talent" should disappear from our technical vocabulary; more so, within the DMGT framework, it is a clear oxymoron, just as "innately gifted" would be!

If natural abilities cannot be labeled "innate" as defined above, what does innate mean exactly? Where does the "gift" in giftedness reside? It certainly does not reside in the upper basement of Figure 1.2, since most of these anatomical structures result from extensive development; usually, they do not reach maturity until adolescence or adulthood. They are clearly not innate in the way we defined that term. If we go one basement down to the level of neurophysiological processes, we might be in a grey zone where it becomes difficult to separate innate processes from those that result from developmental activities. For example, most stages in the process of embryogenesis are governed by genetic rules (Dawkins, 2010). If the development is strictly maturational, then we could probably speak of innateness. Most importantly, however, it is clear that the lowest basement, devoted to gene activity, is almost—but not totally, according to the new field of epigenetics—completely under inborn control.

In conclusion, we hope to have clearly shown that most natural abilities, except maybe some very crude ones (Fagan, 2011), are not innate, nor do they appear suddenly at some point during a person's early—or later—development. Just like any other type of ability, natural abilities need to develop progressively, in large part during a person's younger years, but, as shown in Angoff's criteria (see Table 1.1), they will do so spontaneously, without the structured learning and training activities typical of the talent development process.

Note on Treffert's "savants" The above conclusion leaves aside a group of exceptional talents displayed by special individuals who have received the label "savants." Treffert (2012a, 2012b) has devoted a large part of his career to the study of these exceptionally talented individuals. He describes a diversity of examples of almost unbelievable achievements manifested by autistic

individuals, young and adult, which he labels “innate talents” or “islands of genius”. The vast majority of these achievements involve extraordinary memory processes applied to specific fields (e.g. mental computing, playing a musical instrument, photographic memory, graphic skills). Here is one example—the case of a blind mentally retarded subject (IQ of 58) called LL, who began playing the piano when he was 8 years old, and then mastered half a dozen other musical instruments.

One evening, at about age 14, LL heard Tchaikovsky’s Piano Concerto No. 1 for the first time as a theme song to a movie on television. To his foster parents’ complete astonishment, LL played that piece back flawlessly from beginning to end later that evening, having heard it just that one time. Since then LL’s piano repertoire, completely from memory, has expanded to thousands of pieces. Professional musicians who have witnessed LL’s piano playing have indicated that he seems to know “the rules of music” instinctively and innately.

(Treffert, 2012b, p. 105)

How can such an example not bring spontaneously to mind the adjective “prodigious?” In his recent book (Treffert, 2012a) and chapter (Treffert, 2012b), Treffert describes dozens of additional cases of similar “instant talent”. He considers them innate because they appear suddenly, often in early youth, and express themselves at a high level of quality, with a few of them rapidly reaching a prodigy level with a minimum of systematic learning. Treffert (2012b) proposes a novel interpretation, namely the existence of a “genetic memory” that ensures “the inherited transfer of specific *talents* and actual *knowledge* in addition to all the other physical characteristics, instincts, traits, proclivities, inclinations and dispositions that our inherited genes carry forward in each of us from conception” (p. 109). He further proposes “that there exists in each person already at birth an enormous amount of inherited, ‘factory-installed, hard wired’ circuitry for certain abilities, coupled with considerable likewise genetically transferred knowledge itself regarding the ‘rules’ of those talents, unconsciously remembered” (p. 110). Both of these theoretical proposals will probably receive limited support from the scientific community; they suggest major changes in perspective from most researchers in neuropsychology. Moreover, the rarity of the savant syndrome in the population, which represents a small percentage within an already small autistic population, incites us to caution with regard to his second hypothesis about each one of us having such inherited, but dormant, hard-wired circuitry for certain complex skills. Still, we cannot ignore the reality of these extraordinary learning behaviors from individuals whose general cognitive aptitudes remain well below average. For the time being, because we have not yet examined this phenomenon in depth, we will just acknowledge their existence, and the fact that they appear to question our view that abilities cannot be innate. It might well be that the IMTD cannot, in its present form, explain every expression of talent. Yet, for the time being, it represents a theoretical framework that covers adequately the vast majority of talent development situations, whatever the field.

2. Describing the DMNA

If natural abilities do develop, how does that development proceed? Figure 1.3 shows that process through the *Developmental Model for Natural Abilities (DMNA)*. At first glance, it might look similar to the DMGT illustrated in Figure 1.1. But a closer look shows major differences between the two, at both the component and the subcomponent levels. The main difference is of course a transfer of the G component from the left side to the right side; aptitudes—and their outstanding expression in gifts—are now the outcome of this particular developmental process. Here, the three levels of biological underpinnings, structural elements as well as processes, become the building blocks for the phenotypic natural abilities. Genotypic foundations are isolated with an arrow showing their action on both endo- and exo- phenotypes. The two upper basements are linked

Figure 1.3 Gagné's Developmental Model for Natural Abilities (DMNA).

Reproduced from François Gagné, From genes to talent: the DMGT/CMTD perspective, *Revista de Educación*, 368, p. 30, Figure 3, DOI: 10.4438/1988–592X-RE-2015-368-289 © 2015, Ministry of Education, Culture and Sport. General Technical Secretariat.

because of their parallel influences on the growth and manifestation of outstanding aptitudes. We will mention later (see Part IV-D) examples of these biological foundations that are specific to musical aptitudes.

The developmental process that characterizes natural abilities appears here in summary form, with just two macroprocesses identified. Maturation covers a diversity of biological processes at each of the three basement levels, from embryogenesis upward, that govern the growth of mental and physical abilities. These maturational processes have no direct relationship with the talent development process; they mold the natural abilities that will become, in turn, the building blocks of talents. As for the learning subcomponent, it is called “informal” because it lacks the structured organization (e.g. curriculum, access rules, systematic schedule, formal assessment) typical of talent development activities. It takes the form of spontaneous learning acquired mostly subconsciously, with little daily or weekly attention to its growth. We could subdivide that informal process into the three subcomponents—activities, investment, progress—adopted in the case of talent development, but the lack of systematization would make these elements difficult to assess in any systematic way. Of course, parents will be able to identify their children's physical or mental activities, the approximate amount of weekly investment, and their approximate standing among age peers. Beyond that, we would be moving into talent development territory.

One cannot imagine a developmental process without catalytic influences, both intrapersonal and environmental. These two sets of catalysts appear here structurally unchanged, with the same subcomponents and facets. As we will see below, the exact contents within each element will differ, as well as their relative causal significance. Two subcomponents, self-awareness (IW) and resources (ER), appear in lighter font in Figure 1.3 because they play a much more modest causal role. For example, we cannot expect young children to show the same level of self-awareness (IW) of strengths and weaknesses as do older individuals. But, we will see (Part VI) that intense interests and passions (IM) can manifest themselves very early. Similarly, within the realm of mental

traits (IP), very large individual differences appear as soon as we start assessing any of them, either through self, parent, or teacher ratings. For example, in an often-cited research program, Jerome Kagan (1989) was able to distinguish inhibited toddlers from uninhibited ones, and follow their development for a number of years. Children express very early their desire—or lack of it—to engage in all kinds of daily activities: physical exercise, reading, playing a musical instrument, video games, playing with friends, and so forth. To a significant extent, their level of interest will influence the amount of their short-term or long-term investment, as well as their decision to participate in a talent development program and maintain their involvement in it (Evans & McPherson, 2014; Evans, McPherson, & Davidson, 2013).

Finally, environmental catalysts also play a significant role in fostering or hindering the development of human aptitudes; and all three subcomponents—Milieu, Individuals, and Resources—are involved. Here are just a few examples. With regard to the Milieu (EM subcomponent), recent studies have shown that the degree of heritability of cognitive abilities varies with the socioeconomic level of the families; the genetic contribution decreases significantly in low-income families (Harden, Turkheimer, & Loehlin, 2007; Tucker-Drob & Harden, 2012). In fact, the whole area of gene–environment interactions belongs to the E component. It is worth noting also that the strict environmentalist ideology, often called the *Standard Social Science Model* or SSSM (Pinker, 2002; Tooby & Cosmides, 1992), gives predominance to this source of causal influences on the development of cognitive aptitudes. With regard to the Individuals (EI) subcomponent, any interventions by the parents to create a specific family environment, either propitious to general knowledge learning, to musical activities, or to athletic ones, could impact the development of related natural abilities. The same applies to their active efforts to involve their children in such activities, like visits to museums or concerts, winter or summer family sports activities, or any other activities that could foster a child's natural mental or physical gifts. In the case of the Resources (ER) subcomponent, the informal nature of the children's developmental activities strongly reduces its causal role. Yet, government programs developed to improve the school preparedness (a.k.a. cognitive abilities) of at-risk children represent an interesting example of efforts to build up these natural abilities. But, since most of them target children with average or below average abilities, their relevance for the emergence of cognitive giftedness remains disputable.

In sum, natural abilities proceed through a developmental process somewhat similar to the talent development process. The same basic “ingredients” are involved in fostering or hindering their growth. But, as Angoff (1988) perceptively highlighted, the most significant distinction between gifts and talents remains the amount of direct genetic contribution. The DMNA makes that point clear in its choice of building blocks.

Note. Because of space limitations, we chose not to discuss here the biological underpinnings of most intrapersonal catalysts, as well as some environmental catalysts, especially those belonging to the EI subcomponent. When relevant, we will introduce them in our analysis of musical prodigiousness.

C—Merging the DMGT/DMNA into the IMTD

As soon as the DMNA was conceived, it became clear that joining the two developmental models into a *Integrative Model of Talent Development* (IMTD) would bring closure to these theoretical musings. Figure 1.4 illustrates the result, with the G component's central position ensuring the linkage between the development of outstanding natural abilities on the left side and the talent development process itself on the right side. The CMDT shows that talent development has its distal origins in the progressive development of natural abilities, as early as through the chance meeting of a sperm cell and an ovum. This produces a unique genotype in the fertilized egg. Through the complex

Figure 1.4 Gagné's Integrative Model of Talent Development (IMTD). Reproduced from François Gagné, From genes to talent: the DMGT/CMTD perspective, *Revista de Educación*, 368, p. 34, Figure 4, DOI: 10.4438/1988-592X-RE-2015-368-289 © 2015, Ministry of Education, Culture and Sport. General Technical Secretariat.

process of embryogenesis, that single egg will multiply and its descendants will diversify into hundreds of different cell types, each with millions of exemplars, in a coordinated developmental process closely supervised by the genotype that will lead to the birth of a new baby. The maturation process will continue after birth as the various natural abilities, mental and physical, progressively take form at a particular level, thanks to the contribution of the two sets of catalysts, as well as innumerable daily occasions for informal learning and practice. At some point, usually during childhood or early adolescence depending on the type of talent chosen, some gifted individuals, or those not too far from the DMGT's cut-off threshold of top 10%, will choose a talent field that fits their perceived profile of natural abilities and interests, and begin the long and complex journey leading to eventual top performance, as described through the DMGT framework. Some will go far beyond the basic 10% threshold, but others will not, and the reasons behind the level of expertise achieved by these talents will be as diverse as the facets that comprise the DMGT.

D—Summing up and planning ahead

The first author assumed writing responsibility for this brief overview (Parts I and II) of his theoretical framework of talent development. It is hoped that the description, as compressed at it needed to be, still conveys his preoccupation for conceptual and terminological rigor. It extends well beyond the crucial differentiation between the concepts of giftedness and talent, or the borrowed parallel distinction between the concepts of motivation and volition. It also involves efforts at comprehensiveness and rigor in the identification and definition of the subcomponents for all five components of the DMGT; it includes similar efforts in the creation of third-level facets for many subcomponents, as well as the delineation of the biological underpinnings of natural abilities. All these efforts culminate in the dynamic integration of all parts within the IMTD.

Both authors will now share the complex task of applying this theoretical framework, component by component, to the “dissection” of musical prodigiousness (MP). It is indeed a complex task because, except for a few recent empirical studies (e.g. Ruthsatz & Urbach, 2012) and theoretical considerations (e.g. Vandervert, 2009), the quasi-totality of our information on musical prodigies comes from anecdotal sources, essentially one book (Kenneson, 1998), one extensive chapter in Solomon's (2012) book, a few biographical books and chapters (e.g. this volume) devoted to individual musical prodigies, and finally the million or so websites that descriptors like “musical prodigies” identify. Other sources (e.g. Feldman, 1986; Radford, 1990; Sacquin, 1993; Winner, 1996) offer less relevant information because their samples include just a few musical prodigies as part of a broader coverage (e.g. science, mathematics, visual arts, literature, chess, sport). Still, we will borrow from them whenever the information seems relevant to our discourse. Which theoretical framework shall we use: the DMNA, the DMGT, or the IMTD? The choice of the most appropriate framework depends on the analytic focus. Here, the focus will be the emergence of a particular talent, namely musical prodigiousness. Consequently, except for the occasional mention of some relevant biological underpinnings, we will adopt the DMGT's analytical framework.

Harris (1998) cautions researchers about the limits of anecdotal sources: “as social scientists like to say, the plural of *anecdote* is not *data*” (p. 214). If we want to use such sources effectively, we must first make a selection based on some relevant set of criteria, and then analyse their content systematically with the help of appropriate tools, just as social scientists commonly do with interview data. We found only one such attempt in the musical literature (Sosniak, 1985) but, as we will see, her sample did not include bona fide musical prodigies. As a compensatory measure, we did our best to extract from the anecdotal materials recurring observations that could hint at potential generalizations concerning prodigies' developmental characteristics. We will introduce these observations with the caution that their impressionistic origin requires. We will be looking for characteristics that seem to distinguish musical prodigies (MPs) from less exceptional peers.

As we stressed in our introductory comments, our mission consists in pinpointing what makes a difference between becoming a musical prodigy as opposed to “just” reaching high musical talent.

We will begin (Part III) by discussing the exact meaning of the concept of prodigy, considered of course as an exceptionally high level of musical talent; we will give special attention to its quantitative nature and, consequently, to its conceptual frontiers. Then, in Part IV, we will try to bring some conceptual and terminological logic and order to the current chaotic vocabulary that different scholars use to describe musical aptitudes, the DMGT's G component. In Part V, devoted to the developmental process itself, we will discuss among other things the central issue of musical practice through Ericsson's (2014) construct of “deliberate practice” (DIE/DIT); we will also discuss the MPs' phenomenal pace of progress (the DPP facet), Kenneson's (1998) hallmark characteristic of prodigies. We will then search for the intrapersonal (Part VI) and environmental (Part VII) catalysts that best contribute to the emergence of musical prodigiousness. Finally, we will conclude this chapter (Part VIII) by proposing our personal answer to the key question: “What makes a difference?”

III—MPs and the talent component

Because of its central role as target construct for this entire book, it is important to analyse closely the proper meaning of the constructs of “musical prodigy” and “musical prodigiousness”. We will show that a concept that appears at first glance very simple and brings to mind vivid images can hide unsuspected complexities.

A—The core nature of musical prodigiousness

First, which label best fits musical prodigies: “gifted” or “talented” musicians? The DMGT definitions proposed at the very beginning of this chapter leave no doubt that because of their outstanding competence, MPs are first and foremost “talented”. Within the DMGT framework, the systematically developed mastery of high level musical competencies (knowledge and skills) means “talent”. But can we also call them “gifted musicians?” We will answer that question in Part IV. Second, what qualifier of talent level from the DMGT's MB system best applies to them: “high” (1:1,000), “exceptional” (1:10,000), or “extreme” (1:100,000) talent? We will address that key question later in the present section. For the time being, following the commonly held view as well as Webster's almost hyperbolic definition mentioned in the Introduction, we will consider them “extremely” talented. Finally, in logic, the “intensional definition” (see Wikipedia's eponymous entry) of a term should specify all the *necessary* and *sufficient* properties required to produce that definition. With respect to musical prodigiousness, it seems an easy task: we need only the two *outcome* characteristics identified at the outset of this chapter—(a) pre-teen, and (b) high level mastery—to properly identify the *core* of the MP construct.

There is no dearth of extremely talented young musicians, past or present. The hundreds of names we can extract from a variety of Wikipedia websites or from compendia of case studies (e.g. Cooper, this volume, Chapter 7; Kenneson, 1998; Radford, 1990; Sacquin, 1993; Solomon, 2012) confirm the richness of prototypical examples. Who would question the MP status of Ludwig van Beethoven, Julian Bliss, Sarah Chang, Jascha Heifetz, Erich Wolfgang Korngold, Lang Lang, Franz Liszt, Yo-Yo Ma, Lorin Maazel, Felix Mendelssohn, Wolfgang Amadeus Mozart, Yehudi Menuhin, Ervin Nyiregyházi, Camille Saint-Saëns, or Stevie Wonder? Such unequivocal examples of prodigiousness help constitute the core or prototypical population of prodigies.

B—A quantitatively distinct population

If talent expresses itself from “mild” to “extreme”, we should observe a continuous series of intermediate levels of talent between those who barely reach the minimum threshold and the prodigies

who occupy the apex of that competence hierarchy. Yet this hierarchical perspective goes against the common view of most people. Indeed, because most examples focus on the core population described above, scholars and the general public tend to consider MPs as a self-enclosed population, *qualitatively* distinct from average or even highly talented musicians; they appear to stand apart without any close emulators. Morelock defended that qualitative viewpoint with regard to intellectually gifted individuals when she defined giftedness as “asynchronous development in which advanced cognitive abilities and heightened intensity combine to create inner experiences and awareness that are qualitatively different from the norm” (Morelock, 1996, p. 8). In a response to Morelock, Gagné (1997) argued vigorously that gifted or talented individuals do not differ *in any qualitative way* from “normal” individuals, even when their gifts or talents place them far above the norm.

This quantitative perspective extends to musical prodigies who constitute a very small subset of the talented population. If we metaphorically compare the population of musicians with an iceberg, talented musicians (the DMGT’s top 10% among learning peers) represent its visible tip, and prodigies occupy the very small tip of that visible tip. This “tip of the tip” subpopulation includes all highest-achieving musicians, both young and adults. We put together youth and adults because the “iceberg” represents a continuum of competence levels *independent of age*. There has to be a continuous series of levels *within* that “emerged” talented population, from the “tip of the tip” down to those who have barely crossed the threshold of talent, just as in any normally distributed set of human characteristics. If we compare novices and experts, we will of course observe qualitatively distinct learning and performing strategies; it should not be surprising since we are comparing the two extremes of the distribution. But, one would be hard pressed to identify in the long road to excellence a specific moment when processes suddenly switch from novice behavior to advanced level, and then to expert behavior. There are an almost infinite number of intermediate steps in the transformation of a beginning musician into an expert performer, just as there are an infinite number of intermediate generations—approximately 250,000 according to Dawkins (2005)—between us and our common ancestor with our chimpanzee “cousins” about six or seven million years ago. Each generation did not differ in any perceptible way from the next, and the similarities would hold even if we were to look sequentially only at each hundredth ancestor, all 2,500 pairs of them. With respect to MPs, it is first and foremost their more rapid progress, itself a quantitative characteristic, that distinguishes them from very talented, but older, musicians. Indeed, although their skills were mastered much sooner, music teachers will often judge them equivalent to those of much older students, even to adult professional musicians. In other words, their skills will not appear qualitatively different from those of other highly talented musicians.

Do we have any proof of that continuum of achievement levels? The data in Table 1.2 provide empirical support for our position (Mott, 2014). It shows the age distribution over a 3-year period (2011–2013) for piano candidates who completed the Associate in Music, Australia (A.Mus.A) and Licentiate in Music, Australia (L.Mus.A.) diplomas offered by the *Australian Music Examinations Board (AMEB)*. The data shown in Table 1.2 were obtained from the AMEB Office in the State of Victoria. In this system, students will typically do one grade a year and have the possibility of progressing from Grade 1 through to Grade 8, and then on to three increasingly advanced level Diploma examinations (Associate, Licentiate, Fellowship). The table shows a continuous distribution of candidates for a series of age levels, a span of at least 8 years. If we assume that younger candidates reached either exam thanks to higher talent, we have a clear proof of the quantitative nature of musical talent. The much smaller number of candidates at the more advanced L.Mus.A. degree suggests a similar conclusion, namely a *progressive* decrease of advanced students as the talent requirements increase. It would be interesting to examine more closely the possible MP—or quasi-MP—status of the two A.Mus.A 11-year-old candidates and

Table 1.2 Age distribution of A.Mus.A. and L.Mus.A. 2011–2013 candidates, State of Victoria, Australia

Diploma/Age	11	12	13	14–15	16–17	18+	Total	Average Age
A.Mus.A.	2	10	13	50	50	32	157	16.7
L.Mus.A.	0	2	1	14	10	12	40	16.8

NB: No candidate aged 14 or under from the State of Victoria has ever received the most advanced award offered by the AMEB, the Fellowship in Music, Australia (F.Mus.A.).

the two 12-year-old L.Mus.A candidates. And how would the sole 13-year-old L.Mus.A candidate compare with older peers? We can assume with little hesitation that these younger candidates have demonstrated a much higher level of talent much sooner than the older students attempting the same examination. There might not be “true” prodigies among the youngest candidates, but they are no doubt in our estimation “highly” (1:1,000) to “exceptionally” (1:10,000) talented young musicians.

Here is another piece of evidence in support of the quantitative nature of musical talent. Benjamin Bloom—the same Bloom made famous through his *Taxonomy of Educational Objectives*—added to his fame with a major research program in the field of talent development. He supervised a series of interview studies (Bloom, 1985a) with about twenty of the most talented Americans in each of six fields: Olympic swimmers and world-class tennis players in sport, mathematicians and research neurologists in science, sculptors and concert pianists in the arts. The 21 American concert pianists who agreed to participate in the music part of the study were all under the age of 40, and all of them “had been a finalist in one of six international piano competitions that are recognized by experts in the field as being the most important for identifying exceptionally accomplished young musicians” (Sosniak, 1985, p. 19). Nowhere in Sosniak’s text do we find mention that any of them had been judged a prodigy during his youth. Quite to the contrary, her comments strongly suggest that only one of them had known a “professional debut” before adolescence (see note, Sosniak, 1985, p. 20). So, here we have interview data from 20 of the best young concert pianists in the USA during the 1980s, all of them occupying the topmost rungs on the music talent ladder. Yet none of them had been judged a musical prodigy in their youth; in fact, most of them had remained relatively unknown until well into adolescence.

C—Delimiting the boundaries of musical prodigiousness

How far down the achievements iceberg’s tip does the small subset of prodigies extend? Where is the threshold that will separate MPs from “quasi-prodigies”, those whose musical development was not fast enough, early enough, or exceptional enough to reach or surpass the threshold giving access to the MP label? At this point, some readers will probably have in mind a “why bother” objection: considering that so many “true” (a.k.a. core) prodigies are available for study, why bother looking for the threshold of access to the MP club? The answer lies in section I-A, where we discussed the importance of the prevalence issue with regard to normative constructs. As argued there, it is part of the nature of *every* normative concept to possess a frontier, a series of criteria that set the limits of its applicability; it also gives a better approximation of the size of that population, which in turn helps the identification procedures and the planning of services. What would be the usefulness of the BMI system without the threshold values for overweight (25+), obesity (30+), and morbid obesity (35+)? So, let us try to delimit more precisely a minimum threshold for musical prodigiousness.

1. Quantifying musical talent

A threshold is a cutting point on a continuum, in the present case a continuum of musical competencies. Since music offers a curriculum precisely subdivided in “years”, it seems very easy to create such a continuum. But we face a second problem: as stated in the DMGT definition of talent, the assessment of competencies uses only “learning peers” as its reference group—those who have studied for an equal amount of time.

About learning peers Using learning peers makes a lot of sense. Who would think of comparing the achievements of third grade students with those of high school students, or those of first year piano students with those of fifth year ones, except of course in the case of exceptional precocity? Some analysts of MPs’ musical achievements forget to apply that fair comparison rule, thus diminishing considerably the exceptionality of very precocious achievements. For instance, Simonton (this volume, Chapter 6) argues that Mozart did not contradict Ericsson’s 10-year rule since his “first masterwork did not appear until he was a dozen years into his career”. Simonton adopted Hayes’ (1989) criterion for a masterwork, namely at least five distinct recordings. This decision relegates as far less important dozens of Mozart’s previous compositions. But how would the pieces composed when he was 8 or 10 years old compare with those of “learning peers”, the more relevant group of musicians who have accumulated an equivalent amount of musical training? Just for a start how many of them have tried their hand at composing music? In a similar vein, Simonton says: “Nobody would claim today that had Mozart died right after composing his Symphony No. 1 (K. 16) at age 8 that this work would have secured him a lasting place in the repertoire” (this volume, Chapter 6). Is a “lasting place in the repertoire” a fair comparison base for any 8-year-old composer? When did his compositions begin to arouse the envy of professional adult musicians? As a last comment on this subject, keep in mind that, except for general education, the subset of “learning peers” is much smaller than the whole peer population, even that of same-age peers. Just try to imagine how many third year archery (or figure skating, or equestrian) students there are in one country, let alone one province or state! Since MPs do not abound, we will need a fairly large sample of music students to cover a wide range of achievements, especially its top part, in order to better discriminate among high achievers.

The basic scenario Our basic scenario involves three consecutive steps. First, we select as our “population” a large diversified group of music students in a specific performing instrument (for reasons of interpretive simplicity) at various levels of advancement, but with an overrepresentation of above average achievers. The details are not important for understanding the basic scenario. Second, we assess as precisely as possible two measures: (a) a measure of *musical competence* (MC) of young musicians expressed in months (or years with a decimal) for added precision, and (b) a measure of *length of systematic learning* (LSL), which corresponds to the amount of formal musical education, again expressed preferably in months. We can compute MC measures rather easily since music curricula are divided in years just like a typical school curriculum. Finally, we compute *musical progress quotients* (MPQ) for all sample members, using the following equation: $[(MC/LSL) \times 100]$. The multiplier serves to eliminate decimals. Readers who are familiar with the psychometrics of cognitive assessment will immediately recognize a procedure similar to the one initially adopted to compute the well-known IQ, namely the “quotient” of a measure of mental age divided by chronological age (Anastasi & Urbina, 1997).

We now have a large distribution of MPQ values, ranging from below 100 slow learners to well above 100 fast learners. We can combine them because the equation corrects the level of mastery (MC) to account for the time investment (LSL) in reaching that level. Figure 1.5 shows a theoretical distribution of these MPQs, with the vertical axis representing the MC measure and the

Figure 1.5 Cumulative impact of different progress paces on music achievements.

horizontal axis the LSL measure. The diagonal shows the progress of an average music student; she achieved a year of curriculum mastery for every year of musical training, thus obtaining a MPQ of 100. The shaded area *below* the diagonal represents slower music students (MPQs <100). The slowest student shown in Figure 1.5 has an MPQ of 50 (4 years of mastery after 8 years of study). The shaded area *above* the diagonal illustrates the opposite phenomenon, namely above average progress rates; the fastest learner has an MPQ of 200 (8 years of mastery after just 4 years of systematic learning). As measures of slope, MPQ values represent indices of rate of progress, from very slow to very rapid; consequently, their discussion technically belongs to the D component, more precisely the DPP facet (see Part I-B). Yet, their potential usefulness as indices of outstanding exceptionality or high level talent decided us to introduce them in the present section. We will have more to say about them in Part V-C.

Methodological comments The basic scenario describes an innovative assessment approach in the field of music. Its usefulness goes well beyond delimiting an approximate threshold for musical prodigiousness; it creates an objective measure to rank order the competence levels of whole populations of music students independent of their LSL. But readers will no doubt have noticed many methodological difficulties. First, it will probably not follow an exact normal curve, showing instead a definite positive skewness (long upper-end tail) because of the proposed selection bias, and also because very slow music learners rapidly drop out (McPherson, 2005), something school students are not allowed to do until mid-adolescence! Second, the comparability of LSL values depends on equivalent investments in weekly practice and lessons, which are known to vary considerably between music students (Ericsson, Krampe, & Tesch-Römer, 1993; McPherson, 2005; McPherson, Davidson, & Faulkner, 2012; Sloboda & Howe, 1991). An adequate LSL index would have to take these individual differences into account. Third, the MPQ indices could vary systematically over the developmental path of music students, probably decreasing slowly because of the increasing difficulty of new learning materials. In fact, it would be very interesting to create longitudinal MPQ curves to analyse chronic patterns. But since we aimed to just outline an

assessment methodology that could help better circumscribe the zone of musical prodigiousness, we leave to others a more detailed analysis of its technical modalities.

2. Establishing MP thresholds

Biographical accounts of young MPs, past or current, can give us a “peek” at exceptionally high MPQ values. In his article on pianist Tiffany Poon, McPherson (2007) showed that before the age of 8, after just 3 years of music lessons, Tiffany was performing difficult repertoire at about Grade 8 Associated Board level. He judged Tiffany’s technical and expressive ability to be far beyond the level normally expected of someone so young, indeed exceptional enough to use the MP label. If we attribute to Ms Poon an LSL of 3.0 (or 36 months) and an MC of 8 years (or 96 months), then at that time her MPQ would have been close to 265. This is remarkable given that Tiffany reached her talent level without regular lessons from a teacher who could cope with her rapid learning trajectory (McPherson, 2007; McPherson & Lehmann, 2012). As another example, Lang (1994) recounts an anecdote about Dorothy DeLay, a renowned professor at New York’s Julliard School of Music. “She recalled as follows her first encounter with the young prodigy Sarah Chang, who subsequently became her pupil. ‘I think she was six, or perhaps five, and she played the Mendelssohn concerto with real emotional involvement, and I said to myself that I had never seen or heard anything quite like it in my entire life’ ” (p. 123). Ms Chang was playing a piece that AMEB students would not normally perform in public until their eighth year of study, and then only the second movement. The whole concerto appears in the syllabus around the tenth year of study. According to her eponymous Wikipedia website, Ms Chang began her violin education at age 4, so her LSL would not have exceeded 2.5 years. Based on that quote, we would place her MC at a minimum of 9.0, thus creating an MPQ of at least 360. This would certainly be close to a Guinness-level maximum score!

These examples reveal that MPQs could easily exceed 200, a value highly improbable in the case of IQs, because many very talented young music students, especially in the first years of systematic learning, can progress at least twice as fast as the yearly pace proposed in the regular music curriculum. Using the mean and standard deviation (SD) of that distribution would help approximate the threshold for musical prodigiousness. Based on the IQ distribution, the SD equivalents for the MB system ratios are as follows: 1:1000 = +3.0 SD; 1:10,000 = +3.7 SD; 1:100,000 = +4.3 SD. Will that scenario help determine the ratio of MPs in the population? As clearly stated in Part I-A, there are no “objective” values for that threshold. Music scholars and professionals will need to reach some consensual agreement on a minimum MPQ necessary to deserve the MP label for the whole process to be fruitful. What will that ratio be? We believe that it would not be as high as 1:100,000 because of the limited size of the reference population of “learning peers”, even if we include all LSL levels. Moreover, the high percentage of dropouts within the first 2 years sharply reduces the population of young musicians with more than 3 years of systematic learning. And we might not want to use the MP label with beginners, whatever their MPQ!

3. Related issues: age and level of mastery

Our basic scenario leaves many questions unanswered concerning the frontiers of the MP construct. Some of them target the two key outcome characteristics of prodigies: the age ceiling and the expected level of mastery.

Age as index of ceiling First and foremost, age defines a ceiling—not later than—in definitions of musical prodigiousness. In most of them the beginning of adolescence, somewhere between 10 years old (Feldman & Morelock, 2010) and 12 years old (Solomon, 2012), marks its limit of applicability. In other words, musical prodigies need to acquire their MP status as children, a

decision that seems to make the expression “child prodigy” tautological! In everyone's minds, the MP label rapidly loses its relevance in early adolescence, confirming that the advancement gap between these young musicians and their learning peers—their MPQ score—is much larger at these young ages than it will become as they mature through adolescence. The young MPs will either join the ranks of internationally renowned young adult musicians or morph into something else. Whatever their professional destiny, there will no longer be any need to speak of prodigiousness, except as a former status. Notice that the somewhat fuzzy age limit for musical prodigiousness gives added weight to our quantitative approach to the MP construct.

Can the MP label maintain its relevance beyond early adolescence? This might make sense, since the current threshold of early adolescence essentially limits the choice of instruments in which a child could display prodigious talent to keyboard and strings, where children can start as early as age 3. Many other instruments, such as brass and woodwind, need a certain level of physical maturity (e.g. fully developed teeth) before a child can start learning. Because music is an area of choice rather than a compulsory school subject, access and opportunity complicate even further our efforts to establish a specific age ceiling. We could also introduce many cases of “late bloomer” musicians who began composing much later than usual, but progressed at an extremely rapid pace; their MPQ would have been quite high, possibly within range of the MP threshold (Anton Bruckner, César Franck, Leoš Janáček, Elliott Carter, and Iannis Xenakis are examples mentioned by Simonton in Chapter 6, and examples in popular music are John Lennon, Leonard Cohen, and Tom Morello). In summary, establishing a strict and early age ceiling, as is currently the case in most of the literature, does not take into account any of these issues, closes the door to a large number of potential MPs, and tends to restrict the term to those who perform on instruments such as violin and piano where formal education can start very early.

The minimum mastery requirement All the definitions quoted at the beginning of this chapter are quite demanding in terms of the minimally required level of mastery, the musical competence (MC) component of the MPQ index. We observe expressions like “exceptional level of mastery”, “extraordinary abilities and exceptional talent”, “adult professional level”, or “advanced adult level”. How would we operationalize these mastery requirements? Recall the steps of the AMEB system described earlier with their eight initial grades followed by three more advanced Diploma examinations (Associate, Licentiate, Fellowship). We believe that completing the first of these three diplomas could constitute in the minds of many music professionals a minimal operationalization of the above labels, even though the AMEB equates “professional level” with the successful completion of the Fellowship diploma.

The problem with such a high requirement is that it was probably defined with “core” MPs in mind—those who have reached the apex of their musical prodigiousness, usually toward late youth or early adolescence. It does not take into account the early manifestations of musical prodigiousness, when young musicians already exceed the typical achievements of learning peers to such a point that the MP label appears rightly deserved, yet still have a lot of room for additional progress. Recall the example given earlier of young Tiffany Poon who, by the time she had reached Grade 8 of the music curriculum, still only in her third year of formal music education, was judged by the second author and other music professionals to be a definite MP even though her competencies were well below the minimum threshold proposed above (McPherson & Lehmann, 2012). And she would probably have deserved the MP label even earlier than that. In fact, if we adopted MPQ scores, there would no longer be any need for a minimum level of mastery. For instance, a very young musician who could complete 4 years of the music curriculum in her first 12–18 months of systematic music education could deserve the MP label, not because of a minimum mastery requirement but because of her extreme pace of progress (DPP facet). In other

words, the minimum MPQ threshold, still to be determined precisely, would serve as the *only* minimum requirement.

A note on expressiveness Before we move on, it seems relevant to the previous discussion to add this final comment on *expressiveness*. A common criticism of MPs is that while they may possess extraordinary technical skill, they are unable, because of their young age and limited life experiences, to match adult performers in musical expression (Abbate, 1999; Solomon, 2012). But, as shown by Mink and McPherson (this volume, Chapter 19), adult conceptions of what is normal for a child and the general myth that MPs are not able to perform emotionally and expressively at adult levels can be at least partly explained by the fact that adults, and even trained musicians, find it difficult to give a rational explanation of the young MP's unique talent (see also Kopiez, 2011). Yet examples abound of very young MPs showing exceptional expressiveness. Recall, for instance, our earlier Sarah Chang anecdote. Recently, a 13-year-old pianist from Montreal, Daniel Clarke Bouchard, received the following comment from Montreal's toughest music critic: "Miraculously gifted, not only as a technician, but also and above all as a musician, the small child attacked the rarely performed second Shostakovich concerto ... The young soloist made the chords resound with the strength and the velocity of an accomplished virtuoso, and achieved in the slow middle movement the expressiveness of an experienced performer" (Gingras, 2013, our translation). At the very least, these comments, as well as many others we have come across in preparing this chapter, lead us to question any assertion that child performers are not able to reach adult levels of musical expressiveness. And there is little doubt that assessments of the Musical Competence (MC) component will include that dimension.

D—Additional considerations

Almost all musical prodigies are classical piano and strings performers. It makes little sense that we seem unable to identify them in other subfields of music, or even outside the classical music genre. What can we do?

1. Broadening classical subfields

McPherson and Willamon (2006, 2016) distinguish between eight subfields of music: performing, improvising, composing, arranging, analysing, appraising, conducting, and teaching. Each of these corresponds to distinct professional occupations. Examples include professional orchestral musicians, jazz improvisers, composers of original music or arrangers who rework existing pieces for a particular context, professors who teach musical analysis, music critics who review performances, conductors of ensembles, and music teachers. Yet, because of the "Mozart figure" and "high art" representations of prodigies typical in most previous publications (see Mink & McPherson, this volume, Chapter 19), and for reasons stated in section C, the vast majority of MPs described in the literature and the media belong not only to the performing subfield, but more specifically to a small subgroup of instruments, mainly the piano and the violin. For instance, Kenneson's (1998) 40 or so detailed sketches target performers, particularly pianists, violinists, and cellists. He also mentions throughout his text over 100 other well-known (at least in their time) MPs, again most of them performers. Obviously, most subfields involve skills that do not normally develop before early adolescence, because they require abilities and interests not typically available to children. The only other subfield with a significant number of MPs is composing. It is worth noting the significance of composing, since most core MPs (e.g. Beethoven, Mozart, Mendelssohn, and others) owe their lasting fame—if not their MP status—essentially to their compositions. We would certainly discover many non-traditional MPs if we explored more closely other groups of instruments, using the proposed MPQ index as a guide to extraordinary

musical development, as well as other subfields of music, for instance conducting. Concerning that subfield, here is a recent story from the *New York Times*:

Two decades ago in Manchester, England, a teacher at a music school taped a rehearsal that his 16-year-old pupil was conducting. The tape was sent to eminent conductor Simon Rattle. ... He listened, was impressed, invited the teenager for a meeting and decided, as he later told me, that here was “a staggering, natural, physical gift”. “I don’t think any of us could say where it came from”, Mr. Rattle added, “but he had it”. As a result the young man became the maestro’s protégé. ... Before long he became an assistant to Claudio Abbado, who called him “my little genius”. And so began the jet-propelled ascent of Daniel Harding.

(White, 2011)

Is there a better way to acknowledge prodigiousness than to speak of a “little genius” or a “staggering, natural, physical gift” for conducting! Notice the focus on extremely rapid professional development, a fine example of steep MPQ (see this volume for additional examples). Maybe our habit of focusing on “child” MPs is over-influenced by the very young—even preschool—prodigies who fill books and YouTube videos!

2. Rethinking musical genres

Feldman and Morelock (2010) specify in their definition that the adult professional level achieved should be “in a highly demanding culturally recognized field of endeavor” (p. 212). Most contributors to this volume would certainly disagree among themselves as to the exact meaning of that expression; some might even hesitate to include in our MP population individuals like Buddy Rich, Jack Teagarden, Stevie Wonder, Michael Jackson, or Margot Loyola, each of whom worked within a musical genre that is culturally recognized, demanding and sophisticated. Restricting MPs to examples from Western art music seems overly specialized to us because it perpetuates now contested stereotypes that this genre is culturally more advanced and musically more sophisticated than other forms of music.

E—Biological underpinnings?

Before moving ahead, we should examine the possibility that biological influences impact outstanding musical achievements. Are there any biological underpinnings associated with exceptional musical talent? According to the DMGT’s definition of talent, namely a set of systematically developed outstanding competencies, there is no room for direct biological influences. Indeed, two independent lines of evidence support that theoretical position. The first has its source in a recent literature review conducted by Tan and her colleagues (Tan, McPherson, Peretz, Berkovic, & Wilson, 2014) on the genetic investigation of the components of music ability. Out of 21 identified publications on that subject, only one (Vinkhuyzen, van der Sluis, de Geus, Boomsma, and Posthuma, 2010) appears to have used as its dependent variable a measure of self-assessed “musical talent”; all the other studies targeted diverse indicators of musical aptitudes. As a second source of evidence, borrowed from academic talent, studies have revealed (e.g. Thompson, Detterman, & Plomin, 1991; Wadsworth, 1994) that standardized achievement tests show substantial genetic influence. But, as Plomin and Price (2003) pointed out, these “multivariate genetic analyses have consistently shown that genetic effects on intelligence tests account *completely* [our emphasis] for genetic effects on tests of school achievement” (p. 118). In other words, the observed biological effects have their source in the cognitive building blocks, which is probably the case with the natural building blocks of musical talent (see Part IV).

F—Summing up

In the DMGT, talent is defined through two essential characteristics: (a) outstanding achievements (at least top 10%) in a specific field, (b) within a reference group of learning peers, namely

those who have completed an equal amount of systematic learning. That definition allowed us to argue for a basically quantitative view of musical prodigies, placing them among the tip-of-the-tip subgroup within the larger population of talented musicians. That definitional framework led us to propose an operational definition of musical talent borrowed from the well-known concept of IQ. Talented musicians simply possess musical competencies (MC) well above those of other music students who have invested an equivalent amount of time (called LSL—*length of systematic learning*) in the study of music in the same subfield. By combining these two crucial data we created a *musical progress quotient* (MPQ) that we can interpret somewhat like an IQ. Musical prodigies will be identified by their exceptionally high MPQ. To determine the minimum MPQ threshold deemed sufficient to attribute the MP label, we proposed to obtain MPQ values from a large diversified sample of music students from various LSL levels, including a fair number of highly talented individuals, and possibly a few young “potential” or recognized prodigies.

By proposing this totally new approach to the measurement of musical talent we hope to transform commonly held views of musical prodigies as a qualitatively distinct subpopulation within the population of young music students. Of course, we have no intention of diminishing the extraordinary achievements of “core” members of the MP population, those who reach professional level competencies at a very tender age. But we hope to have significantly extended the frontiers of the MP concept by proposing the inclusion into that group of (a) young musicians whose achievements, although extraordinary, place them outside the core group and closer to the periphery of the MP population, (b) young musicians who have not yet reached their peak level of prodigiousness, (c) older musicians who began their music education beyond their youth, (d) musicians who developed their prodigiousness outside the performing subfield of classical music, or (e) musicians who acquired an extreme MPQ outside the traditional field of occidental classical music.

IV—MPs and the giftedness component

Notice in Figure 1.1 that the six natural ability domains do *not* include any “musical” domain or subdomain; the IMTD theory does not recognize the existence of *specific* musical aptitudes. Before accusing this theory of being unfair to musical abilities, note that neither does it recognize an athletic domain, a technical domain, or a business domain. Having taken a crucial step by differentiating potentialities from achievements, we insist in maintaining the theory’s internal logic and consistency. Music, sport, and technology are *fields* of human occupations; learners in each of them “borrow” their learning tools from the natural ability domains to literally build the competencies (knowledge and skills) that define their specific field or subfield (see Part I-B). Let’s not forget the crucial pleiotropic role of the natural abilities; each facet within each subdomain plays multiple building roles with respect to the rich panoply of available occupational skills that humans can master. For instance, social abilities take part in building the professional competencies of talented teachers, psychologists, nurses, car salespersons, waiters, or sport coaches. Similarly, creative abilities are at the core of music composing, fiction writing, car design, architecture, fashion, choreographing, landscaping, and hundreds of other essentially creative occupations. So, why should any of them “kidnap” for its own use a specific aptitude and give it its field’s label? Even in situations where we observe a close relationship between a specific aptitude facet and a particular field, for instance in the case of strength (GMP-power facet) with weightlifting or general intelligence (GIG) with school achievement, the IMTD refuses to bow to that close affinity. It would mean negating the pleiotropic potential of every aptitude facet. Thus we avoid expressions like “athletic” aptitudes, “academic” aptitudes, or “musical” aptitudes, to name just a few.

Consequently, what we will be looking for is a set of natural abilities, dispersed among some of the six domains, which, when applied to a *musical learning situation*, act as building blocks

for the specific knowledge and skills that will define musical competence. Of course, music psychologists have traditionally associated some of them, which belong to auditory perception (the GPA facet), with the concept of “musical aptitude”. As we shall see, that choice leaves aside other equally important building blocks. In fairness to all the building blocks identified below, we will use the expression “*musilinked*” instead of musical; this neologism acts as a shorter label for other synonyms we had in mind, like “music-related” or “music-relevant” aptitudes. Hopefully, this choice will best convey the idea that the mastery of musical competencies requires the active participation of a complex combination of natural abilities. We will only retain from traditional usage the expressions “musical giftedness” or “musical potential” as contextually useful umbrella labels to refer to the *sum of the musilinked aptitudes* necessary to learn to play any musical instrument.

Part IV aims to address two main questions. The first concerns the very existence of biologically anchored natural abilities, whatever their domain, whereas the second focuses on their diversity. As we briefly pointed out in Part I-A, some scholars question the existence of these “alleged” abilities, which they call, somewhat derisively, “innate talent”. Since the first author has devoted the past two decades (e.g. Gagné, 1998a, 1999a, 2007, 2009, 2013c) to defending their existence and circumscribing their exact nature (see Part II-B), it felt logical to borrow from his work the following brief summary of that debate.

A—In defence of giftedness

Few professionals in the field of talent development would deny that we observe major individual differences in the ease and speed with which learners master any set of knowledge and skills, including those in music expression (see Chapters 8, 9, and 11 of this volume). Learners with higher levels of any DMGT natural ability will find it much easier to build competencies in the field they have chosen, and easier learning leads to faster learning. This is why, within the DMGT framework, ease/speed in learning represents the *characteristic trademark* of high natural abilities (giftedness); it becomes even more so the trademark of prodigies. In fact, prodigies constitute the best evidence for the existence of large individual differences in aptitudes, whatever the domain.

The scientific literature on talent development confirms that a majority of scientists and professionals endorse, at least in its broad lines, the above position, some of them somewhat inadvertently. Consider for instance Benjamin Bloom, a convinced environmentalist who stated his key belief in “the potential equality of most humans for school learning” (Bloom, 1985c, p. 5). In their famous interview study of exceptionally talented individuals in six fields, including concert pianists, Bloom (1985a) and his colleagues showed through multiple quotes that exceptional natural abilities, seen through their product manifestation, had characterized most of their interviewees. Here is a quote from Bloom’s (1985b) summarizing chapter. “Another general quality that was noted in each of the talent fields was the *ability to learn rapidly and well* [italics in text]. This ability to learn rapidly and well was especially pronounced in these individuals by the middle stage of talent development” (p. 545). Gagné (2009) labeled as “Pronats” the large majority of academics who endorse the construct of natural abilities. They face a small but vocal minority of researchers—Gagné’s “Antinats”—who deny the very existence of biologically anchored natural abilities, what they insist on calling “innate talent”. They promote the extreme environmentalism of the *Standard Social Science Model* mentioned earlier. Their disbelief extends to all six DMGT ability domains, with special focus on cognitive individual differences. Some popular science writers have widely publicized their views (e.g. Ankersen, 2012; Colvin, 2008; Coyle, 2009; Gladwell, 2008; Nisbett, 2009; Syed, 2010).

But here is the interesting point for our discussion. What will they say when confronted with the extremely accelerated learning pace of MPs? Antinats face a major hurdle; they can no longer invoke the “law” of 10,000 hours of deliberate practice, allegedly sufficient for almost anyone to achieve exceptional performances (see Ericsson, 2014; Gladwell, 2008). So, how do they address the prodigy phenomenon? In one of that group’s frequently cited target articles (Howe, Davidson, & Sloboda, 1998), the authors reacted by questioning the main sources of evidence for the MP phenomenon, namely biographical and autobiographical testimony. They stated: “the accuracy of such autobiographical reports is questionable considering that childhood memories of the first three years are not at all reliable” (p. 401). Gagné (1998a) responded by citing Professor Dorothy DeLay’s comment about Sarah Chang’s extreme precocity (quoted earlier), adding: “Is Professor DeLay an unreliable witness? How can one explain such extreme precocity without invoking some form of natural talent? Examples like these abound; they show ease of learning at its most extreme” (p. 416).

A decade later, in another major target article, another team headed by the most prominent defender of the Antinat position brushed aside again the testimonial evidence supporting the extreme talent of musical prodigies (Ericsson, Roring, & Nandagopal, 2007). These researchers essentially repeated the same argument: “Such evidence is not based on reproducible observable performance but on anecdotes that typically cannot be verified and in particular replicated under controlled test conditions. Such evidence is of little value to scientists and will not contribute to sound empirical foundations” (p. 30). Again, Gagné (2007) responded by restating one of the main assumptions of the Pronat position:

What a strange requirement to ask for controlled replication of publicly known achievements! Here is a short excerpt from Ms Chang’s official biography (Pittsburgh Symphony, 2007). “Born in Philadelphia to Korean parents, Sarah Chang began her violin studies at age 4 and promptly enrolled in the Juilliard School of Music, where she studied with the late Dorothy DeLay. Within a year she had already performed with several orchestras in the Philadelphia area. Her early auditions, at age 8, for Zubin Mehta and Riccardo Muti led to immediate engagements with the New York Philharmonic and the Philadelphia Orchestra”. Here are my questions to Ericsson. 1. Are these accomplishments “verifiable” facts about her extremely rapid progress? 2. Do her performances at age 8 qualify as “expert” performance? 3. Do her 8-year old achievements compare favorably with those of most “expert” *adult* violinists studied by Ericsson? 4. Is this a clear exception to the 10-year rule? 5. And, especially, didn’t Ms Chang’s early progress exceed by “galactic” units the learning pace of those thousands of young violin learners who “screech” their way through years of Suzuki classes? My own answer is predictably “Yes” to all these questions.

(Gagné, 2007, p. 68)

In summary, a small group of disbelievers continue to question the existence of natural abilities, with little chance (e.g. Ericsson, 2014) of any imminent softening of their position. Interested readers will find detailed debates of this question in a variety of sources (e.g. Ericsson, Nandagopal, & Roring, 2009; Gagné, 2009, 2013c; Harris, 1998; Plomin & Price, 2003; Plomin, Shakeshaft, McMillan, & Trzaskowski, 2014; Rowe, 1994, 1997). Now that the theoretical gap has been clearly laid out and our own Pronat position made clear, let us examine our second question: What do musilinked natural abilities look like?

B—Musilinked aptitudes in the existing literature

Music teachers can easily assess *product* characteristics, for instance the normative competence of their students and, occasionally, the faster pace of progress of their few talented ones. But which specific natural building blocks contribute to differences in musical learning pace?

1. Selection criteria

Recall that talented musicians constitute a marginal group (top 10%) among all music learners, and that MPs are a *quantitatively superior* tiny subgroup within the population of talented learning peers. Thus the processes we are looking for should *not* be specific to prodigious talent development; they should account equally well for individual differences among less extreme levels of excellence, ideally covering the whole range of musical achievement. Moreover, since the abilities necessary to progress from first year novice to third or fourth year regular student are somewhat different from those required to master an advanced music curriculum (e.g. the baccalaureate level), the building block processes we are looking for should show stronger predictive effectiveness at the beginning of the learning process.

Angoff's (1988) differentiating characteristics (see Table 1.1) reveal that existing musilinked aptitude tests (e.g. Seashore, Gordon, Wing, Gilbert), which focus largely on perceptual abilities, clearly lean toward the aptitude pole of the continuum. In contrast, periodic tests based on the music curriculum or yearly musical examinations clearly assess systematically developed competencies. So, on the basis of Table 1.1, here are the main identification criteria for the musically relevant aptitudes we are looking for.

1. They should appear as general abilities present in all people, independent of any systematic musical training, and thus assessable before its beginning.
2. They should produce very large individual differences.
3. Having acknowledged biological underpinnings would increase their relevance.
4. They should grow slowly, manifesting resistance to systematic stimulation.
5. They should be operationally related (as building blocks) to the specific competencies (knowledge and skills) to be mastered through the music curriculum, especially in its earlier years.
6. Prodigies or highly precocious young music students should excel very early on measures of such natural abilities.
7. They should reliably predict individual differences in music achievement, especially in pace of progress.
8. Because other causal influences become progressively more important with the amount of systematic learning, the predictive power of these musilinked aptitudes should be highest among less advanced musicians; it should decrease as years of education add up because, among other things, of a strong selection effect from dropouts.

2. In search of a database

Our search of the professional music literature to identify recognized MR aptitudes brought up two major problems.

Questionable existing tests First, most music teachers and academics have little regard for the spontaneous source of such measures, namely tests of “musical aptitudes” (see Table 1.3) that focus on basic aural skills; they invoke their demonstrated limited predictive power across the full range of musical activities, especially musical performance (Hodges & Haack, 1996; McPherson & Hallam, in press). Most of them do not meet some of our selection criteria. The most sophisticated of these tests, the *Music Aptitude Profile* created by Gordon (1965/1995), assesses seven distinct dimensions: tone (melody, harmony), rhythm (tempo, meter), and style preferences (phrasing, balance, style). Gordon created other aptitude measures designed for use with younger children, namely the *Primary Measures of Music Audiation* (K-Grade 3) and *Intermediate Measures of Music Audiation* (Grades 1–6). The tasks request that children tell whether two successive tonal or rhythm patterns are the same or different; according to Winner and Martino (2000), they “may

Table 1.3 The major tests of musical aptitude 1919–1982 (derived from Hodges & Haack, 1996)

Measures of musical ability	Dates of original measures and revisions
Seashore measures of musical talents	1919, 1925, 1939, 1956, 1960
Kwalwasser–Dykema music tests	1930, 1954
Wing Standardized Tests of Musical Intelligence	1929, 1948, 1957, 1960, 1961, 1981
Gretsch–Tilson musical aptitude test	1941
Test of Musicality (Gaston)	1942, 1950, 1956, 1957
Kwalwasser music talent test	1953
Musical aptitude profile (Gordon)	1965
Measures of musical abilities (Bentley)	1966
Primary measures of audiation (Gordon)	1979
Intermediate measures of audiation (Gordon)	1982

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be no more predictive of musicality than possessing good eyesight is predictive of good reading ability” (p. 105). Indeed, it is not sufficient to affirm that X or Y or Z constitute the core natural abilities on which are built musical skills; one also needs to clearly operationalize the proposed construct as reliably as possible in the form of content-valid assessment tools, and then demonstrate that the tools in question have satisfactory predictive power.

Terminological chaos The second problem concerns the terminological diversity among authors, and their lack of consensus over the meaning of the most popular terms (e.g. musical ability, musical talent, musicality, musical aptitude). In her discussion of “musicality”, Hallam (2016) acknowledges this conundrum from the outset: “Overall, there is no universally agreed definition of these terms. Meanings are socially constructed and reflect the cultural, political, economic, and social factors pertaining in the time and place that they are adopted” (p. 67). Here is a typical example: “Musical ability is popularly regarded to be innate; one either is or is not born with musical talent” (Levitin, 2012, p. 633). Compare the phrasing of this quote with the terminological rigor the first author defended in Part II-B! As an additional illustration of this terminological chaos, we need only look at the titles of the major MR aptitude tests: musical talents (Seashore, 1919/1960), musical intelligence (Wing, 1981), musical aptitude (Gordon, 1979), musicality (Gaston, 1957), musical abilities (Bentley, 1966), and even neologisms such as “audiation” (Gordon, 1982). We observe a similar terminological diversity in the abilities these tests measure (see Hallam, 2016): Seashore’s sensory discrimination skills (pitch, loudness, rhythm, time, timbre, tonal memory); Wing’s two dimensions of his musical intelligence, namely ear acuity (chord analysis, pitch, melodic memory) and appreciation of music (rhythm, harmony, intensity, phrasing); Revesz’s musicality defined as the ability to enjoy music aesthetically; Karma’s musical aptitudes (ability to structure acoustical material, sense of tonality, rhythm, harmony); Gordon’s concept of audiation, defined as the ability to give meaning to what is heard, and subdivided into five stages, whose first two (tonal patterns and rhythmic patterns) are labeled musical aptitudes; and so forth. In this regard, we agree with Hallam that because they focus on aural perception to the exclusion of other natural abilities, none are sufficiently robust to predict an individual’s musical progress.

Persson (2009) tried to address this terminological chaos in a way that appeared to us initially promising. He borrowed from the DMGT the potential–achievement differentiation in order to separate common terminological expressions into two large categories: (a) “genotype labels”

that refer to genetically determined potential (e.g. musical aptitude, capacity, or intelligence), and (b) “phenotype labels” that target the developed and observable behavior resulting from a certain genotype (e.g. musical talent, achievement, expertise, eminence). At the same time, he considered the expression “to be musical” as an all-inclusive term covering both categories (see Table 36.1, p. 728). But, just after that initial distinction we began disagreeing with Persson's positions. Discussing our divergent views is beyond the scope of this chapter, but let us see a few more relevant points. First, he did not attribute the expression “musical giftedness” (MG) to one of the above categories, which opened the door to ambiguity. Second, he went on to define the MG construct as follows: “In the following discussion the term *musical giftedness* will be used when referring to individuals who for any possible reason appear ‘more musical’ than most others” (p. 729). This association of the MG construct with “being musical” places that expression among the all-inclusive labels, a position we cannot endorse. Third, except to talk about “talent searches” in the case of pop music, he never used the label “talent” to describe musical competencies. On the other hand, he did identify five specific musical “key skills”, some of which we could consider similar to our musilinked abilities: (a) motor function, (b) appropriate physical attributes, (c) auditory skills, (d) musical memory, and (e) emotive skills. He considered that the first two belonged to the physiological domain, the next two to the cognitive domain, and the last one to the personality domain. We would place his physical attributes in the “anatomical” first basement of the DMNA, and “emotive skills” in the IP subcomponent. Despite our conceptual divergences, Persson's (2009) chapter represents a unique effort to address the field of music's terminological chaos.

Relevant domains We will use the DMGT's six natural ability domains (see Figure 1.1) to bring some order to this diversified inventory and highlight rarely mentioned aptitudes. Of course, both the limits of this chapter and the extensive literature on that subject do not allow a comprehensive inventory of all the so-called “musical aptitudes” proposed over the past decades by scholars within and outside the field of music. As desirable as it would have been ideally, we could find neither time nor space to effect a systematic comparison of the abilities assessed in existing tests (see Table 1.3); so we chose to focus on the most commonly cited measures. We can eliminate outright three domains that received no mention in the above listings: creative (GC), social (GS), and muscular (GM) natural abilities. In the first case, it is clear that creative aptitudes do play a significant role in the subfields of composing, improvising, and even arranging, but their role remains limited and still controversial in the performing subfield, even more so when we focus on beginning young musicians. Concerning the social domain, some scholars, such as Subotnik (see Subotnik et al., this volume, Chapter 11) defend the importance of some social abilities, such as a sense of professionalism, in helping very talented musicians access the very top levels of their profession. But their usefulness with beginning music performers is doubtful, especially with respect to the early manifestation of musical prodigiousness. Irrelevance is even more evident in the case of muscular physical abilities (GM), devoted quasi-exclusively to the development of athletic talents or found in physically demanding occupations (e.g. firefighter, bodyguard).

C—Proposed restructuring

1. Auditory perception (GPA)

Among the four domains left to consider, perceptual abilities, and more specifically the facet devoted to auditory ability (GPA), receives by far the largest number of mentions. It is within this very specific area that we find natural abilities that could have deserved the label “musical aptitudes”. But, faithful to our terminological decisions, we will label them musilinked, just like all the others discussed within this section.

Inventory The GPA facet includes, for instance, Seashore's sensory discrimination abilities (pitch, loudness, rhythm, time, timbre), Wing's ear acuity (chord analysis, pitch), and similar abilities assessed by Karma, Bentley, Gordon, or Vispoel. In an effort to explain what he considers to be the basis of musicianship, Gordon (2012) coined the term *audiation* to describe how people are able to "perform" or "imagine" a piece of music in their mind. To conceptualize this concept, Gordon proposed as an analogy that audiation is to music what thought is to speech. The key element of this explanation is that audiation occurs after the event of perceiving music, and requires a deeper understanding of the music. Better "audiators", according to Gordon, are able to process what they are listening to faster. In some ways, these processes appear to be related to what Winner and Martino (2000) described as a possible core ability of musically gifted children: their "*sensitivity* to the structure of music—tonality, key, harmony, and rhythm, and the ability to hear the expressive properties of music" (p. 102). By this, Winner and Martino meant that children with musilinked gifts are able to notice and then later understand (or audiate) structural aspects of music that enable them to remember, play back, transpose, improvise, and create music at a much more sophisticated level than their peers. It might offer some conceptual overlap with the concept of mimicry discussed below.

Absolute pitch Among all perceptual abilities, one stands out in the scientific literature—absolute pitch (AP). It seems to be a very rare phenomenon within the general population, with some reports suggesting a prevalence level of less than 1:10,000 (Bachem, 1995; Profita & Bidder, 1988; Takeuchi & Hulse, 1993). Among musically trained populations indices vary widely and range from close to 15% in music conservatories or professional orchestras to around 4% of liberal arts college music students (Gregersen et al., 2013). However, it seems to characterize a significant proportion of the MP population, including virtually every MP mentioned in this book (e.g. Ludwig van Beethoven, Pablo Casals, Sara Chang, Glenn Gould, Jascha Heifetz, Lorin Hollander, Michael Jackson, Erich Wolfgang Korngold, Franz Liszt, Margot Loyola, Yo-Yo Ma, both Felix and Fanny Mendelssohn, Olivier Messiaen, Wolfgang Amadeus Mozart, Ervin Nyiregyházi, Derek Paravicini, Artur Rubinstein, Clara Schumann, Jack Teagarden, Stevie Wonder). It is possible that music is accessible to MPs in a way that is not evident in the normal population.

But absolute pitch remains at the centre of a few heated controversies, with regard not only to its innate foundations, but also to its contribution to the development of advanced musical talent (Mandelman & Grigorenko, 2013). Gregersen (2013) cites evidence that the general population contains individuals who possess AP without knowing it because they have not learned some sort of note naming convention (see Ross, Olson, Marks, & Gore, 2004). Extending this conception, Ross and his colleagues have been able to show that encoding of stimulus frequency can be independent of musical experience, and may even be present in some very young children before they begin formal music education (Ross & Marks, 2009). We could add to the above Gardner's (2009) comments about harpsichordist and conductor Laurence Cummings, who suggests that AP is invaluable for understanding music quickly: "It helps you to read scores in your head ... and it's good when you're listening to a piece of music for understanding the structure" (p. 37). In this way, AP would seem to give young musicians an advantage over their peers, because their learning benefits from an ability to better comprehend pitch structures and patterns without having to refer back to the notation or to a reference pitch (McPherson & Williamon, 2006).

Mimicry According to Solomon (2012), "musical talent can be divided into three components: the athletic, the mimetic, and the interpretive" (p. 419). About the mimetic component, he states: "To be a musician, the person has to have a mimetic capacity to reproduce others' techniques" (p. 419). He then quotes the music critic Justin Davidson: "Musicians who have a tremendous gift for mimicry can produce very refined interpretations at a very young age" (p. 419). This

"gift for mimicry" seems to involve both an auditory aptitude, the ability to pick up the specific musicality of an interpretation, and a motor aptitude, the ability to reproduce that specific musicality. Harris (1998) describes in a similar way the aptitude for languages: "Some people are apparently born with an ear for languages. A small fraction can continue to pick up new languages, and learn to speak them like a native, even when they are well advanced in age. They are *natural mimics*" [our emphasis] (p. 388). Of course, it makes little sense to ask which of the two natural abilities, auditory or motor, is more important; both probably need to express themselves at the gifted level (top 10%) in order for the "refined interpretations" to happen.

Pending questions The above inventory raises two major questions. First, is there any hope of bringing some structure to this wide diversity of terms and associated measures? In his seminal work on the structure of human cognitive abilities the late John Carroll (1993) reanalysed over 400 factor analyses of dozens of distinct cognitive measures. He proposed a three-level structure of abilities, with the "g" factor at its apex (Level III), and underneath eight broad "Level II" subgroups of abilities; he called one of them "broad auditory perception". He stated from the outset: "There are few if any trustworthy and *extensive* [his emphasis] factor-analytic studies of musical talent [the DMGT's giftedness]; those reviewed here prove to be relatively unsatisfactory, in that they fail to yield conclusive statements about the structure of musical abilities" (p. 364). The main reason for such an unsatisfactory result was, in his opinion, major measurement problems: "Nearly all measures of musical aptitude depend to a great extent on tests of quite elementary discriminations among tonal materials, with only meagre musical contexts, if such contexts are present at all" (p. 376). Looking at the future, he mentioned Shepard's (1981) work as follows: "some of the experiments he reports could well be the basis for new tests of musical ability" (p. 376). It was beyond our mandate to examine that document. We believe that scholars interested in the measurement of musical aptitudes will find invaluable information in Carroll's seminal handbook and Shepard's work.

The second question concerns the outcome of the search for structure. Will it lead to a general underlying musical ability, similar to the cognitive "g" factor that underlies all IQ tests (Jensen, 1998), or produce a set of relatively independent aptitudes? These divergent perspectives both already exist in the field of music. Ullén, Mosing, Holm, Eriksson, & Madison (2014) described them as follows.

These are the "atomistic" tradition of Seashore and the "omnibus" approach of Wing. ... The atomistic approach is based on the assumption that musicality is made up of several relatively narrow and distinct musical abilities. This leads to an expectation of statistical independence (Gordon, 1969; Seashore, 1919/1960) or at least low intercorrelations (Seashore, 1947) between tasks that tap into different abilities. Tests in this tradition have typically focused on basic sensory abilities, such as discrimination of various musically relevant sound stimuli. ... In contrast, in the omnibus approach to musicality testing, musicality is considered a general high level ability. Tests developed within this tradition are less concerned with characterising components of musicality but rather tend to use a holistic approach where complex, acquired musical knowledge is assessed. Typical test items may involve quality judgments of musical performances or the production of musically meaningful responses to stimuli (for example the tests of Wing and Révész.

(Ullén et al., 2014, pp. 87–88)

If the authors are correctly summarizing the two tendencies, it would mean that the "omnibus" approach assesses competencies—complex, acquired musical knowledge—instead of aptitudes. We did not examine the existing tests in enough detail to confirm or refute Ullén et al.'s statement. One thing is clear: a lot of work remains to be done to bring some clarity to this question of the nature of GPA-based musilinked auditory aptitudes. And, if we are to believe Carroll's judgment,

the first step will require that music scholars better identify key natural abilities with relevant musical content validity, and then create predictively valid tools to measure them.

2. The key role of memory (GP/GI)

Leaving the realm of *the most broadly recognized musilinked* aptitudes does not mean moving away from important predictors of exceptional musical talent. In fact, as we shall see, it is quite the opposite! Let us examine in more detail the first of the less highlighted musilinked aptitudes: memorization. We will not discuss here the controversial question of the pros and cons of playing from memory in performances. As Clarke (2002) said: “The ability to memorise music for performance has a particularly cultural value, although some might argue that there is as much to be said against it as for it” (p. 62). Our goal is strictly to examine the memorizing aspects of every young musician’s efforts at mastering a musical instrument, even when they have access to the score.

Examples Just read any collection of MP biographies and one group of abilities will rapidly stand out: the extraordinary memory abilities of these young musicians. Page after page, you will find recurring impressive examples of rapid memorization of musical pieces, even from novice musicians of childhood age. Of course, one example outshines them all. As the legend goes (see Chapters 5, 23, and 24 of this volume), the young Wolfgang Amadeus Mozart, barely 14 years old, was visiting Rome with his father in April 1770 during Holy Week. He attended the presentation in the Sistine Chapel of Gregorio Allegri’s famous *Miserere*, a music transcription of Psalm 50 whose score the Vatican kept secret. Mozart came back home, and sat and reproduced on paper the complete 15-minute score, with its two-choir, nine a capella voices. It is said that he went to listen to it a second time two days later to complete minimal omissions. If this really happened as reported, it represents one of the most remarkable feats of memorization by a professional musician, past or present. Think of it: almost 15 minutes of music faithfully memorized from a single listening! The vast majority of professional musicians would hardly go further than the first 10 or 15 seconds of any new musical opus they would want to memorize (see also Chapters 5 and 24 of this volume).

More modest yet quite impressive examples of memory achievements abound. Consider, for instance, the case of Erwin Nyiregyházi who reportedly “learned to play Robert Schumann’s *Piano Concerto in A minor*, Op. 54 by heart in only 10 days, although he played it through only once a day” (Kopiez & Lehman, this volume, Chapter 5). Similarly, when world famous pianist Lang Lang was about 4 years old, “his teacher was astonished by his memory; he could memorize four big pieces every week” (Solomon, 2012, p. 445). Kenneson (1998) tells the following story about violinist Jascha Heifetz: “By the time he was six, Jascha had mastered the Mendelssohn concerto ... The six-year-old continued to add new works to his repertoire; after only two years of study at the music school in Vilna, the astounding prodigy violinist graduated at age seven” (p. 134). There are also numerous examples of the ability of musical prodigies to perform a complete concert from memory from a young age, such as in the case of Teresa Carreño (Chapter 27), Glenn Gould (Chapter 29), Camille Saint-Saëns (Chapter 6), Stevie Wonder (Chapter 32), and Felix Mendelssohn Bartholdy (Chapter 26). We collected dozens of similar examples from these short biographies. In fact, the biography of any musical prodigy most likely includes multiple examples of extraordinary progress based on powerful memory processes. Whilst the accuracy of some of these historical reports might be questioned, or in some cases exaggerated, the consistency of instances among the most famous musical prodigies found in this volume and elsewhere nonetheless demonstrates the highly developed memory processes that distinguish musical prodigies from less exceptional learning peers (see Chapters 8 and 9).

Treffert's autistic savants again When we drafted the detailed plan of this chapter, we discussed the relevance of including some of Treffert's "islands of genius" among our population of musical prodigies. As illustrated earlier (see Part II-B), many of the savants who adopted music as their medium of expression manifested extraordinary aptitudes and often progressed at the pace of many of our bona fide prodigies. Here are a few additional examples. One of Treffert's protégés, a blind, autistic, musical savant, received at age 15 a scholarship to the prestigious Berklee College of Music in Boston, eventually graduating magna cum laude (Treffert, 2012a, p. 138). Treffert also recounts the celebrated case of Thomas Bethune—Blind Tom—who was considered "the most celebrated black concert artist of the nineteenth century". Here are a few details about him.

He was an internationally recognized musical savant around the time of the American Civil War ... and the greatest musical prodigy of the age. ... [His vocabulary] was less than 100 words but his musical repertoire was over 7000 pieces. ... Every note of every piece Tom heard was indelibly imprinted on his mind, and he was able to reproduce any piece from beginning to end without a moment's hesitation. His repertoire included Beethoven, Mendelssohn, Bach, Chopin, Verdi, Rossini, Donizetti, Meyerbeer and many others. ... [One newspaper] reported that his memory was so accurate that he could repeat, without the loss of a syllable, a discourse of 15 minutes' length, of which he seemingly did not understand a word.

(Treffert, 2012a, pp. 87, 88, 89)

Notice how the last quote parallels young Mozart's memorization of the *Miserere*! These examples argued strongly in favour of bringing these extraordinary individuals within our population of musical prodigies, mentioning them as MPs without any special differentiation. Yet there were clear distinctions, not least of them their mental deficiency and autism; as labeled by Treffert himself, they were really "islands of genius". We finally decided not to ignore them, but just briefly acknowledge their talents in this special short mention within the section that reflected their most distinguishing aptitude: memorization. We leave to others a more extended analysis of Treffert's controversial theoretical proposals, as well as detailed comparisons of similarities and differences between MPs and savants.

Typology of memory processes What does "exceptional musical memory" really mean? Spontaneously, the "musical" qualifier points at abilities related to the GPA facet. But learning to memorize a piece of music involves much more than auditory abilities: the piece will have to be played, which means mastering a complex fingering that calls into operation the synchronous movement of both hands and their five fingers. The memorizing process has just become much more complex. What does the field of memorization have to say about learning to play a musical instrument? We must first confess our limited expertise in this complex field; we will limit ourselves to basic considerations, hoping that they will give at least a general idea of the challenges young music students face, and the possible sources of individual differences between those who progress slowly and those who advance at high speed.

We can subdivide the field of memory processes along many dimensions. Two of them have special relevance to the present discussion: the *content* being memorized and the *duration* of the memorized information (Medin & Ross, 1997). In the first case, specialists distinguish between *declarative* and *procedural* memory. Declarative memory deals with general or technical knowledge (*semantic* memory), as well as knowledge about our short-term and long-term personal history (*episodic* memory). For its part, procedural memory takes charge of all kinds of sequential operations that help to solve daily problems (e.g. tying our shoes, driving our car, having structured conversations, singing our preferred tunes) or more specialized ones (e.g. doing a surgery, conducting an interview, and of course playing a musical instrument). When mastered,

our procedural memory processes function mostly subconsciously and tend toward complete automaticity.

With respect to duration, specialists distinguish mainly two processes: *short-term* or *working* memory, and *long-term* memory where we store all our declarative or procedural knowledge. The effectiveness of each of these memory processes depends on both high quality encoding and high quality search processes. Learning to play a musical instrument involves almost exclusively the creation of procedural memories; during the learning process and after its fruitful completion, they will be brought back from long-term storage when we want to play a particular musical piece. Our short-term working memory will play a crucial role during the memorization process, but that “microscopic” level of analysis is outside the DMGT perspective. Within our more macroscopic view, the most useful information would be to obtain the distribution of the total time required by beginning music learners—or somewhat more advanced learners—to master a typical piece of their repertoire; such information would help to confirm the significance of memorization as a source of individual differences. We have in mind a piece of sufficient length to require on average a few hours of practice to reach a level of mastery judged satisfactory by the standards of that introductory level. We are unaware that such studies have been conducted.

We could also look at the main memory functions called into action to successfully complete that type of procedural learning. Three distinct memory domains seem to play “some” role in that learning process: visual memory, auditory memory, and psychomotor memory. Here are some questions we have in mind. Does visual memory focus on the music score, trying to create a mental representation of it, or on the placement of the fingers on the piano keys (or the violin or any other instrument)? For how long does that visual support remain essential? In other words, when would the young musician become able to play the piece blindfolded? To what extent is such mastery desirable, at least during the first years of learning music? And what should we know about the role of auditory memory? How important is it to begin by memorizing the melody? Is that much easier—at least in the case of beginners’ pieces—than memorizing the fingering? To what extent does it guide the memorization of the fingering? Finally, is the psychomotor memorization process the most difficult part of the whole learning process? Could that be the element that will differentiate slow from fast learners? Finally, does the pace of memorization increase differentially over consecutive months? How can we measure that particular pace?

Scientific evidence According to Clarke (2002), “systematic studies of the process of memorising music from notation for performance are surprisingly scarce, and comparatively little is known about the processes that occur during memorisation and the range of different strategies that performers may use” (p. 62). Schellenberg and Weiss (2012) also mention the uncertainty that currently exists with regard to memory and musical ability, given that “it remains an open question whether memory advantages for musicians are limited to auditory stimuli, and even whether their memory is better for auditory than for visual stimuli” (p. 522). Note that they say nothing about procedural memory (GR)! The ubiquity of memory measures (e.g. tonal memory, melodic memory, musical memory, rhythmic memory) in aptitude tests confirms the importance of these processes, yet says more about possible individual differences in natural abilities than about their impact on real music learning situations. Closer to our quest, McPherson (2005) tested beginning instrumentalists at the end of their first, second, and third years of training across five different aspects of instrumental performance: playing rehearsed music, sight-reading, playing from memory, playing by ear, and improvising. For the play from memory measure, five different levels of task strategy sophistication were identified: *conceptual* (independent of the instrument and how the melody would sound; chanting of rhythm or letters/names of the notes; trying to sing the melody but not explicitly linking this with instrumental fingerings), *kinaesthetic* (trying to chant the rhythm or pitch while fingering the melody through on the

instrument), and *musical* (processing the score holistically by working from the beginning to the end of the piece while mentally rehearsing the melody). McPherson reports striking differences in pace of progress, with the most successful learners employing more sophisticated task strategies for each of these styles of performance, including the play from memory measure, mentioned earlier. These students went on in the second and third years of their learning to achieve at a much higher level than their peers. What do these “musically appropriate” strategies tell us about memorizing a musical piece for piano or violin?

Some recent scientific evidence seems to support the idea of a powerful role of memory processes in high level talent development. For instance, Ericsson (2014) cites his own past research showing that “expert performers develop long-term working memory (LTWM), where information is rapidly stored in long-term memory (LTM) associated with retrieval cues that allow the expert to access this information efficiently whenever the information is relevant for processing” (p. 82). Similarly, in Chapters 8 and 9 of this volume, Vandervert describes how efficient working memory processes observed in musical prodigies to help explain their high attention and accelerated learning. The most interesting data so far originate from recent studies by Ruthsatz and her colleagues (Ruthsatz & Urbath, 2012; Ruthsatz, Ruthsatz, & Ruthsatz-Stephens, 2014). They administered the Stanford–Binet test (5th edition) to a small group of prodigies, most of them in music, and discovered that *all* of them reached exceptionally high scores on the working memory scale, well beyond the top 1% of the general population. This emerging research provides, in our view, a very significant clue to circumscribing the types of natural abilities involved in the extreme pace of progress of musical prodigies. Note that in terms of content, the Stanford–Binet, like all similar tests, uses semantic material, usually increasing lists of numbers to be memorized and recalled either directly or backwards.

The proper domain placement We mentioned in this section three different types of memorization content-wise. Should we include all of them within the GI domain? All modern theories of intelligence include memorization as one of its important components (Davidson & Kemp, 2011). For instance, in the seminal study mentioned earlier, Carroll (1993) created a Level II broad factor called “general memory and learning”; he recognized that “individuals differ in a general memory ability that affects, to a considerable extent, performances in a wide variety of tasks and behaviors involving memory” (p. 302). On the other hand, he added: “There is evidence, strong in most cases, for additional, more specific factors of memory ability” (p. 302). These specific factors included both visual and auditory memory. This suggests support for some partially independent memory abilities that we could associate with distinct domains. Two of them, visual memory (GPV) and auditory memory (GPA), would be embedded within the perceptual domain. Carroll briefly mentioned psychomotor abilities, but considered them essentially outside the conceptual field he had delineated. This judgment speaks in favour of placing the procedural memory of a musical piece’s fingering within the physical domain, more precisely the domain we reserved for all forms of fine motor control (GR), which we will now discuss.

3. Motor control aptitudes (GR)

“It is not uncommon for concert pianists to play at speeds of ten or more notes per second in both hands simultaneously, in complex and constantly changing spatial patterns on keyboard, and with distinct patterns of rhythm, dynamics and articulation” (Clarke, 2002, p. 59). Recall also Solomon’s (2012) subdivision of musical talent “into three components: the athletic, the mimetic, and the interpretive. It takes physical prowess to move your hands or lips with the precision most instruments require” (p. 419). These two quotes highlight the very significant role played by motor control abilities in the performing world of music. We believe that it is a very important aspect—as well as the most underestimated—since motor dexterity controls all aspects of reproductive quality: exactitude of pitch sequence, modulation of intensity of different notes and or

sections, respect of rhythm subtleties, and so forth. Psychomotor abilities not only underlie all technical aspects of any music performance, but also serve as a medium to convey expressiveness (Palmer, 2012). We are used to thinking of instrumentalists, but these abilities extend to other subfields of music, for instance singing while dancing. Here is a personal testimony from Michael Jackson: “Since I was a very little boy, I’ve been able to watch somebody do a dance step and then immediately know how to do it. Another person might have to be taken through the movement step by step ... But if I see it, I can do it” (Jackson, 2009, p. 136). Psychomotor abilities have close links with two related perceptual abilities: proprioception (sensing our body’s position in space), and kinesthesia (sensing our body’s movements). Exploring these processes further would lead us into microscopic analyses, a perspective we have placed outside the DMGT’s framework.

Major individual differences seem to appear in the earliest phase of music learning, indicating the presence of significant aptitude differences. As an example, when Kenneson recalls the first cello lesson he gave to the then 2-year-old Shauna Rolston, he was especially impressed by “that toddler’s dexterous left hand that was soon acting out musical ideas on the cello with great agility. Shauna was marvellously coordinated. Her right hand, with its deft sense of touch, showed the promise of an unusual talent for bowing. ... Within a year she drew a tone pure as crystal from her little cello” (1998, p. 22). Notice how the procedural memorization process progressively transformed her initial exceptional sense of touch into a bowing movement that produced—at 3 years of age—a “tone pure as crystal”. This example highlights the two distinct dimensions of motor control abilities: (a) the motor dexterity itself, and (b) the procedural memorization of these motor sequences we mentioned earlier. No doubt both dimensions maintain significant relationships. Although we are convinced that psychomotor aptitudes play a major role in the initial progress of young music students, we did not find among our dozens of MP vignettes many descriptions of exceptional psychomotor abilities. It seems that such abilities are taken for granted, as opposed to the attention given to auditory abilities.

Motor abilities have received extensive attention in work-related and sport-related contexts. One of these specialists, Edwin A. Fleishman, is “certainly one of the most influential figures in the field of research on individual differences, particularly as it relates to motor behavior” (Schmidt & Lee, 2005, p. 282). Unfortunately, Fleishman focused on the psychomotor analysis of work-related activities. We have not found in the professional music literature studies that focused on individual differences in motor control abilities among novice performing students. Yet McPherson and Williamon (2006) point out that “music teachers will be able to gauge a child’s motor abilities and physical coordination within the first weeks of learning an instrument” (p. 242). So, why do most aptitude measures focus on perceptual abilities? Why do musilinked aptitude tests focus almost exclusively on aural perception of rhythm, ignoring almost totally the motor ability to reproduce rhythms or just move one’s fingers? Hallam (2006) briefly mentions Gilbert’s (1979, 1980, 1981) tests of motor skills, “performance on which was highly correlated with musical attainment” (p. 100). Why is there so little interest in such a key ability?

4. Cognitive aptitudes (GI)

The DMGT’s subcomponent of intellectual aptitudes (GI) appears to play a very complex, and still partly unexplored, role in music talent development. The main question, which appears regularly in the professional literature, concerns the relationship between general intelligence (coded GIG in the DMGT’s lingo), and musical abilities. Of course, within the DMGT framework, the general concept of musical *ability* has two distinct meanings: (a) musilinked *aptitudes*, with their outstanding manifestations as gifts, and (b) musical *competencies*, with their outstanding manifestations as talents. In correlational studies, the choice of measure for the musical component will determine where a specific study placed its focus. In the first case, namely a possible relationship

between musilinked aptitudes and general intelligence, opinions vary. For instance, Winner (1996) states: "Attempts to correlate musical aptitude with IQ have yielded positive but low correlations. Once an IQ of about 90 is attained, intelligence is not very predictive of musical ability. Nor does high musical ability necessarily predict high intelligence" (p.108).

On the other hand, based on their extensive literature review, Schellenberg and Weiss (2012) conclude: "music aptitude is a marker of general intelligence" (p. 504) because "high functioning children perform well on tests of music aptitude, just as they perform well on many tests of cognitive abilities" (p. 504–5). They believe that music aptitude may act as a "surrogate" for measures of intelligence because it is associated with general intelligence in childhood through to pitch and temporal discrimination abilities in adulthood. They finally point out that "associations between music aptitude and specific aspects of cognition (e.g. spatial abilities, working memory) may be a by-product of the association between aptitude and general intelligence" (p. 504). We might add to their short list ease/speed of long-term memorization. More so than short-term working memory, it might considerably accelerate the progress of young music learners. How are these two memory systems related? How does general intelligence influence either of them? It does not appear that these questions have yet received appropriate answers. Carroll's work, mentioned earlier, confirms Schellenberg and Weiss's (2012) positions; he did create a broad (Level II) factor for auditory abilities that provides significant links with his Level III "g" factor. Finally, in the same vein, the data gathered by Ruthsatz and her coworkers on their small group of prodigies show a consistent trend of elevated intelligence; the MPs displayed an average IQ of 128 ($M = 128$; $SD = 5.31$), with a range of 108 to 147 (Ruthsatz, Ruthsatz, & Ruthsatz-Stephens, 2014).

With regard to the second question, that of a possible link between general intelligence and musical achievements, it would appear from the limited evidence available that there is a relationship, but this may be because high functioning children are more likely to take music lessons and perform better on cognitive tests, even though music lessons seem to exaggerate these individual differences (see Schellenberg & Weiss, 2012). Finally, we had no time to examine in depth two constructs mentioned in the literature: Karma's "ability to structure acoustic material" (structuring ability sounds very cognitive), and Gordon's audiation defined as an "ability to give meaning to what is heard" (to give meaning is also decidedly cognitive). We leave this task to future researchers.

D—Biological underpinnings of musilinked aptitudes

This section is not intended to survey the whole field of research regarding the biological bases of musilinked aptitudes; it aims simply to show through a few examples that it is indeed possible to fill the left component of the DMNA (see Figure 1.3) with a large diversity of evidence relevant to these aptitudes. Of course, the exploration of their biological foundations is hampered by the still partially unclear nature of the key phenotypic aptitudes that contribute to building exceptional musical talent. Moreover, no study has yet included a number of MPs or quasi-MPs in its sample. However, the research literature keeps building up at an increasing pace. We will first focus on the three "basements" (see Part II-B).

The three basements Let us begin with the lowest basement, the "chemical" level. Robert Plomin, one of the most eminent researchers in behavioral genetics, stated as early as 25 years ago:

The first message of behavioral genetic research is that genetic influence on individual differences in behavioral development is usually significant and often substantial. Genetic influence is so ubiquitous and pervasive in behavior that a shift in emphasis is warranted: Ask not what is heritable, ask what is not heritable.

(Plomin, 1989, p. 108)

Since then, literally thousands of empirical studies have strengthened that message, as demonstrated by a recent almost incredible “meta-analysis of twin correlations and reported variance components for 17,804 traits from 2,748 publications including 14,558,903 partly dependent twin pairs, virtually all published twin studies of complex traits” (Polderman et al., 2015). The authors reported an average heritability index of 49% across 20 general trait domains, including psychiatric disorders (1,778 traits), as well as metabolic (464 traits), cognitive (450 traits), cardiovascular (267 traits), and immunological functioning (230 traits). Is there a better confirmation of Plomin’s proposed shift in emphasis?

It applies of course to musilinked aptitudes in every domain we explored in the preceding section. Tan et al. (2014) completed an exhaustive search of studies devoted to the analysis of the genetic underpinnings of various musical phenotypes, including music perception, melodic memory, absolute pitch, music creativity, and congenital amusia. They identified no less than 21 studies that used behavioral genetic or molecular genetic methods to identify genetic markers of these musical phenotypes. Among other things, they showed that genetic factors affect variations in music aptitude not only across the population but also across the various components of music ability within the same individual. Even if many of these recent studies deal with small populations and have yet to be replicated, the birth of this new field will certainly bring about a clearer picture of the genetic mechanisms underpinning musical ability (see Mosing & Ullén, this volume, Chapter 4).

The second “physiological” basement reveals an equal abundance of empirical data. As a summary, Levitin (2012) affirms: “As with vision, music is processed component by component, with specific neural circuits handling pitch, duration, loudness, and timbre. . . . One can attain world-class expertise in one of these component operations without necessarily attaining world-class expertise in others” (p. 633). Finally, we find substantial empirical evidence again at the first “anatomical” level. For instance, many studies have shown that the volume of various cortical areas increases with amount of practice on an instrument (Schneider, Scherg, Dosch, Specht, & Gutschalk, 2002; Steele, Bailey, Zatorre, & Penhune, 2013; Wan & Schlaug, 2010; Zatorre, 2013). Other evidence suggests that “functional and structural properties of auditory and motor systems, and their interactions, can be construed as predictors of behavioral skill and learning in speech and music” such that variance in brain activity “may be a relevant indicator of the degree to which any individual nervous system can adapt to new circumstances and hence could help to explain individual proclivities” (Zatorre, 2013, p. 589).

Absolute pitch A growing body of evidence indicates that absolute pitch (AP) is shaped by genetic predisposition (Wilson et al., 2012). Preliminary evidence from an adult AP possessor who had minimal training but whose ability to perform a pitch memory task was indistinguishable from trained AP musicians, questions whether an early onset of music education (or any music training) is necessary for AP to emerge (Ross, Olson, & Gore, 2003). Rather, AP and non-AP possessors may be using different pitch-processing mechanisms (McLachlan et al., 2013) that reflect, at least in part, genetically influenced neuroanatomical differences. Thus, differences between AP and quasi-AP possessors (who scored between 20% and 90% on a note-naming test) may exist, even for individuals who experience similar early music education (Wilson, Lusher, Wan, Dudgeon, & Reutens, 2009). In an interview with Bruce Fellman (2003) for the *Yale Alumni Magazine*, Ross speculated that differences in brain activity between musicians with and without AP are due to fundamental anatomical differences in wiring.

People with AP possess an additional neural connection that enables them to tap directly into the timing patterns passing along the auditory nerve. Each individual pattern, encoded by the brain, then serves as an absolute representation of each individual pitch. When stored in the brain’s long-term

memory vaults, the codes become a registry that lets the AP-gifted identify tones or reproduce them as easily as someone looking up a number in a phone book.

(Fellman, 2003)

In a subsequent experiment, Ross and Marks (2009) went on to test children before musical training had begun, and found two children who possessed an elevated ability to perceptually encode pitch. This led them to speculate on “an innate perceptual process that may precede (if not predetermine) the traditionally defined AP skill of note naming” (p. 204). These are just a few examples of this growing mine of data on the complex ways our brain deals with musical inputs.

Ease/speed of learning In Section C we did not discuss specifically the subject of speed of learning because, as a “trademark” characteristic, it pervades all natural ability domains. The correct expression we should use is “ease, thus speed” of learning, acknowledging through that specific wording that the speed results from the ease with which gifted individuals master the knowledge and skills typical of their talent development field. Interestingly, there is growing empirical support for biologically based individual differences in ease/speed in learning. The closest recent evidence comes from Zatorre and colleagues (Zatorre, Delhommeau, & Zarate 2012; Zatorre, 2013) who, using a microtonal pitch discrimination task, found a significant relationship between speed of learning and fMRI activity, even before the commencement of training.

Looking ahead Taking all of the above into account, we might comfortably predict that the coming decades will see enormous advances in knowledge about the genotypic and biological foundations in the DMNA. In view of these advances, allow us a controversial parting shot. The eminent geneticist Sir Richard Dawkins affirms that “if you set your mind to it and had enough time and enough political power, you could breed a race of superior body-builders, or high jumpers, or shot-putters; pearl fishers, sumo wrestlers, or sprinters; or (I suspect, although now with less confidence because there are no animal precedents) *superior musicians* [our emphasis], poets, mathematicians or wine-tasters” (2010, p. 38). We would argue that there is a rapidly growing body of evidence to support his statement!

E—Summing up

Now that we have completed our survey of potentially useful building blocks of musical talent, we hope that readers will better understand our decision to put aside the traditional label of “musical aptitudes” and adopt instead the “musilinked” neologism. Although natural abilities from the auditory perceptual facet (GPA) might deserve the label of musical aptitudes, this is not the case for all other natural abilities described above, especially long-term memorization and manual dexterity. Just think for instance of the breadth of uses for manual dexterity: painting, sculpture, dentistry, surgery, video games, etc. We felt unable to adopt the “musical aptitude” label for these natural abilities, even as we acknowledged their core relevance as building blocks of musical skills. Beyond this initial terminological revision, we believe to have made many innovative suggestions. They are summarized below.

A new aptitude typology Our dissection of the musical aptitude literature has led to a revision of the classic view of these aptitudes, a view centred on auditory natural abilities (the GPA facet). Endorsing the severe judgment of most music researchers on the limited validity of existing aptitude tests, we looked for different types of musilinked aptitudes. Thanks to the DMGT's structure of six natural ability domains, we could make a systematic search for more appropriate building blocks of musical excellence. We did not invent new aptitudes, but found many interesting candidates that had been left in the background despite multiple indices of potential relevance.

For instance, as we read through the case studies in this volume and in the other books we cite throughout this chapter we were struck by repeated references to impressive memorization processes by past and current musical prodigies. We proposed to distinguish two main types of long-term memorization—declarative and procedural—devoted to the score and the fingering respectively. We also proposed giving much more significance to motor control abilities in the form of manual dexterity. In this respect, specialists should take a closer look at Gilbert's (1980, 1981) tests of motor skills, which seem to have shown strong predictive power. We finally proposed following up on Ruthsatz's observation concerning the gifted-level cognitive abilities of MPs (Ruthsatz & Urbach, 2012). Keep in mind that we are looking for natural abilities that will manifest their predictive power especially during the first two or three years of systematic music learning. By that time, exceptional achievers will have raced far ahead of their learning peers. We are well aware of the conceptual limits of this first attempt to restructure the broad domain of musilinked aptitudes. A proper treatment of that fascinating subject would easily imply a book-length involvement. Still, we hope that our efforts to bring some clarity to both the concepts and the terminology will inspire others to pursue in the same direction

Future musilinked psychometrics A potentially fruitful avenue of exploration could combine both abilities into an instrument targeting long-term memorization of procedural fingering patterns. Testimonial data suggest that very competent beginning young musicians show a remarkable ability to do just that. Of course, this does not preclude assessing other types of memorization, using musical content if possible. Researchers should also follow up on Carroll's (1993) suggestion of examining Shepard's (1981) work more closely. The next step would require experimenting these new types of measures with large samples of music students, first with beginning students, observing them over the first year of music training. Given that approximately a quarter of beginners abandon their studies before the end of the first year (McPherson, 2005; McPherson, Davidson, & Faulkner, 2012), it would be interesting to assess how well these new measures of motor dexterity and memorizing abilities would discriminate those who quit from those who persevere. They should also correlate strongly with performance levels at the end of that first year. We are convinced that very young beginners destined to emerge as musical prodigies or exceptionally talented performers will have significantly distanced themselves from their learning peers just within that first year of training. We are thinking of progress that would translate into MPQs of 180–200, or even more. The only mitigating element in this scenario comes from Sosniak's study where her concert pianists, although definitely advanced during their first years of lessons, did not progress exceptionally fast until early adolescence. Will the natural ability measures pinpoint with good accuracy who they are? Exploring this question would open a fascinating avenue for future research.

Miscellanea Here are two final points that complete our exploration of musical giftedness. First, having covered all six domains of the G component, we still have to decide what to do with a series of proposed “musical aptitudes” that do not fit within any domain. Here are a few examples taken from Hallam (2006) and McPherson and Williamon (2016): Wing's “appreciation for music” (appreciate seems to refer to a quality judgment), Révész's “ability to enjoy music aesthetically” (enjoyment and aesthetics have little to do with abilities), and finally Persson's “ability to respond to an emotional musical message” (emotional response fits much better within the IP subcomponent of intrapersonal catalysts). In the absence of clear descriptions of what is concretely assessed, all these alleged natural abilities seem to us to belong much more relevantly to emotional (IP) or motivational (IM) predispositions (appreciating music, enjoying music aesthetically, responding to the emotional musical message, sensitivity to the structural and expressive properties of music); their discussion seems more relevant in Part V. Second, we promised at the beginning

of this section to answer the following question: should we consider our MPs as gifted or as talented? There is no doubt that their abilities (natural and systematically developed) make them fit both definitions. When talking about them generally, we would favor the "talent" label because the spontaneous image is that of exceptional musical achievements. Yet, at the same time, their extreme precocity highlights their high level musilinked gifts. In brief, they are undoubtedly both gifted *and* talented. But, since such extreme talent implies high giftedness, whereas the reverse is not necessarily true, we recommend that music professionals give precedence, as we do, to the talent label.

V—MPs and the talent development component

As detailed in Part I, the DMGT's Developmental Process (D) component comprises a diversity of subcomponents and facets that help circumscribe the developmental course of talentees from their first steps in a systematic talent development process until its full achievement as mature experts in their chosen field of occupation. Some specialists even consider it relevant to follow ex-talentees through their career until their eventual—sudden or progressive—retirement from their active occupational involvement. We will adapt that broad developmental tapestry to our MP target population.

How will we define the respective entry and exit points of their talent development process? In the case of the entry point, we could adopt the technical definition of talentee, namely "becoming actively involved in a talent development process", but by so doing we would be ignoring not only their initial musical education, which might be quite standard (non-talent-oriented) in many cases (see Sosniak, 1985), but also any earlier signs of exceptional musical precocity which can appear even before a child's first birthday. Accordingly, we propose to set the point of entry as soon as these early signs of musical precocity appear, thus providing us with relevant markers to assess the nature and level of the child's musical giftedness. At the same time, these pre-TD activities help set the scene for the events that will result in the decision to move from leisure music lessons to a systematic talent development program. As for the exit point, we could decide either to stop our analysis when MP status becomes obsolete, by early adolescence in most cases, or to keep following the MP talentee's talent development until its professional peak, still remaining attentive to developmental patterns that keep distinguishing them from other highly talented musicians. We chose to adopt the most common time parameters of our target construct, namely early adolescence.

All nine current D facets proposed within the DMGT framework have some direct bearing on the specific developmental path of musical prodigies. Our focus on these nine developmental facets implies that we will ignore inputs from intrapersonal (Part VI) and environmental (Part VII) sources of influence; in other words, we will not embrace the full complexity of the talent development of musical prodigies, which includes their personal traits, motives, needs, and volitional strengths or weaknesses, as well as the crucial roles played by the rich tapestry of cultural, socio-economic, interpersonal, or educational influences. We will address that dynamic integration of causal sources in Part VIII. In view of the already mentioned dearth of empirical data, except Sosniak's interview study, the following discussion will include as many questions as proposed answers.

A—Developmental activities (DA)

Recall that the DA subcomponent comprises three distinct facets: developmental access modalities (DAA), curriculum (DAC), and learning environments (DAF). Each facet suggests its dedicated list of themes and questions.

1. Access (DAA)

The core of this facet targets the entry procedures into a systematic talent development program (as described briefly in Part I). But there is an earlier phase which has special relevance in the case of musical prodigies. How was that exceptional giftedness discovered? How did it first manifest itself? Are there initial premonitory signs beyond the very rapid pace of learning to be discussed below (DPP)? Indeed, in many cases, if not most of them, there seems to be an early falling in love, a literal *coup de foudre* for music in general and/or for a specific music instrument (see Part VI-B). Whatever the means of initial discovery of exceptional musical giftedness, what then happens in terms of systematic musical training? Do they begin their formal learning at an earlier age than their less exceptional peers? To what extent does the formal launching of a musical education have its source in the child's initiative as opposed to a parental decision? For those who begin their musical education before showing any special signs of potential prodigiousness, when do these signs appear as the systematic learning progresses? Concerning these questions, Sosniak (1985) provides the following basic information about her professional concert pianists: "The majority of the pianists we spoke with (16 of 21, or 76%) were taking piano lessons by the time they were six. One started as young as three; one as late as nine. All but two of the pianists began instruction because a parent decided that the child ought to do so" (p. 27). The last sentence, showing major parental initiative, indicates an approach quite different from the more frequent child pressures observed in the MP biographic vignettes we examined.

2. Content (DAC)

The concept of "content" refers to two distinct elements: the curriculum or subject matter, and the pedagogy or teaching strategies. Recall that the DMGT's definition of talent uses the expression "outstanding mastery of systematically developed competencies (knowledge and skills)". This means that the subject matter of most curricula involves two distinct types of content-related memory processes: (a) declarative memorization for the knowledge elements, and (b) procedural memorization for the skills elements (see Part IV-C). Of course, learning to play an instrument probably targets procedural memorization more than declarative memorization. There is little to say about the musical subject matter offered to musical prodigies, since all music students follow the official curriculum offered in their country, state, or province. What will distinguish MPs from less exceptional music students will be the pace (DPP) at which they progress through that curriculum (see DAF below). Is it possible to identify a pedagogical approach that would be more specific to musical prodigies today? It is difficult to answer this question properly, mainly because most of them integrate programs that cater to a broader range of musically talented children.

3. Format (DAF)

The "format" facet is probably the most difficult to differentiate from its related environmental subcomponent, ER-resources, especially when we talk about a group of individuals, here musical prodigies. In theory, we use the ER (Resources) subcomponent to inventory the diversity of options available to the particular population being the focus of our analysis. In contrast, we examine within the DAF facet when, how, and to what extent MPs use these various options as they progress from their first systematic music learning activities toward the peak of their MP status.

Musical education In this section we describe the major markers of typical MP educational paths in music, keeping in mind the breadth of individual differences. We could look at this phenomenon from a historic, geographic, or cultural perspective, but that is not the main focus here. Let us limit ourselves to a contemporary view, which can still include international comparisons.

The universal *accelerative enrichment* offered to musical prodigies represents the most significant format element: they move ahead through the formal curriculum as soon as they are ready to do so. Although music teachers view this administrative decision as normal and sensible, similar accelerative measures, like entering school early or skipping grades, remain immensely controversial in general education (Colangelo, Assouline, & Gross, 2004).

The DAF facet suggests many additional questions whose answers remain to be collected. For example, do MPs move more rapidly from their initial music teacher to a more specialized teacher? About that question, Sosniak (1985) points out: “over a period of four to seven years, all but one of the pianists switched teachers once, and 50% switched twice. . . . Some pianists moved to better instruction in gradual increments, and others made big leaps” (p. 42). And she adds: “The pianists began studying with master teachers somewhere between the ages of twelve and nineteen. The majority began between ages fifteen and seventeen” (p. 61). Again, we observe a significant delay when we compare them with the MPs described here. This is the type of information that touches the core of the present section. Of course, we would want the discussion to focus on the potential causal impact of that information on the talent development process. Here are a few additional subjects of interest. Do MPs enter a specialized music school or conservatory earlier than most other music students who attend these institutions? If so, how much earlier do they gain access? Some of the most eminent MPs never completed a music degree; they do not need to since their international concert career begins well before that. But, do some of them pass through a more typical musical development path? And what would be the characteristics of that more typical path? How much younger are they on average than their learning peers, at least in terms of achieved mastery? We have already mentioned numerous examples of children who were barely of school age when they joined a major music conservatory, and many more examples appear in this book. How often does their search for a more propitious learning environment imply a move to another city, even another country? Do music conservatories gather information about the actual/past MP status of their students? How would such information, if made available, enrich our knowledge of MP prevalence and MP musical development?

Regular schooling Most MPs pursue a regular K-12 education in parallel with their music lessons. To what extent do these two parallel activities harmonize or create some conflicts? Do MP students succeed well in their regular studies, even possibly showing signs of academic talent? That might signal high cognitive aptitudes in addition to their exceptional musical giftedness. When the music education occupies a significant percentage of the child's daily activities, there is often some risk of conflict with the requirements of a local school system. Do such conflicts happen, and if so how frequently? Some major music schools (e.g. the Juilliard School, the Curtis Institute of Music) offer to their brightest students the possibility of pursuing their general education by enrolling in specially accredited public or private schools, or in approved home-school environments. How many MPs follow that particular course of study, and how old are they when they do so? Note that three of the prodigies described in this chapter—Sarah Lang (Juilliard), Tiffany Poon (Juilliard), and Lang Lang (Curtis)—received this form of education.

Competing and performing publicly This paragraph focuses on the role of music performing and competitions in the developmental trajectory of musical prodigies. Among possible questions, we could look at the first state or national competitions that MPs participate in. Are they much younger than other participants? Most of Sosniak's (1985) concert pianists participated in their first competitions (local or regional youth competitions) during adolescence; they were “the most exciting and challenging experiences during these years” (p. 51). Do MPs begin winning such important competitions at a much younger age? How frequently, for example on a yearly basis, do they participate in such competitions compared with learning peers? In the case

of public performances, we would want to know if and to what extent they influence MP recognition, and how they contribute to the growth of their talent. There are examples in Solomon (2012) where “potential” MPs became publicly recognized only in mid or late adolescence, thus being “discovered” more as ex-MPs than as real ones. So, what percentage of MPs begin performing publicly before school age or before early adolescence? Is there a relationship between the level of prodigiousness and the age of initial public performing? Again, we can use Sosniak’s (1985) data: “One of the pianists played an important performance at age six, which led to a regular schedule of performances thereafter. Another pianist did not play a major event until eighteen. The majority of the pianists began performing regularly, and in some especially significant events, between the ages of thirteen and fifteen” (pp. 51–2).

B—Developmental investment (DI)

With respect to investment modalities, the DMGT separates them into three distinct areas: time (DIT), energy (DIE), and finances (DIF).

1. Time investment (DIT)

This facet includes two distinct elements, named differently depending on the field of talent development: class time and personal study in general education, teaching and training in sport, lessons and practice in music. In general education, most of the time investment goes into teacher supervised classroom time; from one year to the next it probably amounts to between 70% and 80% of the students’ total time investment in their K-12 education. Moreover, individual differences tend to be limited, and they apply mostly to personal study. In contrast, music lessons account for little more than 15–25% of total time investment over the course of a music talent development program. Students devote most of their time to practice. As opposed to reminding or encouraging their child to practice, during the first years, only a small percentage of parents (we estimate less than 10%) will supervise practice by sitting with the child during practice sessions, thus creating an environment partially analogous to the lessons (McPherson, Davidson, & Faulkner, 2012). In line with the DMGT’s macroscopic perspective, we will ignore the minutiae of the practice activities, specific parental duties as practice supervisors, or any other similar daily variations. We are basically interested here in long-term trends, evolution over months and years, and of course, in the differentiated practice habits of musical prodigies.

Practice habits We can find in the music literature a lot of statistics on practice time by young music students at different talent development levels (e.g. Ericsson, Krampe, & Tesch-Römer, 1993; Jabusch, Alpers, Kopiez, Vauth, & Altenmüller, 2009; Kornicke, 1992; McPherson, 2005; McPherson, Davidson, & Faulkner, 2012), but we know little about the specific situation of MPs. At least one observation stands out clearly: even among MPs, individual differences are large, from young musicians who practice on average little more than two hours daily to others who will spend at least twice as much. Sosniak’s (1985) study provides an additional source for the learning habits of highly talented young musicians. Writing about the pre-adolescence period, she notes: “The time the twenty-one pianists spent practicing in the early years of learning varied tremendously. Some of the pianists spent ‘every free minute I had’ at the piano. ... Others spent only as much time practicing as was required by a parent or teacher” (p. 34). By early adolescence, “the time the pianists spent at the piano increased dramatically in this period of learning. Those who had been practicing forty-five minutes to an hour a day began spending two hours a day ... those who had been practicing two hours a day found themselves working as many as four” (p. 47). Then, by mid-adolescence, “a

tremendous amount of time was devoted to learning to be a musician. In general, this was at least equivalent to a half-time job" (p. 57). These quotes leave a lot of questions unanswered, and open many possibilities for in-depth exploration of the DIT facet.

The "10-year rule" Do MPs invest much less time than other exceptionally talented music students to reach their MP status? A positive answer seems evident, but it faces strong objections from those who defend the well-publicized "10,000-hour rule", also called the "10-year rule". Recall that it was invoked briefly in our description of the debate between Pronats and Antinats (Part IV-A) over the existence of natural abilities. This rule has its origin in the work of A.K. Ericsson, whose key construct of deliberate practice we will discuss in the next section. It became famous through its use as the title of the second chapter in Gladwell's (2008) bestseller *Outliers*. In its strictest form, endorsed by many media people, this rule states that for any individual to reach the level of expert in any field, 10,000 hours of practice are necessary (no less) and sufficient (no more). The specification "any individual" means of course that natural abilities play no significant role in that developmental process. To be honest, Gladwell himself did not endorse this strict interpretation, but recognized the existence of "innate talent". For example, he said: "The question is this: is there such a thing as innate talent? The obvious answer is yes" (2008, p. 38). But he then almost totally ignored that concept's developmental role in the rest of his book. Note that there is no mention of individual differences in learning pace, leaving the impression that they are either nonexistent or vary minimally; they are certainly judged to be small enough to justify a wide application of that rule. Moreover, nowhere do we find a precise definition of "expert" in terms of achieved level of excellence; for some it means world-level expertise, and for others a more modest, but unspecified, high level of excellence. The "10-year rule" rapidly became the target of an intense controversy (e.g. Ankersen, 2012; Epstein, 2013; Howe, 1999; Levitin, 2006; Simonton, 2013; Syed, 2010; and dozens of others!); roughly stated, there is a large overlap between those who endorse it and general Antinat beliefs. As interesting as this subject can be, its discussion would lead us away from our main subject. Suffice it to say that the MP phenomenon, with its steep learning curves (high MPQs) and rapid access to exceptional expertise, represents one of the strongest arguments against the "10-year rule".

2. Energy investment (DIE)

Energy investment represents the capacity to maintain sustained attention on a task or set of tasks for long periods of time. When talentees concentrate for hours on end on their learning and practice, repeat exercises dozens of times, with perfect mastery as the only acceptable goal, they are demonstrating that energetic quality typical of high level talent development. Just think of young Wolfgang Amadeus who could keep "improvising for hours off the top of his head" (Keefe, this volume, Chapter 24), Clara Schumann who said "my fingers strengthened so rapidly that I could now play difficult pieces for two hours on end with fair persistency" (Kenneson, 1998, p. 79), or Ginette Neveu who objected to her mother's requests to stop practicing with comments such as "it has got to be beautiful" (Kenneson, 1998, p. 203).

Attention versus concentration The most common use of "attention" targets short-term focus and resistance to distractibility, just as it appears in expressions like "selective attention", "undivided attention", "attention deficit disorder", and so forth. It is also a key ingredient for individual differences in working memory (Vandervert, this volume, Chapter 8). Goleman's (2013) most recent bestseller targets the concept of focus or attention, which he considers the "hidden driver of excellence". In his seminal work on the structure of human abilities, Carroll (1993) reviewed the existing literature on the concept of attention. He considered that term to represent "a very broad category in psychological theory" (p. 547), pointing out that "an individual differences factor

could often be equally well interpreted either as a factor of some particular cognitive ability or as a factor of attentional ability” (p. 547). He added the following observation.

Information on whether there are different kinds of attentional abilities is relatively sparse. Much of what is available has been summarized by Davies, Jones, and Taylor (1984), who point out that in experimental psychology there has been little concern with individual differences in attention. They review the field under two broad rubrics: *selective* attention, and *sustained* attention (or *vigilance*).

(Carroll, 1993, p. 548)

This dichotomy fits well with our desire to differentiate short-term selective attention from long-term “vigilance”, especially since attention tests commonly assess relative absence of errors in very simple short-term tasks of resistance to distractibility (Carroll, 1993). The concept that most interests us here is sustained attention over long periods of times; we adopted the label “concentration” instead of vigilance. Note that according to this definition the expression “sustained concentration” becomes tautological!

Empirical evidence As shown in the above examples, musical prodigies appear to manifest much more energetic investment than less talented music students. Yet the lack of reliable measures for that particular construct, apart from self or third-party judgments, limits the validity of any generalizations. Still, these judgments confirm many stereotypes. For instance, through videotape analyses, McPherson and Renwick (2001) showed that young musicians rarely (if ever) demonstrate any concentration during their practice sessions: “almost all of the children’s practice consisted of simply playing the piece through without any other strategy being used” (p. 172). In another study, Williamon and Valentine (2000) observed that a DIE measure was a better performance predictor than a global DIT index. They asked 22 pianists (categorized according to four levels of ability) to learn a piece by Bach over a short period of days. Practice sessions were recorded, and experienced listeners assessed the quality of the performances in terms of musical understanding, communicative ability, and technical proficiency. Practice was coded according to the total practice time across the period of learning (DIT), and the researchers also coded the average length of each practice segment (DIE), computed as the average number of notes played before stopping and moving on to a different section. These researchers found no association between total time spent practicing and the final performance, but they observed a significant association between the average length of the practice segments and the learner’s final performance quality. These examples confirm the partial independence between time and effort investments.

3. Ericsson’s “deliberate practice” (DIT/DIE)

If there is one construct that summarizes the idea of “investment” in musical practice, it is without doubt Ericsson’s concept of deliberate practice (DP). Each of the two words refers to a distinct IMTD facet; this is why we consider Ericsson’s construct as covering both the “time” (practice) and “energy” (deliberate) facets of the DI subcomponent.

The nature of deliberate practice The concept of deliberate practice emerged in the talent development literature thanks to a now famous pair of studies of musicians’ practice habits (Ericsson, Krampe, & Tesch-Römer, 1993). Using a diversity of data collecting methods, including retrospective data, interviews, and a one-week diary of actual practice time, the authors found very significant differences in accumulated hours of practice between groups of musicians differing in professional competence. Their analysis brought them to conclude that long-term DP was “the” key to elite performance: “We view elite performance as the product of a decade or more of maximal efforts to improve performance in a domain through an optimal distribution of deliberate practice” (Ericsson, Krampe, & Tesch-Römer, 1993, p. 400). But how does Ericsson define DP?

It is “a very special form of activity that differs from mere experience and mindless drill”, is “not inherently enjoyable”, and “does not involve a mere execution or repetition of already attained skills but repeated attempts to reach beyond one's current level which is associated with frequent failures” (Ericsson, Roring, R. W., & Nandagopal, 2007, p.18). “Deliberate practice [involves] repeated attempts to reach beyond one's current level which is associated with frequent failures. Aspiring performers therefore concentrate on improving specific aspects by engaging in practice activities designed to change and refine particular mediating mechanisms, requiring problem-solving and successive refinement with feedback” (Ericsson et al., 2007, pp. 18–19). These excerpts focus more on the improvement process, but imply the “energy” component present in focused concentration. They confirm that the DIE aspect trumps the DIT component; it is the focus on “quality” practice that makes a difference, much more than the strict DIT element. In fact, high level concentration can reduce significantly the time necessary to achieve mastery; of course, the more of both the better!

Debating its predictive power The main criticisms addressed to Ericsson and his followers target two key arguments: (a) the quasi-sufficient explanatory role of DP, and (b) their denial of natural abilities. We discussed the second point earlier (Part IV-A). With respect to the first argument, dozens of studies with a diversity of samples (e.g. general education, music, sport) have examined the causal power of DP to account for individual differences in achievement. The journal *Intelligence* devoted a full issue (Volume 45, 2014) to both aspects of that debate. Although a detailed discussion is beyond the limits of the present text, we can at least cite the most recent meta-analytic studies of the predictive power of time investment as operationalized through the DP construct. Note that most measures confound the DIT and DIE facets by using strictly DIT measures. A recent meta-analysis (Macnamara, Hambrick, & Oswald, 2014) identified over 100 empirical studies of that specific subject, covering 157 distinct effect sizes (measured as percentages of explained variance, or $r^2 \times 100$) in five major fields (sport, education, music, games, and professions). The explained variance ranged from a high of 26% (games), down to 1% (professions); it was 21% for music, 18% for sport, and 4% for education. The authors concluded: “amount of deliberate practice—although important as a predictor of individual differences in performance from both a statistical and a practical perspective—is not as important as Ericsson and his colleagues have argued” (p. 8). In reaction, Platz, Kopiez, Lehmann, and Wolf (2014) published another meta-analysis based on 13 music studies ($N = 788$); they reported an aggregated effect size of $r_c = 0.61$ between accumulated practice and musical achievement.

These back and forth exchanges do confirm one thing: the exact contribution of deliberate practice in the acquisition of expertise remains a heated subject of debate. Clearly, more systematic and tightly controlled empirical studies are needed to understand how and to what extent DP may shape musicians' development. It seems clear, however, that DP is an important variable in determining musical expertise. Musical prodigies cannot achieve their high level of performance without having devoted thousands of hours of deliberate practice to refine their craft. We agree with Ericsson and his colleagues that the development of extraordinary talent in music involves focused and concentrated effort, and that this typically occurs (but in our opinion not always) from a very young age. However, we strongly disagree with both Ericsson's key statements; we believe that high level musical expertise requires much more than deliberate practice, and especially the contribution of exceptional musical giftedness.

4. Financial investment (DIF)

This facet's significance varies considerably according to the field of occupation examined, even to specific subfields. Just imagine the difference in developmental costs between sports like football

(soccer) or basketball as opposed to hockey, tennis, or figure skating; the equivalent in music would be the differing costs of playing a piano or violin as opposed to playing a trumpet or a guitar. In the first case, high quality instruments can cost tens of thousands of dollars, whereas high quality trumpets or guitars cost just two or three thousand dollars. In line with the perspective adopted in all other D component facets, we will examine financial matters from the point of view of the receivers—the MP talentees—rather than the givers (e.g. parents, sponsors, scholarships). We are not concerned here with environmental inputs per se, like surveying the diversity of scholarships available (ERF facet) or the importance of parental financial sacrifices (EIF facet), or any other similar themes. For instance, it is important to assess to what extent a high quality piano is included as a significant budgetary item, even when the MP is still very young, but we will reserve the discussion of these costs on parental finances for Part VII-B (EIF facet). Our basic question is simple: what can we say about the financial balance sheet—costs and revenues—of bringing MPs from initial identification to mature professional emergence? In a profession that is highly demanding and extremely competitive, financial success in adult life is not guaranteed merely by a musician's level of talent.

How do these costs—and revenues, if any—evolve during the MP's youth? How significant are individual differences in that respect? How early do significant costs, let us say beyond weekly lessons with a neighborhood music teacher, begin to accumulate? How much comes from the parents as opposed to other significant sources? How many receive a scholarship to an important music school? Is there a relationship between the level of prodigiousness, as measured for instance with an MPQ, and the size of the scholarship? Considering that a select few MPs would have begun earning significant amounts of money in their early youth, could their talent development path produce a positive balance sheet, even to a significant degree? Sarah Chang, for example, was performing with major orchestras by the age of 9, released her first commercial recording at age 10, and within a couple of years was performing around 150 concerts a year. Michael Jackson was recording commercially and performing publicly well before he was 10, whilst a number of other MPs surveyed in this chapter (e.g. Wolfgang Amadeus Mozart, Felix Mendelssohn, Teresa Carreño, Buddy Rich, André Mathieu, Stevie Wonder) were regularly performing in public before or soon after the age of 10. Of course, such revenues vary enormously depending on the parents' willingness to allow these opportunities and their ability to control their frequency. Is it possible to estimate, even roughly, the incidence of such "precociously profitable" investments?

Again, beyond some disparate anecdotal information, we know very little about the talent development costs of musical prodigies; even Sosniak (1985) does not bring up the subject. Testimonies indicate that costs probably exceed by many orders of magnitude the strict educational fees (music school and music teacher) of typical MP learners, especially in cases where parents have to move their residence closer to a well-renowned school in order for their child to pursue a more appropriate course of studies. As a final sadder note, in contrast with the documented huge financial investments made by many prodigies' parents, we will never know how many budding musical prodigies never bloomed because of their parents' lack of willingness or capacity to extend themselves financially so that their child could receive appropriate musical support from professional teachers and/or institutions.

C—Developmental progress (DP)

The Progress (DP) subcomponent also comprises three main facets: Stages (DPS), Pace (DPP), and Turning points (DPT). Each of these, but more so the Pace facet, has direct relevance for a better understanding of the talent development of musical prodigies.

1. Stages (DPS)

Just like distance reminders on a highway, stages serve as longitudinal markers along any talent development path; many of them are used as quasi-qualitative descriptors of progress, although in reality they convey quantitative changes in content mastery. If we imagine talent development as a stepladder, stages will represent the various rungs. These stepladders do not contain any pre-established number of rungs, but, as we create more of them, the view progressively switches from macroscopic to microscopic, a direction we try to avoid within the DMGT perspective. Stage systems can take many forms. We will describe here a categorizing system that distinguishes two broad types of stage, depending on whether they utilize *product* or *process* characteristics.

Product-based stages The *product* perspective builds its rungs with *direct* or *proxy* indices of rank-ordered acquired competencies or achievements. The simplest prototypes of a direct approach use coarse categories like novice, advanced, expert, and so forth. That coarseness in itself precludes the identification of clear transitions, thus limiting their practical usefulness in ranking talentees. Other prototypes adopt hierarchically scaled skill descriptions, for instance the 16 skill levels used in tennis to rank players, all the way from beginners (Level 1) to top 100 ATP players (Level 16) (see *Universal Tennis Rating*, 2014). Many sports, like tennis and chess—yes, professional chess is considered a sport!—have adopted proxy stage systems based on competitive success; points are added or deducted according to wins and losses with higher or lower rated competitors. These scores can be transformed into rankings that reflect level of expertise. Another popular competency-based proxy system commonly used in sport has chosen geographically based levels of excellence for its rungs (Gulbin, Oldenzel, Weissensteiner, & Gagné, 2010); this is easily adaptable to music. For instance, winning a local music competition would place young talentees on the first rung of that system; they would then move up to broader reference groups (e.g. regional, state, national) until reaching international status or fame. Of course, the most common product-based proxy stage system available in most fields of talent development, including music, follows the grade levels of an official curriculum, just like those found in all school systems. With respect to music, we can mention the *Australian Music Examinations Board* (AMEB), or the *Associate Board of the Royal Schools of Music* based in the UK but offered in a number of Commonwealth countries around the world. For example, we followed the AMEB hierarchical system to create our MPQ index (see Part III-C).

Process-based stages The *process* perspective immediately brings to mind the seminal study conducted by Benjamin Bloom and his colleagues (Bloom, 1985a), already described in Part III-B. The research team opted for a three-stage system that could fit all six groups of talented interviewees. Because of major trajectory disparities between these groups, they chose very broad chronologically based labels: *early years*, *middle years*, and *later years* (Bloom, 1985b). They then used distinct process characteristics in each group to describe each stage. With respect to concert pianists, Sosniak (1985) followed that basic template of process-based descriptions. For instance, she summarized the critical elements of the first stage, which extended approximately between the ages of 4 and 10, in the form of four goals: (a) developing an identity as a pianist, (b) developing a practice routine, (c) developing a motivation for subsequent learning, and (d) developing increasing aspirations (Sosniak, 1985, pp. 44–5). A decade or so later, Côté (1999) proposed a three-stage system adapted to talent development in sports, acknowledging its general similarity with Bloom's proposal. Notice the process-based labels he chose: *sampling years*, *specializing years*, and *investment years*. He mentioned a logical extension beyond the developmental phase, which he labeled “performance” or “perfection” stage. Abbott and Collins (2004) built on Côté's system by developing the fourth stage and renaming it *maintenance* stage. Recently, McPherson

and Lehman (2012) adapted the Abbott–Collins four-stage system to musical talent development (see Figure 1.6).

Product versus process Which stage system should be favored? Both have their virtues and limits, and we could summarize their differences by opposing, on the plus side, the precision of most product approaches with the descriptive richness of process approaches, and on the minus side the unavailability of ranking systems in some performance areas with the fuzzy transition points of the process approaches. They can also find their best usefulness in particular situations. For example, we had to use a product-based system to create the MPQ values (see Part IV-B) that quantify pace of progress. On the other hand, process-based stages offer better views of the differential characteristics typical of successive moments in the developmental process. Of course, such descriptions must cover as broadly as possible the diverse aspects of that process, which the DMGT framework so well illustrates. In the case of Côté's stages, his explicit focus on family influences and, we might add, his strong environmentalist leanings, distinctly shaped his stage descriptions; as expected, both the Abbot–Collins and McPherson–Lehman adaptations retained that selective environmental outlook. A broader perspective would integrate other categories of influences, like natural abilities and intrapersonal catalysts. Moreover, most children learning an instrument rarely progress beyond the specialization stage; music never becomes the most important priority in their lives (McPherson, Davidson, & Faulkner, 2012). In contrast, MPs reach the McPherson–Lehman *investment* stage well before adolescence. They differ significantly from other talented music students who reach the investment stage definitely later, toward the end of high school as indicated by Sosniak's (1985) study, which means when they face the decision to study (or not study) music at the university level.

2. Pace (DPP)

Among the nine facets that the D component comprises, one stands well above all others in terms of its significance for musical prodigiousness; it is the extremely rapid pace of progress of MPs. Its key descriptive and explanatory role made us include it as a defining *process* characteristic of musical prodigiousness. The distribution of this characteristic espouses a normal curve shape, with a majority of learners around a middle pace typical of the specific learning situation examined, and progressively fewer learners toward both ends of the distribution. The more difficult the learning tasks are, the more we will observe with time an increase in the gap between the slowest and fastest learners (Baltes, 1998; Gagné, 2005). This should be the case with learning to play musical instruments, a task that gets more and more difficult with time, except for the fact that many of the slowest learners quit within a few months—around 25% in the first year, and over 50% by the end of the fifth year (McPherson 2005; McPherson, Davidson, & Faulkner, 2012; Evans, McPherson, & Davidson, 2013).

Pace of progress is the key quantitative index to assess *normatively* the growth of any type of learning; good DPP knowledge will help professionals ponder the advisability of retaining very slow learners in the same grade, and of accelerating very fast learners through the grades. All learners will also estimate their own subjective DPP index, a kind of personal feedback loop, to determine how well they are keeping up with their learning peers. A low DPP index might become a central motive to drop out—when possible!—of a learning program. Pace of progress is such an important concept that it became the core element of the MPQ values we created to assess levels of talent, and to establish a minimum threshold for musical prodigiousness. Since we examined the DPP phenomenon in detail in Part III-C, there is no need to repeat ourselves here.

3. Turning points (DPT)

The concept or turning point refers to a major change in pace of progress during the talent development process, either accelerating or decelerating it; can even be the main reason for a music

Figure 1.6 McPherson and Lehman (2012) macrostages of musical development.

Adapted from "Eliminating the dichotomy between theory and practice in talent identification and development: Considering the role of psychology," Angela Abbott and Dave Collins, *Journal of Sports Sciences*, 22(5), pp. 395–408, DOI:10.1080/02640410410001675324 © 2004, Taylor & Francis. Reprinted by permission of the publisher (Taylor & Francis Ltd, <http://www.tandfonline.com>).

talentee's decision to quit. It is hard to imagine any talent development trajectory without at least one turning point. Sooner or later, usually sooner in the case of musical prodigies, all talentees encounter at least one significant event that will become a turning point (DPT). Turning points vary tremendously in nature; they can have their source in any of the DMGT's components: suddenly discovering a special aptitude (G & IW), suffering from a major illness (IF), receiving the financial help of an important sponsor (ERF), unexpectedly winning a high level competition (T), and so forth. In the case of many of these events, their labeling as turning points is essentially "in the eye of the beholder!" For instance, the death of a close family member, an important financial setback, or a long period of mental illness may become major negative turning points for some young musicians but not for others. Of course, some events will impact almost all talentees similarly, like being accepted at Juilliard or Curtis! But in many cases, probably the majority, the talentee's personal history will determine strength of impact. Just recall why the DMGT's figure places the I component partially in front of the E component.

Are there any turning points more typical of MP career paths? Our MP vignettes would reveal dozens of significant moments in their lives, but because of the lack of any systematic classification, it would be little more than a long list of anecdotes. However, one such turning point has received special attention from music scholars; it concerns the identity crisis that many musical prodigies—if not a majority—seem to confront during adolescence as they move from the MP limelight to the more competitive world of young professionals attempting to find their niche or regain a new international prominence as soloists (Bamberger, 1982, this volume, Chapter 12). In this regard, although it is virtually impossible to come up with a hard figure, the limited existing literature suggests that only a minority of musical prodigies achieve a successful transition into an adult career. Goldsmith (2000), for example, provides surprising statistical data for a very specific locale and era.

The San Francisco area proved to be a particularly fertile area for the identification and development of young musicians ... more than 70 musical prodigies were actively performing in the area in the '20s and '30s. ... Of these 70 unusually talented young musicians, only six had notable musical careers as adults: pianists Leon Fleisher, Ruth Slenczynski, and Hephzibah Menuhin and violinists Issac Stern, Ruggiero Ricci, and Yehudi Menuhin. We know nothing of the musical fates of the remaining 64 children, nothing of the events and decisions that shaped their life courses. In all likelihood, some continued in less visible musical careers, perhaps teaching music or playing professionally in orchestras, chamber groups, or bands. Others may have chosen to integrate music into their lives avocationally rather than professionally.

(Goldsmith, 2000, p. 91)

This quote tells a very sad story of mostly unrealized dreams! Of course, we will never know to what extent the ulterior career paths of these 60+ former MPs were the result of an undesired downward turning point as opposed to a well considered decision not to pursue a career path perceived as offering more disadvantages than advantages. It would be very interesting to explore in greater depth these turning point motivations and gather current data that would allow some extrapolation from the above very limited situation to the much broader contemporary North American context.

D—Summing up

Part V stands out as one section with little supporting empirical data in each of its three subcomponents: activities (DA), investment (DI), and progress (DP). Within the first subcomponent, we mostly inventoried the diversity of questions that could enrich this area. They first address the modalities through which the exceptional aptitudes and early talent are discovered and how they

lead to a systematic music education (DAA). We then identified questions pertaining to the developmental process itself, in terms of both the curriculum followed by the young talentees (DAC), which was judged generally similar to that of other young music students, and the learning environment (DAF). We noted that the main differentiating format element was the accelerated pace with which the curriculum was pursued, with earlier access than average to special schools and special teachers.

In the case of the second subcomponent, we first pointed out the probable significant differences in length of weekly practice (DIT) between MPs and their learning peers, even very talented ones. We brought up the controversial subject of the “10-year rule”, according to which almost anyone could reach expert status by investing 10,000 hours of practice time. We rejected the need for MPs to invest that much time during their talent development; we also strongly questioned the belief that practice is sufficient to reach exceptional goals, a position that denies any significant contribution from outstanding natural abilities. We introduced a distinction between short-term *attention* and long-term *concentration*, judging the second construct to better represent the type of energetic investment typical in talent development situations. We took time to describe and analyse Ericsson's key construct of “deliberate practice” (DP) as a prominent contributor to expertise. We showed how that concept overlapped the DIT (practice time) and DIE (deliberate monitoring) facets of the DI subcomponent. We surveyed the controversy over the degree of explanatory power attributed to the DP construct, endorsing a much more nuanced position than the one defended by Ericsson and his supporters. With respect to the financial investments (DIF) required to reach fully developed MP status, we had to focus, again for lack of appropriate data, on relevant questions about the various costs and on the potential compensatory input of significant revenues from early performing activities.

Finally, with respect to the third subcomponent of progress, we first surveyed the various ways of creating developmental stages (DPS), proposing a clear distinction between product-based and process-based systems. Then we showed how pace of progress (DPP) was both a crucial developmental index and a key measure of the target construct itself through its contribution to musical progress quotients (MPQs). We also mentioned how these MPQs could play an important motivational role, potentially justifying decisions to pursue or abandon music studies. We completed this fifth part by addressing the delicate question of the few turning points (DPT), positive as well as negative, that will have a major impact on the course of the talent development process.

Note that we did not create a special section for the possible biological foundations of the developmental process. We could not find any relevant data, except maybe potential biologically anchored individual differences in terms of capacity to maintain long-term concentration (Goleman, 2013).

VI—MPs and intrapersonal catalysts

Two large groups of influences constantly modulate the talent development process: intrapersonal (I) and environmental (E) catalysts. The first group comprises five subcomponents (see Figure 1.1): physical (IF) or personality (IP) characteristics, awareness of potentially significant influences (IW), as well as motivational forces (IM) and volitional investments (IV). Our literature review suggests that four of these (IF, IP, IM, IV) might harbour relevant causal influences with regard to the growth of exceptional music talent.

A—The IF subcomponent

The IF subcomponent brings together a variety of potential influences. These influences have their source in physical characteristics that are independent of ability-based physical characteristics

that more specifically underlie the two physical subcomponents GM and GR. We are interested in differences that will catalytically affect the developmental process, for instance the physical maturity required to begin learning wind instruments; we mentioned a few of these in Part I-A. With respect to musical prodigiousness, we found in the literature only one potential differentiating candidate—sex. Let us point out immediately a terminological precision almost unique to the English language, namely the difference between “gender” and “sex”. The first term refers to behavioral differences that have their origin in sociocultural influences, like parental stereotyping or peer group pressure to comply with particular gender roles; the second implies biologically anchored differences. Political correctness strongly suggests that we use the “gender” label unless there is clear evidence to the contrary! But, since gender effects have their origin in biologically created phenotypic differences in appearance, we will use here the “sex” label to describe factual differences, as well as our special hypothesis.

Differential sex prevalence As our starting point, we examined the population of MPs in search of potential sex differences in prevalence. If we observe significant overrepresentation of one sex relative to the other, it means that this characteristic acts as a notable predictor of MP emergence. In other words, whatever the reasons, being a boy or a girl significantly influences a young child’s chances of becoming an acknowledged musical prodigy. If we move back to the 19th century and beyond, the evidence for differential prevalence is clear: male musical prodigies clearly outnumber their female counterparts. For example, in his analysis of 137 child composers born before 1900, Cooper (this volume, Chapter 7) lists 15 females out of a total of 137 composers; this represents about 11% of the total number of child composers. Looking at only those children who were composing before the age of 9, we find five females and 32 males; thus female composers represent approximately 15% of that age group. The spontaneous interpretation of such a large disproportion targets the cultural values of that period about women’s limited rights to participate in what was considered at the time essentially a man’s world, music belonging of course to that world. Yet, according to Cooper (personal communication, January 2015) “certain instruments (chiefly keyboard and harp) were often played by girls, and of course girl/woman singers were also extremely common”. Moreover, many of the females that Cooper identifies went on to have important musical careers despite their gender.

But what about more recent statistics? Has the feminist movement of the past few decades succeeded in equalizing the representation of both sexes? Although young girls have definitely increased their presence within the MP population, we would argue, even in the absence of strong supporting data, that girls still constitute a minority. For instance, Sosniak’s (1985) sample of 21 concert pianists includes only five women (24%). Some would probably argue that this study dates from three decades ago, and that most of the pianists had begun their talent development more or less 20 years earlier, in the early 1960s. However, we could also add Kenneson’s (1998) description of 41 musical prodigies from Wolfgang Amadeus Mozart to more current times, in which 11 (28%) are female. Whatever might be the case, we believe that there still exists a significant overrepresentation of boys among this group of extremely talented young musicians. If such were the case, it is clear that the prevalent environmentalist ideology would immediately look for residual cultural influences adverse to girls’ access to proper talent development of their musical giftedness; these scholars would not even imagine possible biological underpinnings for the observed prevalence gap. But, a biological hypothesis does exist.

An interesting hypothesis This hypothesis targets musilinked natural abilities, probably most—if not all—of those we identified in Part IV-C; we borrowed it from another ability domain, namely cognitive (GI) abilities. When psychometricians examined separate IQ distributions for boys and girls, they found no differences in average values (sorry ladies!) but kept observing significant

differences in the variability (SD or standard deviation) of these distributions, with significantly larger SD values in the case of boys. Discussing these results, Macintosh (2011) points out: "The implication is that even if there were no sex differences in average IQ there would be more males than females with an IQ over 140 and, equally, more males than females with an IQ below 70 [sorry boys!]" (p. 367). This seems to be exactly the case. Macintosh goes on to cite at least half a dozen very large studies with significant SD differences. We believe that similar differences could appear in other natural ability domains, like those we discussed in Part IV-C, thus creating an overrepresentation of boys among musically gifted youth. It would certainly be an interesting question to pursue if statistical data did confirm our hunch about a prevalence disparity favouring boys among MP youth, as well as their quasi-MP peers.

As a final comment, let us point out the risks we are taking by bringing up the subject of sex differences in a field belonging to the social sciences; it might open a huge can of worms! Macintosh (2011) mentions that D.F. Halpern, in her seminal book on cognitive sex differences (Halpern, 2000), prefaced her chapter on biological hypotheses with the warning, printed in bold: "Some of the research and theories described in this chapter may be disturbing to your basic belief systems" (p. 379)! As Macintosh points out sensibly: "it can hardly be disputed that the ultimate cause of any sex difference in cognition is genetic: the difference between males and females is, after all, a genetic one, in the vast majority of cases, the possession of two X chromosomes or of one X and a Y chromosome" (pp. 379–80).

B—The IP subcomponent

As already noted in Part IV, we found that some alleged "musical aptitudes" belonged more relevantly to personality characteristics, notably the concept of "musical sensitivity". We also found in the existing literature two personality constructs that deserve closer attention: (a) Winner's (1996) "insistence on marching to one's own drummer", and (b) exceptional attention to detail (Ruthsatz & Urbach, 2012).

1. Special sensitivity to music

Every dictionary defines "sensitivity" as an emotional concept, whose synonyms are susceptibility, vulnerability, empathy, touchiness, hypersensitivity, and so forth. So, when Winner and Martino (2000) describe as a possible core ability of musically gifted children their "*sensitivity* to the structure of music—tonality, key, harmony, and rhythm" (p. 102), we tend to disagree with that definition of sensitivity. Instead, we prefer Révész's (1954, 2001) "aesthetic enjoyment of music" or Persson's (1996; Persson, Partt, & Robson, 1996) "responding to the emotional musical message". In our view, both expressions more aptly describe the intense intellectual curiosity and emotional engagement MPs experience when interacting with music, and the type of "boundless enthusiasm" that Keefe (Chapter 24) and others in this volume and elsewhere use in their descriptions of young MPs. The concept of "intellectual curiosity" brings to mind the recent work of von Stumm, Hell, and Chamorro-Premuzic (2011) who argue that this personality trait (the O in the FFM *OCEAN* acronym proposed in Part I-C) is the third most important predictor of academic achievement (after cognitive aptitudes and conscientiousness). In another text, Winner (1996) does point out that "the earliest clue that a child is gifted in music is a strong interest and delight in musical sounds" (p. 93). Notice in that quote the close association between emotion (IPE facet) and interest (IMI facet); these fuzzy boundaries between concepts recur again and again in the scientific (and popular) literature, no doubt because of the closeness in subjective experiences. We will observe this strong overlap in the examples in Section C below. However, their exact operational representations remain ambiguous, a problem that music scholars should try to address, especially through more concrete definitions and validated measurements.

We can enrich through a few examples our core meaning for the concept of sensitivity. When pianist Drew Peterson was just 2 years old, he “didn’t produce much sound at that stage, but he already cared about it deeply. ‘Church bells would elicit a big response,’ [his mother] Sue said. ‘Birdsongs would stop him in his tracks’ ” (Solomon, 2012, p. 417). All the other examples are taken from Kenneson (1998). The mother of MP violinist Nadia Koutzen described the following story of her 3-year-old daughter listening to a young violinist invited to play at their home. “As long as I live I will see our tiny Nadia sitting in her little chair completely absorbed in the playing and tears streaming down her face. After they were gone she resolutely stated that she wanted a violin for Christmas” (p. 123). “When Jascha [Heifetz] was eight months old, his face beamed with joy when his father played a beautiful tune on his violin” (p. 132). “When his two older sisters began piano lessons at home, he was happiest nestled by their feet beneath the keyboard. Only three years old, Artur [Rubinstein] was amazingly responsive” (pp. 152–3). Finally, Glenn Gould’s father recalled that “as soon as Glenn was old enough to be held on his grandmother’s knee at the piano, he would never pound the keyboard as most children will with the whole hand, striking a number of keys at a time; instead he would always insist on pressing down a single key and holding it down until the resulting sound had completely died away. The fading vibration entirely fascinated him” (p. 160).

Although there is virtually no research on this phenomenon in music, there are hints that the intense emotional reactivity to musical sounds we find in the life stories of some prodigies can be accompanied by a sophisticated sense of the “goodness” of tone and timbre, as evident in examples of famous musicians such as Rubinstein and Menuhin who, as young children, broke their toy violins because the tone was so poor (Winner & Martino, 2000; Rolfe, 1978). Gordon (1984) even devised a test, the *Instrumental Timbre Preference Test*, involving seven different types of synthesized timbres, that attempts to help children select an instrument to learn. He was convinced that students who play instruments that match their timbre preference perform better and have a 50% lower dropout rate. Although such efforts have been largely ignored or criticized by music educators, there is some evidence that personality (extraversion and openness) is related to differential timbre sensitivity, gender, and music instrument selection (Payne, 2009).

In summary, we believe that there is something very important in the fact that some very young children react with strong emotions to hearing music. It is probably a (very) rare phenomenon, and we tend to believe that it would be more prevalent among children with exceptional musical gifts. If such an early sensitivity were to manifest itself, it could be an important clue to the existence of exceptional musical giftedness.

2. Attention to detail

In some of the examples given in the preceding section, the young children manifested exceptional sensitivity to sounds, what might be perceived by some clinicians as a form of hypersensitivity, and there are indications that such high sensitivity could have its roots in autism spectrum dysfunctions. Solomon (2012) affirms: “Some researchers claim that musical predisposition is a function of an autism-type hypersensitivity to sound. ... A number of the musicians described in this chapter likely meet clinical criteria for autism-spectrum disorders” (p. 426). Attention to detail represents another set of behaviours that has links with the autism spectrum complex, and there is recent evidence that musical prodigies manifest that preoccupation more so than other young people. As part of the study described earlier (see Part IV-C), Ruthsatz and Urbach (2012) administered the Autism-spectrum Quotient (AQ) questionnaire (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). The use of that instrument came from the authors’ previous observations of an apparent overrepresentation of autistic individuals among their prodigies’ close kin. The results revealed a significantly higher score for the small group of eight prodigies

with respect to a control group, as well as a particularly high score on one of the five theoretically created subscales of the AQ questionnaire, entitled “attention to detail.” This significant trend was maintained on an additional sample of ten prodigies assessed since that publication (Joanne Ruthsatz, personal email communication, 15 August 2014). Our examination of the factor loadings of the ten items (see Hoekstra, Bartels, Cath, & Boomsma, 2008) indicates that high scores on that subscale correspond to a special fascination for dates and numbers. Since five of their prodigies came from the music field, it could be hypothesized that these people would tend to show somewhat stronger patterns of behavior generally associated with the broad quantitative spectrum of autism, but well below any level indicative of a diagnostically recognizable syndrome. This result has not yet been replicated. However, these observations may be further supported by Vandervert’s explanation of the refinement of attentional focus (see Chapters 8 and 9 of this volume), which begins with genetically driven emotional sensitivity, and is then guided by the cerebellum toward finer and finer attention to details.

3. Winner’s drummer march

Winner (1996) defined giftedness through three characteristics which, in her view, differentiated such children “qualitatively” from other children: (a) precocious mastery of a particular domain (DMGT’s *field*), (b) an insistence on marching to their own drummer, and (c) a rage to master. There is an important reason for us to mention Winner’s definition of giftedness in a chapter devoted to prodigiousness. Although, as quoted in our introduction, she defines a prodigy as “a more extreme version of a gifted child”, all the gifted children she presents in her book manifest in reality exceptionally high levels of precocity and excellence, levels we would estimate well beyond a 1:1,000 ratio. In contrast, typical prevalence estimates for the population of gifted children vary between 3% and 10% (Gagné, 1998b). In other words, we would argue for a closer similarity between her “gifted” children and our prodigies than with the “run-of-the-mill” gifted children appearing in the professional literature of gifted education.

Description Winner (1996) describes her second characteristic as follows: “They need minimum help or scaffolding from adults in order to master their domain, and much of the time they teach themselves. ... Often these children independently invent rules of the domain and devise novel, idiosyncratic ways of solving problems. ... This means that gifted children are by definition creative” (p. 3). The label that best summarizes the first sentence is “autonomy”; moreover, their insistence to act autonomously is a form of assertiveness. Both constructs clearly belong to the realm of personality dimensions. In the second sentence, Winner associates this personality trait with creative behavior, which the DMGT considers an aptitude domain (GC) distinct from cognitive aptitudes (GI). The degree of association between cognitive and creative behaviors remains a disputed subject (Sternberg & O’Hara, 1999).

Empirical evidence There is empirical support for assertive autonomy in highly talented children. For instance, Gagné (1999a) conducted interviews with 39 multit talented young adults and their parents. These young people had been named by their peers, and then confirmed by the research team, as being talented in at least two fields, and often three, placing them well above the top 1% threshold of their age cohort; 75% were between 16 and 19 years old. To analyse the interview data the researchers created a coding system based on the DMGT that included a category called “personal management strengths”. They then summarized the 106 interview excerpts from that category under four headings: *autonomy* (the ability to organize their daily schedule without outside supervision), *concentration* (being very attentive during classes—our DIE facet—so that home study time was minimized), *discipline* (careful daily planning and rigorous respect of that planning), and *self-awareness* (honest self-criticism). Nowadays, we would categorize most of

these behaviors within the I component, in the IP, IW, or IV subcomponents. No less than 95% (37/39) of these multit talented individuals were judged by their parents to show special strength in one or more of the four dimensions, especially autonomy. Gagné (1999a) concluded: “There are many impressive aspects to this self-organizational behavior. First, it appears very early, usually during elementary school. Second, as confirmed in many parental interviews, it is not systematically taught by parents but appears spontaneously. Finally, it seems to be such a rare phenomenon, so atypical of average adolescents” (p. 38).

Considering that most young music students are rarely self-regulated and need extensive parental “scaffolding” (McPherson & Zimmerman, 2011), it seems to us very relevant to associate high autonomy with young musical prodigies. In his observations of Tiffany Poon, McPherson has consistently seen evidence of a highly autonomous and self-directed learner. Watching video recordings and discussing Tiffany’s progress with her parents, he has observed how she played along with recordings on her toy piano for long periods of time (aged 2), how she made music practice a priority by practicing first thing in the morning, and how she listened actively to CD recordings as a means of selecting pieces she wanted to learn. Indeed, even in her early years of learning the piano, Tiffany would complain to her parents if her teachers were not moving fast enough or covering sufficient repertoire; she would also refuse to practice pieces chosen by her teacher if she did not like them herself.

C—The IM/IV subcomponents

The IMTD’s distinction between goal identification (IM) and goal attainment (IV), which was inspired by *Action Control* theory, is just one of many competing views among scholars. Consider for instance Winner’s (1996) “rage to master”, which includes elements of intrinsic motivation (IM) and obsessive concentration into mastering new knowledge (IP/DIE), or Duckworth’s concept of “grit” (Duckworth, Petersen, Matthews, & Kelly, 2007), which also includes clearly defined passionate goals (IM) and a strong determination to reach them (IV). For this reason, we decided to combine the two subcomponents in our analysis of motivated pursuits. Within this duo of intrapersonal catalysts, three phenomena have retained our attention because of their potential relevance in the emergence of exceptional musical talent: (a) falling in love with music, (b) maintaining a passionate long-term involvement, and (c) manifesting strong determination and perseverance to attain one’s personal goals.

1. Musical *coups de foudre*

Falling in love with music, often with a specific musical instrument, is without doubt the epitome of intrinsic motivation (IMI facet); interestingly, it is a recurring theme in biographies of young MPs. Examples show how its intensity has all the hallmarks of a typical amorous *coup de foudre*. Walters and Gardner (1986) examined this phenomenon informally in three fields (music, visual arts, mathematics), using the much less colourful label of “crystallizing experiences”. Jacqueline du Pré described in her biography one of the best known and often cited examples among musicians of a musical *coup de foudre*; it happened just before her fifth birthday.

“I remember being in the kitchen at home, looking up at the old-fashioned wireless. I climbed onto the ironing board, switched it on, and heard an introduction to the instruments of the orchestra. It must have been a BBC *Children’s Hour*. It didn’t make much of an impression on me until they got to the cello, and then . . . I fell in love with it straightaway. Something within the instrument spoke to me, and it’s been my friend ever since”. According to du Pré, it was shortly after this experience that she told her mother “I want to make that sound”.

(Easton, 1989, p. 26)

Gagné (2000) used the DMGT framework to analyse the fascinating story of young Dat Nguyen, a South Vietnamese boy born blind in 1971 during the Vietnam War. He soon became an orphan with the responsibility of a younger sister. For many years they both lived in Hồ Chí Minh City (Saigon) as homeless beggars, getting just enough to eat by selling lottery tickets. Dat's musical aptitudes were discovered by chance when he was about 10 years old, and, 2 years later, he began taking piano lessons from a Mr Truong, who was himself blind, one of the city's finest classical music teachers. According to Bartholomew (1997), one Sunday morning in 1989, Dat tuned Truong's radio to the classical music hour, featuring a concert by Spanish guitarist Andres Segovia. Dat had never heard anything so beautiful and complex; in an instant he knew he had to learn to play the guitar like that. Five years later, Dat, now living in California, won a state-wide classical guitar competition. A Sunday morning *coup de foudre* had launched a professional career. Finally, Lang Lang describes in full detail in his biography (Ritz, 2008) and in various media interviews, a *coup de foudre* he experienced when watching an episode of a *Tom and Jerry* cartoon—The Cat Concerto—which “made a lasting impression on me, and each time it aired, I was riveted” (p. 17).

As an informal check of their prevalence in prodigies' early lives, we chose at random 50 pages (pp. 92–141) in Kenneson's (1998) book; they cover the lives of six musical prodigies (Pablo Casals, Horace Britt, Gaëtane Britt, Nadia Koutzen, Jascha Heifetz, and Emmanuel Feuermann). We found four clear instances of a musical *coup de foudre*, a prevalence level of 67%. First, concerning the young Pablo Casals, Kenneson recounts that at a chamber music concert presented in his native town of El Vendrell (Tarragona), “eleven-year-old Pablo saw and heard a real cello for the first time. ... The boy was fascinated and that same evening said to his father, ‘That is the instrument I want to play!’ His earnestness persisted; he began to play his violin upright between his knees as though it were a cello” (p. 95). Then we have the case of the famous violinist Nadia Koutzen, whose emotional epiphany we described in Section VI-B. Then, Kenneson writes about the very young Jascha Heifetz: “When Jascha was eight months old, his face beamed with joy when his father played a beautiful tune on his violin. His mother, Annie, remembered that later her son's reactions to hearing the violin became so distinct that his father indulged him with a miniature quarter-size violin for his third birthday” (p. 132). The final example targets the renowned cellist Emmanuel (Munio) Feuermann. “One day when a neighborhood boy was brought to the Feuermann home with his small cello to have a lesson with Maier [Munio's father], Munio grabbed the little cello and demanded to be taught to play it. For Munio this day [he was 5 years old] was the end of violin playing” (p. 141).

All these descriptions suggest that musical *coups de foudre* have two closely related components: (a) an intense emotional reaction to a musical input, which fits perfectly with the concept of musical sensitivity, or at least some definitions of it, and (b) triggers an immediate equally intense intrinsic motivation to learn to play that musical instrument. How can we explain such *coups de foudre*, and even more so their appearance at such a young age? How can we explain how the young Jacqueline, Pablo, and Munio fell under the spell of the cello sound? Why do other young music students react as strongly to other instruments? Some fall in love with the piano, others with the violin, others with the clarinet, and so forth. Where do these idiosyncratic reactions to the sound of a particular instrument originate? Their sudden appearance as well as their high intensity cast aside any form of cultural or familial transmission. And we have little idea of the prevalence of such sudden attractions in the general population. It certainly seems to us a fascinating research area.

2. Vallerand's *Dualistic Model of Passion*

Thunderbolts toward music and specific musical instruments are just the first moments of an intense relationship that will continue for years, even a lifetime. Their intensity makes them

analogous to passionate love involvements. The subject of passionate investments in music and their potential contribution to extreme musical prodigiousness brings up the seminal work of Robert Vallerand and his coworkers on the subject of passionate investments in personal activities or professional occupations.

Description and psychometrics Vallerand, Mageau, et al. (2003) proposed a theoretical framework, called the *Dualistic Model of Passion*, which distinguishes two types of passionate involvement in daily activities: positive or “harmonious” passion (HP), as opposed to negative or “obsessive” passion (OP). In the first case, it is the result of an autonomous internalization of the activity into the person’s identity. “[It] produces a motivational force to engage in the activity willingly and engenders a sense of volition and personal endorsement about pursuing the activity” (p. 757). In contrast, OP results from a controlled internalization, whereby “certain contingencies are attached to the activity such as feelings of social acceptance or self-esteem, or because the sense of excitement derived from activity engagement becomes uncontrollable” (p. 757). The model led to the construction of two parallel seven-item HP and OP scales, subsequently slightly transformed in content and length to six-item scales (Vallerand, 2008). They assess level of passion by asking respondents to identify an activity that is “dear to their heart” and then rate it on a four-item criterion scale of passionate involvement. All three scales compute means through a seven-point (do not agree at all/completely agree) scale. A score of four (mid-point included) on the criterion scale serves as the index of passionate involvement in that “dear to heart” activity. Adapted versions have been produced to study specific populations (e.g. musicians, athletes, romantically involved people). The two scales are not equally attractive, with the HP scale values mostly above 5.00 and the OP values below 3.50. It suggests that a minority of study participants obtain above average means on the OP scale, a major observation that we have not found discussed in the texts examined. Recent psychometric analyses have confirmed the construct, convergent, and discriminant validities of the HP and OP scales (Marsh et al., 2013)

Research overview The HP and OP scales produce low to moderate positive correlations between each other. Despite that, their respective scores tend to diverge significantly in terms of the types of associations observed with other psychological constructs. Vallerand (2008) summarized the results of dozens of studies as follows.

Harmonious passion was found to promote more adaptive outcomes than obsessive passion on a number of cognitive, affective, behavioral, interpersonal, and performance outcomes, on a variety of activities and with various populations ranging from children to the elderly. ... The evidence is highly consistent, always pointing in the same direction (harmonious passion being positively correlated with adaptive outcomes and obsessive passion with less adaptive ones).

(Vallerand, 2008, p. 10)

With respect to our theme, one study focused on the passionate involvement of classical musicians (Bonneville-Roussy, Lavigne, & Vallerand, 2011), using a sample of 143 advanced music performance students and 44 professional performers. The authors aimed to test a process model based on previous research linking passion and performance via achievement goals (Vallerand, Salvy, et al., 2007). Their main assumption was “that passion represents the motivational mechanism that explains the commitment towards music and eventually the attainment of expert levels of performance” (p. 127). According to their criterion threshold, they found that virtually all subjects (99%) were passionate about their musical career, but showed much stronger HP scores (combined mean of 5.55 on the seven-point scale) than OP scores (combined mean of 2.84). A path analysis led the authors to conclude among other things: “the two types of passion predict different outcomes. While harmonious passion was found to predict the use of mastery goals,

obsessive passion mainly predicted the use of performance goals" (p. 132). They also observed that "harmonious passion positively predicted life satisfaction and that obsessive passion was unrelated to it" (p. 133).

Comments The Dualistic Model of Passion currently represents a major theoretical paradigm for the analysis of motivational pursuits in a large diversity of human situations, professional as well as personal. Yet its basically negative description of obsessive passionate involvement conflicts with the descriptive vignettes of our musical prodigies, most of whom "plunge" into the music world with an intensity that cannot be described much differently than "obsessive", but without any maladaptive undertone. Indeed, when we examine the items used to assess the OP scale (e.g. "I cannot live without it", "I have difficulty imagining my life without this activity", or "The urge is so strong, I can't help myself from doing this activity") (see Vallerand, Mageau, et al., 2003, p. 760), we can easily imagine most of our MPs strongly agreeing with such statements, thus making them "obsessively" passionate about music. Should it be considered as negatively as Vallerand's team has defined that term? We tend instead to endorse Winner's more positive view of "obsessive" involvement as a key ingredient of exceptional talent (see below). Consider, for instance, Albert Einstein's view of his achievements: "I know perfectly well that I myself have no special talents. It was curiosity, obsession, and sheer perseverance that brought me to my ideas" (Folsing, 1998, p. 7). Biographies of famous scientists, inventors (e.g. Edison's 99% perspiration), or artists are replete with similar quotes. Our somewhat diverging viewpoint suggests that it would be interesting to investigate the HP/OP ratios of young musicians who demonstrate high MPQ scores as opposed to other music students who, although judged very talented, progress at a less advanced pace.

3. McPherson's "commitment" study

The above discussion does not solve the problem of assessing individual differences in strength of interest for music and their potential explanatory power for differences in musical growth curves, including the extraordinary MPQ values we estimated earlier for musical prodigies. Again, we are faced mostly with testimonies from the prodigies themselves, and from those of significant individuals around them. One study might help cast a partial look at the impact of intrinsic motivation on musical progress. McPherson (2001) reported initial data from a three-year longitudinal study aimed at identifying the best predictors of musical perseverance and progress among 150+ 7–9-year-old beginning music students in eight Sydney primary schools offering an instrumental band program. Among the many questions asked in an interview that preceded the education program were two questions about their *commitment* to music training: an open-ended question and a multiple-choice one. Answers were condensed into three categories: short term (just this year or until the end of primary school), medium term (until I leave school), and long term (into adulthood and for the rest of my life). From interviews with the mothers at three points during the next 9 months, the researchers created a measure of *weekly* investment in practice (DIT facet), which was again subdivided into three categories of approximate averages of 20 minutes (bottom 20%), 50 minutes (middle 60%), and 95 minutes (top 20%).

At the end of the school year, the researchers administered a standardized achievement test for beginning instrumentalists to the music students. Figure 1.7 shows the performance achievement by practice level and by commitment level. Those who had expressed low commitment did not improve much whatever the amount of practice; practice had its most powerful effect within the highly committed group. The fact that the commitment measure was obtained before the beginning of the training gives it strong causal predictive relevance. McPherson pointed out that the lowest end-of-year achievers had given mostly extrinsic reasons for their involvement in the program (e.g. "I wanted to learn because all my friends were joining the band", "My sister told me

Figure 1.7 Relationship between initial commitment, average weekly practice, and performance achievement after one year of music learning.

Reproduced from Gary E. McPherson, “Commitment and practice: Key ingredients for achievement during the early stages of learning a musical instrument,” *Bulletin of the Council for Research in Music Education*, 147, p. 124. © 2000, The Council for Research in Music Education.

music and the band was good and that you get to go and have McDonald’s after performances”), and a majority of them had dropped out during the second year of the program. Conversely, the highest achievers were all among the highly committed, who had given intrinsic motives for their involvement (e.g. “I’ve always liked music and rhythm for as long as I can remember”, “When I was little I used to watch music on TV and I really liked it. I used to like dancing and singing”) and kept practicing for at least the second year. In subsequent analyses of the students’ progress, Evans and McPherson (2014) have shown that even after a period of 10 years, the learners’ initial commitment of how long they thought they would play continued to predict the length of time spent in music learning.

Would that expression of planned long-term commitment be considered akin to “passion?” We doubt it, but again we are faced with definitional problems and operationalization decisions! We must also ask ourselves if the label “commitment” initially adopted by McPherson correctly reflects the latent concept measured through that question. Indeed, as part of a follow-up study a decade later, Evans and McPherson (2014) rejected the “commitment” label, and proposed another interpretation centred on the concept of “musical identity”; the length of time they planned to learn music was seen as expressing the strength of that musical identity. They even concluded from their results that the learners who possessed a sense of where their future learning might take them and whose personal identity included a long-term perspective of themselves as a musician were better positioned to succeed and persist with their instrumental learning. Looking back at these two studies, an alternative interpretation comes to mind: there is a definite possibility that this index of “planned commitment” was simply a proxy for the level of their intrinsic motivation for music at the time of the data collection.

4. Extrinsic motivators

Everything we have said until now has focused on various forms of intrinsic motivation, which is the case with *coups de foudre*, passionate involvement, and commitment. But interests and passions are rarely the unique motivations for embarking on a long-term talent development

program; other needs do play a significant role in determining involvement in musical training, and in maintaining perseverance through difficult periods. For instance, when Lang Lang admits that “all the [parental] pressure helped me become a world-famous star musician, which I love being” (Solomon, 2012, p. 449), he is acknowledging the power of fame as an important motivator. Here is another example about the late Michael Jackson's motivation.

He was more intense than anybody. ... He was driven by his hunger to learn, to constantly top himself, to be the best. He was the consummate student. ... Even at nine years old, his passion was to be the greatest entertainer in the world. He was willing to work hard and do whatever it took to become what he indeed was—the undisputed “King of Pop” the world over. ... Michael loved it all—every moment on stage, every moment in rehearsal.

(Berry Gordy, in the new introduction to the 2009 re-issued edition
of *Moonwalk* by Michael Jackson)

This quote depicts the close association between intrinsic (hunger to learn) and extrinsic (becoming the greatest entertainer, loving the limelight) motivators that we see in the life stories of many MPs. Indeed, within the highly competitive concert stage, a number of international careers would not have been launched if the MP had not focused on winning an international piano or violin competition. Likewise, the extrinsic motivation of wanting to please a parent or teacher, especially when the MP is willing to adopt the same value system (e.g. practicing to win a competition, gain approval from a teacher) can help MPs concentrate on the gruelling practice schedule needed to attain their personal best. And we could also cite Kenneson's (1998) description of Piatigorsky and Rostropovich, as well as Ritz's (2008) tale of Lang Lang. The poverty and hardship each of these MPs experienced in their early childhood made music an escape route and something of beauty in the midst of adversity and poverty. therefore we should not be surprised that a variety of extrinsic “ego goal” motivators (IME) can coexist with loftier “mastery goal” intrinsic motivators (IMI) to optimize musical development.

5. Winner's rage to master

Here is how Winner (1996) presents her well-publicized concept, the third differentiating characteristic of her “gifted children”.

Gifted children are intrinsically motivated to make sense of the domain in which they show precocity. They exhibit an intense and obsessive interest, an ability to focus sharply and what I have come to call a rage to master. They experience states of “flow” when they are engaged in learning in their domain—optimal states in which they focus intently and lose sense of the outside world [DIT facet]. The lucky combination of obsessive interest in a domain along with an ability to learn easily in that domain leads to high achievement”.

(Winner, 1996, pp. 3–4)

This short paragraph perfectly illustrates the terminological looseness so common in the “scientific” areas of psychology associated with talent development, a looseness that allows presenting a series of terms as if they were closely related. Consider the four sentences above. In the first, the author highlights a typical concept from the IM subcomponent, namely intrinsic motivation. Note that intrinsic motivation does not differ much—if at all—from the common concept of interest, as it is used in popular tests like the *Strong Interest Inventory* (see Anastasi & Urbina, 1997); this test is based on Holland's theoretical model, presented earlier as the basis for the T subcomponents. The second sentence adds a qualifier, the idea of “obsessive” interest, which appears here to be a desirable characteristic, in contrast with Vallerand's somewhat pejorative use of that term. She then introduces the ability—the term “power” would be more appropriate here—to focus sharply, a concept very similar to that of “concentration”, which we associated with the DIE facet. She then

brings in her “rage to master” as a construct distinct from those already mentioned. The exact nature of the “what” in that sentence remains unspecified, but the term “rage” suggests some form of determination or willpower (the IV subcomponent) coupled with strong emotional investment (IP); there is a distinct analogy with Duckworth’s concept of “grit” mentioned at the beginning of this section.

In the third sentence, Winner mentions Csikszentmihalyi’s (1996) concept of “flow”, correctly described as intense focus or concentration (another DIE construct) that can last for hours. The last sentence gives the impression that the key concept is obsessive interest, with an accent on its obsessive nature. In the next chapter of her book, she does describe even further that rage to master through the two case studies of Michael and David. And we find there expressions like “being driven to master reading” (p. 16), “David’s intellectual curiosity [IMI facet] had another streak to it: persistence” (p. 20), and “Michael showed the same kind of persistence, drive, and rage to master as did David” (p. 21). In summary, the most significant labels associated with her rage to master are, in our view, persistence, obsessive pursuit of knowledge, and intense mental energy—all terms included in the DMGT’s IM and IV components. However, we couldn’t find in her text either a clear definition of that concept or some form of operationalization that would help identify its presence in the biographies of musical prodigies. It remains that the strength implied in the “rage” term would be more typical of musical prodigies than of less exceptional musicians.

D—Biological underpinnings of I catalysts

The subject of the hereditary or biological underpinnings of common personality and motivational constructs is rarely discussed in the talent development literature. Most professionals, as well as lay people, assume that, except for occasional unconscious influences, goals, motives, or volition are under the total control of talentees. Yet, a large and growing pool of empirical research has shown significant hereditary roots for most facets of both IP and IM–IV subcomponents: interests, values, needs, motives, or volitional styles. Recall our brief mention in section A of Vandervert’s assertion that emotional sensitivity was genetically driven (see Chapters 8 and 9 of this volume). Also, with respect to the IP subcomponent, we pointed out in Part I that the concept of temperament implies strong hereditary foundations. Rothbart (2012) defines it as “constitutionally based individual differences in reactivity and self-regulation, influenced over time by genes, maturation, and experience” (p. 9). We also mentioned in Part I the biological underpinnings of the five components of the FFM. Concerning all five members, there is growing evidence for a close relationship between temperament dimensions and adult personality traits (Rothbart, Ahadi, & Evans, 2000); this relationship probably explains why all FFM dimensions have significant genetic underpinnings (Rowe, 1997). Finally, Daniel Goleman’s two bestsellers, *Emotional intelligence* (Goleman, 1995) and *Social intelligence* (Goleman, 2006), survey dozens of studies of the biological bases of most social and affective characteristics (e.g. altruism, impulsivity, shyness, aggressiveness, empathy).

With respect to the dozens of distinct constructs included in the IM and IV subcomponents, the weight of the evidence is no less convincing. We could cite dozens of studies revealing that every IM–IV characteristic mentioned in this section has significant biological and genetic roots. We prefer to cite a special and unique research program—the *Minnesota Study of Twins Reared Apart* (MISTRA). Its 20-year life story was recently told by one of its major contributors (Segal, 2012). Segal’s book not only contains hundreds of personal vignettes of the participating twins, but also describes all major data collections and their results. She also cites parallel studies, confirmatory or conflicting, discussing methodological similarities and discrepancies. Here is how she summarizes that program.

The MISTRA came into being in 1979 and lasted for twenty years. It conducted comprehensive psychological and medical assessments of eighty-one MZA [monozygotic twins raised apart] and fifty-six DZA [dizygotic twins raised apart] twin pairs, with each assessment lasting for an entire week. The study's goal was to identify associations between differences in the twins' life histories and the twins' behavioral differences. ... It shows that common genotypes can interact with different prenatal and postnatal environmental features to produce different outcomes. The MZA twins in some of our pairs differed in IQ, religiosity, or body size, but *the MZA twins as a whole showed greater within-pair resemblance than the DZA twins, indicating genetic effects*. ... The MISTRA had substantial impact on our understanding of individual differences in intelligence, *personality, values, interests*, religiosity, sexual orientation, mate choice, *job satisfaction*, sociality, and health. ... *The consistently greater resemblance between the MZA than DZA twins showed that genes affect virtually every measured trait.* [our italics]

(Segal, 2012, pp. 8, 10, 11, 12)

We believe that the MISTRA results by themselves provide evidence beyond doubt concerning the genetic foundations of constructs belonging to all intrapersonal subcomponents. In addition, the MISTRA results bring equally convincing evidence for the genetic underpinnings of all G subcomponents.

E—Summing up

Four intrapersonal subcomponents (IF, IP, IM, IV) offered a particularly rich source of potentially differentiating characteristics of musical prodigiousness. With respect to physical traits (IF), we focused on just one—the sex of MPs. We hypothesized that even in current developed countries, where sexist stereotypes concerning the education of women have almost disappeared, we might still observe an overrepresentation of males among musical prodigies. It would have its source in a peculiarity of natural abilities, well documented in the case of cognitive abilities, namely a greater variability of these abilities among males. This phenomenon increases male proportions at both ends of ability distributions. If confirmed in the case of musical aptitudes, it would produce more exceptionally gifted male musicians.

In the case of temperamental and personality characteristics (IP), we highlighted from the literature three differentiating traits: (a) a special emotional sensitivity to music, (b) attention to detail, and (c) autonomous management of one's activities. Emotional hypersensitivity to musical sounds is a very rare phenomenon; it can manifest itself at a very young age, sometimes even before the first birthday. It might become the earliest specific sign of future musical prodigiousness, preceding any formal introduction to music. We borrowed the second trait from Ruthsatz's work (Ruthsatz and Urbach, 2012) and other sources. Attention to detail has been associated with the autism spectrum syndrome, and could appear in mild forms among prodigies, not only MPs; the modalities of its causal impact remain to be ascertained. The third trait, autonomy, is analogous to Winner's concept of "marching to one's own drummer". The capacity to organize one's life and to be very selective towards environmental inputs might help young MPs manage their daily schedule of activities, especially the space given to their musical practice.

We decided to merge the last two subcomponents because so few scholars acknowledge the theoretical differentiation we have endorsed between establishing goals (IM-Motivation) and working to reach them (IV-Volition). Three of the characteristics we singled out are directly related to intrinsic motivation. Early *coups de foudre* for a particular instrument, found recurrently among MPs, represent a strong initial Big Bang that will automatically evolve into a long-term passionate involvement with that instrument. We added to this pair McPherson's (2001) concept of "intended commitment" announced before any systematic lessons because it bears distinct similarity to the level of intrinsic interest. We included as a fourth characteristic strong extrinsic achievement and ego-enhancing motivators that incite young MPs to dream of wide recognition and fame. We

finally added willpower as a fifth characteristic; it is a key volitional element with many associated labels (e.g. perseverance, determination, grit, Winner's rage to master). We concluded by stressing that all the characteristics identified in Part VI had definite biological and genetic roots.

VII—MPs and environmental catalysts

In the minds of most social science scholars, environmental influences should take the lion's share in the discussion of causal influences of developmental outcomes. This is what we described in Part II as the *Standard Social Science Model* (SSSM). We were able to observe the high prevalence of this type of information in all the biographical vignettes from the books repeatedly cited in the preceding sections. Of course, daily interactions between the MPs, their parents, siblings, music teachers, and peers are highly visible, much more so than temperament or personality characteristics, natural abilities, or biological foundations. We will try here to bring some structure to the rich environmental tapestry presented by authors and biographers. But, again, strong empirical data remain scarce.

We saw in Part I that the DMGT organizes all environmental catalysts into three separate subcomponents: global socioeconomic influences from the talentees' milieu (the EM or *social* dimension), influences from significant individuals (the EI or *psychological* dimension), and developmental resources (the ER or *educational* dimension). Because of a predominant research literature targeting interpersonal dynamics between parents, teachers, and other people in the immediate family environment, we will devote more space to the EI subcomponent. Two categories of significant individuals will receive closer scrutiny, namely the children's parents or immediate family (the EIF facet), and their music teachers (the EIT facet). But other significant people, such as peer group members (EIP facet), siblings (EIS), or mentors (EIM), can also affect the talent development process for better or for worse. We will examine, if relevant, such influences. We face again the same basic question that has arisen previously: within this large inventory of potential causal influences, which should be viewed as having a differential impact on the blooming of these exceptionally gifted and talented young musicians?

A—The music milieu (EM): the *social* dimension

The "milieu" subcomponent serves as an umbrella for a large diversity of perspectives concerning the analysis of specific talent development situations. We can group them into three different dimensions. The first dimension has to do with breadth of view, comparing distal influences as opposed to more proximal ones. Think for instance of examining national policies about music education or focusing on smaller geographical units, like a state, a city, or a smaller community; the socioeconomic characteristics of families represent the smallest unit of analysis within this section. Another dimension concerns the particular social perspective chosen as the focus: historical, cultural, political, economic, educational, and so forth. The specific contents addressed within a given perspective will of course vary if we focus on artistic talent development, as opposed to sports or academic talent development. Here, we chose to highlight a few viewpoints more typical of the MP phenomenon. It remains open to further enrichment by other contributors.

1. Distal historical and cultural outlooks

Attitudes and outlooks regarding extremely gifted individuals have changed significantly across centuries from a theological view, in which gifted children were regarded as "heavenly", as a gift from God, to a metaphysical phase that emphasized individual aptitudes, but which also fostered many myths such as the stereotyped "crazed genius", portrayed in many movies (Stoeger, 2009). Musical prodigiousness goes back at least four centuries (e.g. some old names in Sacquin's (1993)

book or in this volume), and probably to the beginning of music as a formal artistic field. When we survey the history of music, it seems clear that Europe witnessed a Golden Age of Western classical music between the 17th and the 19th centuries. Thus it follows logically that most MPs identified during that period would come from that continent.

Not only did they come from Europe but there seems to have been an overrepresentation of musicians from Jewish communities. Various authors who study prodigies (e.g. Morelock, 2013; Feldman, this volume, Chapter 2) have cited Yehudi Menuhin's nephew Lionel Menuhin Rolfe (Rolfe, 1978) who discovered that his family came from a direct line of descendants of the hereditary chief rabbis who created Chabad Hassidism, an expressive group of Jews for whom music was a major part of their lives. Rolfe reports that Yehudi's father (and very likely his mother) were descendants of the rabbinical families who had been producing prominent leaders of their community for centuries; the chief rabbis of these communities were treated like royalty, revered and almost worshipped by their followers. Even though Yehudi's parents sought to break with the past by immigrating to the USA, "the tendency for a child to be selected, supported, and prized above others along with the exalting of music persisted. While the family became secularized, this same process continued. Music retained its centrality in the family and became manifested through Yehudi's uncanny spiritual mastery" (Morelock, 2013, p. 93). However, as interesting as such hypotheses can be, the lack of parallel support, as well as plausible alternative explanations (e.g. genetic transmission of aptitudes and personal dispositions), invites caution in their endorsement.

One special aspect of cultural practices in past centuries was the way parents reacted to the exceptional musical giftedness of a girl as opposed to a boy. The case of Wolfgang Amadeus Mozart's sister Nannerl has been well documented; it shows how the social environment in which she grew up in the 1750s and 1760s would not have allowed her to perform in public or to become a professional musician. Lehmann, Ericsson, and Hetzer (2002) show how large were the differences between the two siblings' upbringing.

While Wolfgang learned composition and instrumental performance, his sister was restricted to instrumental performance. Her own attempts to compose (songs) were encouraged by the brother, but the father ignored his daughter's work. ... Despite her excellence at the piano, she was later forced to stop performing in public when she reached a marriageable age.

(Lehmann et al., 2002, p. 429)

Just a few decades later, Felix Mendelssohn's sister Fanny suffered a similar fate; her father forbade her to publish her compositions or perform in public "lest she become ambitious and compromise the feminine virtues of 'love, obedience, tolerance and resignation' " (Taruskin, 2009, p. 188). Taruskin adds that her life "is compelling proof that women's failure to 'compete' with men on the compositional playing field has been the result of social prejudice and patriarchal mores" (p. 189). However, only one or two decades later, we begin observing significant changes, illustrated among other things by the remarkable career of Clara Schumann (née Wieck) (1819–96), one of the earliest documented cases of a female MP. Clara received a meagre general education but a superb musical education, with opportunities to study violin, theory, harmony, orchestration, counterpoint, fugue, and compositions with prominent teachers in Leipzig, Dresden, and Berlin (Reich, 2001). From the age of 11, her prodigious gifts led her to become one of the most distinguished concert pianists of the Romantic era, and one of the first to perform in public concerts from memory, a feat she excelled at from around the age of 13.

Beginning with the 20th century, that special population saw the addition of musical prodigies from the New World, for instance Teresa Carreño, Yehudi Menuhin, Glenn Gould, and André Mathieu, all of whom are described in this volume. In recent decades, we have witnessed an

explosion of interest in classical music throughout Asia, and a massive increase in the number of Asian students who study classical music across the globe. Solomon (2012) affirms: “For many years, the prodigies were mostly Jews from Eastern Europe; now, the field is dominated by East Asians. Gary Graffman, himself one of the Jewish prodigies, has only six students, all of them Chinese” (p. 454). Recent statistics on the ethnic distribution of doctoral-level music students in the USA reveal an impressive overrepresentation of students of Asian origin (foreign or immigrant). For instance, although they account for just 4.3% of the US population, they comprise almost 17% of all doctoral-level music students, and an almost incredible 43% (10:1 ratio) in the combined piano and violin departments (Gagné, 2011, Table 4, p. 9).

2. Policies and structures

This particular facet of the EM subcomponent brings together many specific questions. For instance, we can survey policies and/or structures at various decision levels, from the proximal level of schools or school districts to the much broader level of states and countries, even sometimes groups of countries (e.g. the European Union, the ASEAN community). If we choose to examine laws and regulations, we can distinguish those that have a direct, as opposed to an indirect, impact on the specific type of talent development under scrutiny. In terms of direct impact, think for instance of laws that clarify a given state’s investment in the preparation of Olympic athletes, or policies that specify how a school district will identify and serve its academically talented students. As an example, we can mention the decision taken some years ago by the Chinese government to create two prestige music schools with the specific mission of preparing musical performers who will attain international eminence (see section C below). It will be interesting to verify within the next few years to what extent these schools, as well as the explosion over recent decades of opportunities for classical musicians to perform within China, will keep young promising musicians from emigrating, as so many musical prodigies (e.g. Lang Lang, Yang Liu, Di Xiao) have had to do over the past decades. More indirectly, we could mention laws or regulations that frame the education of teachers or the expertise required to obtain employment as special “gifted education” teachers, certified music teachers, or professional coaches in specific sports. Both government agencies and private organizations, like sports federations, can write and adopt these kinds of regulations.

With respect to structures, we could analyze the vertical organization of talent development in a particular field, from the highest government levels to the small entities working “in the trenches”. For example, is there a department at state level responsible for the supervision of musical education? What power does it have over lower structures? What does that pyramidal structure look like in terms of resources and horizontal dissemination? Considering that music schools like Juilliard and Curtis have a private status, how do private and public institutions share talent development responsibilities in different countries or states? How do the public viewpoints expressed by diverse pressure groups (e.g. teachers’ unions, media organizations, parent associations) affect the talent development field? Finally, we should not forget to include here the financial dimension, namely the decisions by public organizations or private groups to offer financial support to talent development activities by subsidizing learning or training institutions, contributing to new infrastructures, offering musical instruments, and so forth. These are just a few of the dozens of questions that come under the present heading. Of course, there are so few musical prodigies in any given community, even at a state level, that very few of the questions raised in this section will be relevant to their talent development.

3. The family as social environment (EMF)

When looking at the family as unit of analysis, the DMGT separates the social and psychological aspects of family life, thus placing information about family structure and social characteristics

within the EM subcomponent, and considering family dynamics as psychological phenomena that belong to the EI subcomponent. It stands to reason that the boundary between these two dimensions remains fuzzy. Here is a case in point. The subject of the social values, opinions, or beliefs held by a particular group of individuals belongs logically to the present facet. For instance, we would insert here a comment Sosniak (1985) made, namely that “all but one of the pianists’ families held the belief that children should have some musical education” (p. 27). This comment indeed contributes to a better understanding of the familial context in which her interviewees were raised. But she adds: “all but two of the pianists began instruction because a parent decided that the child ought to do so” (p. 27). This second quote moves us from the realm of beliefs to that of parental practices, a subject that belongs rightly to the next subcomponent (EIF). We have not yet found a way to overcome that kind of fuzziness.

The search for characteristics that would typify the structure of MP families raises many interesting questions that have yet to be examined scientifically. For example, are musical prodigies raised less/more often in typical two-parent families? Are their parents younger/older than average? Does their birth order distribution differ from that of typical families? Are there any instances of more than one MP in a given family? Do they tend to be raised in families with a smaller/larger than average number of children? The concept of socioeconomic status (SES) refers to three distinct family characteristics: (a) parental education, (b) parental occupational status, and (c) family income. Each of them can be assessed in a variety of ways, usually giving rise to an index that combines the three separate sources of information in a unique quantitative measure (White, 1982). When considering them separately, many questions come to mind about the particularities of MP families. For example, do MP parents have a lower/higher education level than average families (within their particular culture of course)? Are there smaller/larger educational differences between the two parents than in typical families? Does a smaller/larger percentage of parental pairs have an occupation? With respect to the type of occupation held, are there fewer/more parents professionally involved in music than in average families? Did either parent show in his/her youth any special musical talent? How do MP families compare in terms of family income with respect to typical families? If we combine all three SES indices, do MP families tend to show a lower/higher SES level? If they differ from average families in their community, how do they compare with families of outstanding professional musicians who were not recognized as MPs in their youth?

Currently, there is virtually no robust evidence concerning most of these issues. The short biographies we have kept borrowing from in this chapter show a large diversity of family situations. Very few of the MPs surveyed in this book came from single-child families, thus showing a considerable diversity among the population of MPs. We could not decipher any trend with regard to birth-order effects, other than noting that a number of the most prominent 18th and 19th century prodigies described in this volume had older siblings. Nonetheless, Harris (1998, Appendix 1) strongly questioned the alleged birth-order effects defended by Sulloway (1996). Even though the professional literature gives several examples of the musical culture of the family, it is difficult to draw firm conclusions. The only “hard” data again come from Sosniak’s (1985) study. She divided her pianists’ families into four groups according to their members’ musical involvement. In two of these groups (45% of the sample), at least one member was a professional or amateur musician, whereas her two other groups (55%) included just passive listeners and those without any musical involvement. She concluded:

While it may seem from table 2 that the percentage of musically oriented families is high in our sample, the numbers come close to matching those of a 1974 Market Facts study. Almost 44% of the 848 households [nationally representative sample] surveyed included an amateur musician, approximately

79% of all the families said they listened to records often, and about 69% agreed with the statement that “every child should learn at least one instrument”.

(Sosniak, 1985, p. 24)

Sosniak’s observations suggest caution in giving undue causal importance to musical activities within families. Keeping this in mind, we now turn our attention to the psychological dimension.

B—Influential individuals (EI): The *psychological* dimension

Two groups of individuals have the best opportunities to influence the professional development of MPs: their parents and their music teachers. These two sources will receive most of our attention in the present section. But, in line with our theoretical leanings (see below), we will introduce the potentially significant role of a third group, the peer group, defined here in the broadest possible way.

1. Parental influences (EIF)

In terms of rich anecdotal parenting lore one book stands out: Solomon’s (2012) *Far from the tree*. It explores the multiple facets of parenting children with disabilities (e.g. deafness, dwarfism, Down syndrome, autism, schizophrenia, transgender), including among them the “positive” abnormality of musical prodigiousness. The voluminous chapter devoted to MPs presents 21 short biographical vignettes based on interviews with the MPs themselves and significant individuals around them, mostly parents, but also music teachers or music professionals. The author makes no formal attempt to extract general observations that would confirm similarities or disparities within that group or with parents of the other groups he describes. As they appear to us more as images of unique paths with occasional overlaps, we will use them here as illustrative support. But, before we proceed to a discussion of parenting styles, we need to introduce a theoretical note.

Preliminary caution We pointed out earlier the overarching presence of parents, especially mothers, as major sources of developmental influences in their children’s overall growth. We noted that some scholars even coined the SSSM expression to label that theoretical orientation. Within that framework, believers in the SSSM theoretical viewpoint will automatically interpret any study showing a correlation between a particular child behavior and some corresponding parental behavior as a unilateral parental causal effect. Even nowadays, this spontaneous theoretical perspective remains the mainstream view of most developmental psychologists and other related social scientists and practitioners. Pinker (2002) pointed out that SSSM promoters consider infants as “blank slates” or *tabula rasa* on which the environment, and mostly the parents, will write the rules of proper socialization. The SSSM bias can manifest itself in extreme ways, as shown in the following quote from an eminent scholar in the field of music: “With sufficient energy and dedication on the parents’ part, it is possible that it may not be at all difficult for parents to produce a child prodigy” (Howe, 1990, p. 138). Of course, we strongly disagree with that statement.

In her controversial but powerfully debated bestseller *The nature assumption*, Harris (1998) directly challenged that mainstream position. Reflecting on the popular “nature–nurture” dichotomy, she affirmed: “the use of ‘nurture’ as a synonym for ‘environment’ is based on the assumption that what influences children’s development, apart from their genes, is the way their parents bring them up. I call this the *nurture assumption*” (p. 2). She described her mission as follows.

My first job is to show that the nurture assumption is nothing more than that: simply an assumption.
My second is to convince you that it is an unwarranted assumption. My third is to give you something

to put in its place. What I will offer is a viewpoint as powerful as the one it replaces—a new way of explaining why children turn out the way they do.

(Harris, 1998, p. 2)

She based her thesis on three main sets of data. First, she described the two key conclusions from dozens—if not hundreds—of studies conducted within the framework of behavioral genetics, namely that “reared-together siblings are alike in personality only to the degree that they are alike genetically. The genes they share can entirely account for any resemblances between them; there are no leftover similarities for the shared [family] environment to explain” (p. 37). Second, she stressed what many developmental psychologists before her had signaled, namely that we can easily interpret parent–child correlational studies in the opposite direction, thus showing parenting as a “two-way street”. In other words, “parents tailor their child-rearing style to the individual child. Child-rearing is not something a parent does to a child: it is something the parent and the child do together” (p. 25). She even made the bold claim that “children would develop into the same sorts of adults if we left their lives outside the home unchanged—left them in their schools and their neighborhoods—but switched the parents around” (p. 359). Rowe (1994) had already proposed an explanation for that exchangeability of parents.

Some three-quarters of American families fall into this range of social class categories, where rearing effects have been proven weak, despite massive differences in levels of funding for their public schools and massive differences in home intellectual environments. Of course, I do not intend to imply that intelligence develops without exposure to schools, books, television shows, magazines, and good conversations. I mean simply that these exposures can be found in three-quarters of American society in significant abundance to support full intellectual growth.

(Rowe, 1994, pp. 124–5)

Finally, summarizing a vast amount of empirical evidence on peer interactions, Harris proposed an alternative viewpoint, what she called her “socialization theory”, which she based on the powerful impact of peer group influences, especially during middle childhood. In a later publication (Harris, 2006), she detailed the three main modules of her theory: a *socialization system* that explains how they absorb language, customs, and skills that make them appear alike, a *relationship system* that enables them to tell people apart so that they can then deal with each person appropriately, and a *status system* that enables them to work out how to compete with others. We need to consider all three systems in order to explain how the environment shapes a child's personality.

Our description of Harris's theoretical viewpoint aims to tone down, not cancel, the significance of parenting behavior on MPs' talent development, especially since we are not directly interested in the global socialization process of these young individuals, but more specifically on the progressive growth of their extraordinary talent. It could well be that the balance of influences from significant individuals differs significantly when we focus on the talent development process as opposed to the broader aspects of these individuals' personality development. We should constantly keep in mind that the parents' beliefs and their interactions with their child might result from the precociousness they observe in their highly gifted child's daily musical behavior. In our view, both aspects play a part in any form of musical development. For the musical prodigy, however, the latter is perhaps much more significant.

Parental goals The literature on parenting distinguishes between parental *goals*, parental *styles*, and parental *behaviors* or *practices*. As Darling and Steinberg (1993) stated: “one must disentangle three different aspects of parenting: the goals toward which socialization is directed; the parenting practices used by parents to help children reach those goals; and the parenting style, or emotional climate, within which socialization occurs” (p. 488). The values, beliefs, attitudes,

and aspirations held by parents shape the specific goals they hold for their children (Spera, 2005; Wentzel, 1998). There is no doubt that a large diversity of parental goals concern the various aspects of a child's musical development. However, considering that the DMGT focuses on one essential goal, namely the emergence of talent, we will focus here on that specific developmental goal. Whether they pertain to the parents or the child himself, goals refer to expected outcomes, and thus to the IM subcomponent as seen from the parents' perspective. We could examine more closely potential divergences between the two parents—whenever that particular family structure is applicable—in terms of vocational goals envisioned for their MP child, but it would bring us too far into this particular aspect of our general subject.

If there is one thing that distinguishes the phenomenon of musical prodigiousness from all other situations of musical talent development, it is the fact that the question of an eventual professional musical career poses itself to the parents much earlier and with much more clarity than is the case with less endowed or precocious young musical students. Indeed, both the intensity of the young MP's musical progress and its very precocious manifestation force the career question on the parents' minds well before the young MPs themselves realize the long-term professional implications of their nascent extraordinary talent. It will soon become the crucial goal to either endorse or reject: structuring the child's developmental path around that eventual professional goal. Again, considering the common saying among social scientists that the plural of *anecdote* is not *data*, we have little systematic information about the expressions of that goal; for instance, when it first manifests itself in the parents' consciousness, how it evolves over the childhood years, when and how the child himself becomes aware of it, and so forth. As with so many other subjects we have introduced in this chapter, that particular question would make the subject of an interesting empirical study.

The central parental goal of a future musical career can give rise to parallel, subordinate considerations. For instance, to what extent would their child's eventual fame impact the family's socioeconomic status? As an example, Beethoven's father lacked the level of musical expertise and was far less inclined and skilled at promoting his son than was Leopold Mozart (see Derry, this volume, Chapter 25). For their part, possibly because they were independently wealthy, the Mendelssohn parents showed less interest than Leopold Mozart in the commercial success of their son, yet they made sure that Felix got both an excellent general and an excellent musical education (see Todd, this volume, Chapter 26). Directly related to this down-to-earth question is the question of public exposure; how early (or late) should public exposure of the child's extraordinary talent begin? The literature shows the whole span of parental decisions, from choosing to multiply early childhood performances (e.g. Mozart; see Cowgill, this volume, Chapter 23; Keefe, this volume, Chapter 24) to insisting on waiting until adolescence to begin such public activities, with occasional strong disagreement between the two parents involved (Solomon, 2012). These choices might have their origin in the parents' personal aspirations for the child or in attempts to market the child for their own economic gain. Others just consider it their duty to support their child's extreme level of giftedness and the talent they see unfolding. Some young musicians had their prodigy status more or less questioned because of their late access to public exposure (e.g. Glenn Gould; see Maloney, this volume, Chapter 29).

Parental styles Spera (2005) extensively surveyed the literature on parenting, including its impact on adolescent school achievement. He proposed adopting Baumrind's (1971, 1978) typology of parenting styles, which he considered the “most well-known and influential typological approach” (p. 134). The three styles, authoritarian, authoritative, and permissive, were based essentially on degree of parental control, and were described as equally acceptable. However, the authoritative style, defined as “a constellation of parent attributes that includes emotional

support, high standards, appropriate autonomy granting, and clear, bidirectional communication" (Darling & Steinberg, 1993, p. 487), came out as definitely more desirable. Maccoby and Martin (1983) completed the typology by creating a two-dimensional framework; they labeled its two axes "responsiveness" and "demandingness", respectively. Authoritarian parents were judged high on demandingness, but low on responsiveness, with inverse intensities in the case of permissive parents. The authoritative profile was characterized by both high responsiveness and high demandingness. To complete the 2×2 system, these authors introduced the "indulgent" or "neglecting" style (low on both dimensions).

There is no lack of examples of each of these profiles in the MP vignettes (Kenneson, 1998; Solomon, 2012), and in most chapters of this volume. Some parents of MPs described in this book (e.g. Wolfgang Amadeus Mozart, Lang Lang, Michael Jackson) implemented their authoritarian style by tightly controlling the destiny of their child, and even acted as managers of their child's careers to ensure their commercial success (Lehmann & Kristensen, 2014). Others have been much more permissive, and much more accommodating of their child's non-musical needs. Glenn Gould's parents, for example, were very aware of their son's musical gifts, but never wanted him to be spoken of as a prodigy (see Maloney, this volume, Chapter 29). One parenting style, the "indulgent" or "neglecting" style, does not appear at all in any of the references we reviewed for this chapter. We suspect that it would frequently lead to lack of support and supervision of a very young child who shows emerging exceptional potential. In summary, the diversity in styles confirms that we cannot systematically associate any particular profile to successful development. However, since all our illustrations describe successful MPs, we cannot compare them with others whose initial exceptional musical giftedness did not bloom. How many of these remained "undiscovered", or had their high developmental hopes crushed early? Most of the short biographies presented by Kenneson (1998) or Solomon (2012) talk about the most involved parent, frequently ignoring the other parent. We did not analyse that phenomenon in detail, but exploring parental differences in style, and their evolution over the past two or three centuries, would certainly constitute an interesting research subject.

One theme that comes up regularly in the literature on MPs is the level to which parents push their children to succeed during their early years, an aspect that Solomon (2012) refers to as parental demandingness: "While some parents push their kids too hard and give them breakdowns, others fail to support a child's passion for his own gift and deprive him of the only life that he would have enjoyed. You can err in either direction" (p. 475). We can compare Solomon's comment with a viewpoint commonly held by both professionals and the general public, namely considering musical prodigies as largely the product of pushy parents; it appears in Mink and McPherson's analysis of YouTube comments about prodigies (this volume, Chapter 19). Among professional musicians, one such quote comes from concert violinist and teacher Isaac Stern:

There *has* to be someone pushing, a parent or a teacher. Every one of the kids I've guided has someone like that in their lives, pushing them, sometimes gently, sometimes horribly, sometimes, unfortunately, to the point of driving the child away from music. It's the quality of parental pushing that helps determine the eventual outcome of the prodigy.

(Winn, 1979, p. 40)

Stern's view, stressing the "quality" of parental pushing, definitely favors the authoritative perspective. But the threshold between authoritativeness and authoritarianism leaves much room for subjectivity, on the part of both the parent and the child; just as with love, a lot is in the eye of the beholder! Examples of well-received "extreme authoritarianism" abound. Clara Schumann's father was generally perceived as "high-handed", despotic, and even cruel; yet she frequently lauded his

role as mentor and manager of her prodigious talent. Here is an excerpt from a letter she wrote in 1894:

My father had to put up with being called a tyrant; however, I still thank him for it every day; I have *him* to thank for the freshness that has remained with me in my old age (at least in my art). It was also a blessing for me that he was exceedingly strict, that he reprimanded me when I deserved it and, in so doing, prevented me from becoming arrogant from the praise the world showered on me. At times the rebuke was bitter, but it was still good for me!

(Litzmann, 1927, p. 585)

The above examples confirm one key argument advanced by Harris (1998), namely the constant interaction between parents and children: child rearing is a two-way street. Moreover, children react differently to a particular parental style; in contrast with Clara Schuman's—and Lang Lang's—positive reaction to parental authoritarianism, that same style, as the Winn quote above suggests, probably did drive many children out of music. Comparing cultures, Harris (1998) points out:

What they [researchers] find, in fact, is that Asian-American parents are the most likely of all American parents to use the Too Hard [authoritarian] style and the least likely to use the Just Right [authoritative] style, and yet in many ways Asian-American children are the most competent and successful of all American children.

(Harris, 1998, p. 49)

In summary, we should be careful before promoting one particular parental style over others.

Parental practices If parenting styles determine the “tone” of the relationship between parent and child, the “parental practices” dimension addresses concrete roles and behaviors. The empirical literature reveals that parents can intervene in at least four distinct ways in their child's talent development process: (a) supervising music practice, (b) offering emotional support, (c) planning and managing their child's early musical career; (d) assuming the necessary financial costs. It is beyond the scope of this chapter to examine in detail each of these four major roles. In terms of more global questions, we could explore how the two parents divide them up between them, how soon after formal MP identification each role becomes activated, in what ways their implementation differs from that of parents who have less exceptionally talented children, when they begin a progressive phasing out, and so forth. With respect to the specific role of music practice supervision, we have already mentioned (Part V-B) that even with very promising young music students most parents need to enforce a strict practice regimen (Sosniak, 1985), a role they will progressively abandon when their child reaches adolescence. Does this practice apply to young MPs? Do they necessitate the same close supervision, or does their passionate involvement and high degree of autonomy (see Part VI-B) make that monitoring role practically unnecessary? In terms of emotional support, we found little data in the music literature, but there is no reason to imagine that we would find less diversity in behavior among parents of MP children. It would be interesting to explore possible differences between the two parents, trying to confirm or reject spontaneous stereotypes, as well as analysing possible differences related to the child's gender.

We have already touched on the subject of career planning when we discussed parental goals, stressing that the extreme precociousness of musical prodigies forced parents to address this touchy subject very early, and then soon follow up with major decisions (e.g. choice of a proper music teacher, a quality music instrument, an adequate teaching institution). Sosniak (1985) pointed out that her non-MP but exceptionally talented young musicians did not face the “career” question until early adolescence, at which point they were old enough to make the decision themselves. No doubt they asked their parents to act as counsellors during that major

decision process. And what about the financial role? Although, in the case of Sosniak's pianists, significant financial investments were not required before they reached their early teens, the problem manifests itself much earlier in the case of musical prodigies. This advanced career path will require extensive emotional and financial sacrifices on the part of most parents. Let us survey them briefly.

Parental sacrifice

All parents of prodigies are making an enormous investment in a dubious outcome with huge risks: forsaken social development, crippling disappointment, chronic relocation, even permanent family rifts—all in the hope of an elusive lifestyle that may not be what the grown-up version of the prodigy turns out to want.

(Solomon, 2012, p. 475)

This summarizes very accurately the situation of most MPs' parents, in terms of both socioaffective and financial costs. The sacrifices vary extensively from family to family. In some cases, they imply that the whole family will move to a new country, with the main breadwinner having to find a new job, as was the case with the family of pianist Natasha Paremski when she was just 10 years old (Solomon, 2012, p. 420). In other cases, one parent will move with the child to live close to the special school where the young MP was admitted under the wings of a master teacher. It may sometimes happen that parents will leave the parenting tasks to others when their young child moves away very early to attend a prestigious music school. For instance, Kenneson (1998) recounts that when Horace Britt was just 9 years old his grandparents "agreed that Horace could live with them while he began to study the cello with the outstanding Belgian teacher, Gustav Faes" (p. 106).

But, we might add, most parents of exceptionally talented non-MP young musicians will also have to make similar sacrifices. Indeed, Sosniak summarizes her subjects' situation as follows. "Parents made many more sacrifices than just giving up a helping hand around the house. ... Even in homes where money was tight, no sacrifice was too great in order that the child have whatever he needed to learn to become a musician" (Sosniak, 1985, p. 54). Financially, some parents will invest well beyond what the vast majority of parents would agree to do. When his son was not yet 2 years old, Lang Lang's father purchased a piano that cost half the family's annual salary (Lang Lang with Ritz, 2008). And because of the extreme precocity of young MPs, these costs will appear much earlier than for less exceptionally talented young musicians, many of whom will have a "regular" music education almost until the beginning of high school (Sosniak, 1985). As a last comment, the high costs and high risks involved in this accelerated path toward early music eminence have their parallel in high level sports talent development, as evidenced in ice hockey (Campbell & Parcells, 2014) and many other "expensive" sports (e.g. figure skating, golf, tennis).

2. Music teacher influences (EIT)

The EIT facet targets all the music teachers who interact with current or future MPs. In Part V (DAF facet) we briefly discussed the progressive passage of MP students from local or community music teachers to more specialized ones; we took examples from Sosniak's (1985) piano students who all followed a more or less similar course, but at different ages depending on their level of achieved talent. We will now leave this perspective centred on talentee development to focus on the dynamic interactions between music teachers and their students, still distinguishing the two major levels of teaching: basic and advanced. We will ignore the possibility of intermediate steps in the passage from local to advanced music teachers. We will also try to keep in mind that we are looking for dynamic elements that can differentiate teaching to current or future MPs as opposed to less exceptional music talentees.

Initial musical education In Part V we focused on the chronological evolution in teaching resources. We now move our interest to potential differential dynamics between the early music teachers and their future MP students. Again, with few empirical data at our disposal, we will circumscribe through a sample of questions the relevant themes that would come under this facet. For example, how long did it take the initial teachers to notice the exceptional musical potentialities of their young students? Did they notice special learning characteristics that contributed to their recognition of exceptional aptitudes? Did they modify their teaching strategies in their interactions with these future MPs, and how long did it take them to realize the need to do so? Did they observe any special temperamental or personality differences with other bright young music students? How difficult was it for them to adapt to their young students' accelerated pace of progress? How long did it take them to acknowledge the limits of their teaching competence and recommend that the child transfer to a more specialized music teacher? Did it take months or years? For instance, in the case of young Jonathan Floril, who only began formal piano lessons when he was 11 years old, Solomon (2012) reports that "within three months, the piano teacher told Jaime [Jonathan's father] that Jonathan had a talent [read 'gift'] too significant for Ecuador and needed to train in Europe" (pp. 443–4). Can most initial music teachers reach a diagnosis of exceptional potential so soon after the beginning of formal lessons? These are just a few of the possible subjects to be explored within that specific area.

Moving to a "master teacher" The world of music differs from most other talent development fields by providing for exceptionally young talented music students the services of a small fraternity of so-called "master teachers" with national or even international prestige. As much as the school in which they teach, and sometimes even more, they serve as poles of attraction for extremely talented young students or their parents. The late Dorothy DeLay (Epstein, 2010; Sand, 2000), who taught a succession of prodigy violin students including the famous Sarah Chang, ranks among the most celebrated master teachers. Other similar examples include Yoheved Kaplinsky, the piano teacher and Artistic Director of the pre-college division at Juilliard, as well as Gary Graffman and Eleanor Sokoloff who have taught (often together) a string of very young exceptional piano students and prodigies at the Curtis Institute. The biographies of these prominent master teachers reveal that some were prodigies themselves (e.g. Gary Graffman) and that many enjoyed an international career as performers before focusing on teaching. As we would expect, most of their protégés are not musical prodigies, but reached their exceptional level of talent at a slower pace. Moreover, we can observe a fuzzy boundary between officially anointed master teachers and "quasi-master" teachers who belong to a periphery of lesser-known professional teachers, yet have good regional renown, enough to attract exceptionally talented young music students.

Master and quasi-master teachers are well aware that their reputation as "producers" of international soloists is at stake; as Epstein (2010) suggests, "their worth is measured by the way their students develop, how well they succeed, and, more subtly, how well they live their lives" (location 55, e-book). Consequently, they will show definite choosiness when looking for new students to take under their wings. As Sosniak (1985) points out, they "do not work with pianists who, although technically accomplished, are not extremely motivated and disciplined. ... The teachers seem to rely on a network of acquaintances and fellow musicians to send them applicants, who are then further weeded for subjective qualities of talent, potential, and determination" (p. 59). Even MPs can find it difficult to become students of master teachers, not only because their prodigiousness is not always known outside their immediate community, but also because some master teachers can harbor negative stereotypes about the staying power of musical prodigies. As difficult as the process can sometimes be, accessing a master teacher is judged a critical step for any young

musician dreaming of reaching the top rungs of a professional performing career. Sosniak (1985) notes: "The most critical step in the transition from being a talented teenage pianist to becoming a professional performing soloist seems to be that of moving to a master teacher" (p. 59). The top American pianists she interviewed moved to a master teacher in their late teens, the majority of them between 15 and 17. The timing differs significantly in the case of MPs; most prodigies surveyed in this volume had an experienced teacher from the outset or very shortly thereafter, and usually transitioned to a master teacher well before entering their teens. In some cases this may have been because the parents had noticed, and were reacting to, the level of precociousness observed in their child. In others, they may have been attempting to choreograph their child's musical development, based on their own aspirations or beliefs about what the child should and should not do.

Master teacher styles, roles, and impact If we applied the system of "parenting" styles described in the preceding section to master teachers, we would easily find typical examples for each of them. For instance, Ivan Galamian, a master teacher from Juilliard, was known as an authoritarian taskmaster, whereas Dorothy DeLay adopted a much more authoritative style; Ms DeLay was famous for calling her students "sugarplum" (Epstein, 2010). However, little more is known about the diversity of teaching styles found within the master-teacher fraternity. In terms of roles, apart from their specific teaching roles, which probably differ little whether the students are MPs or not, master teachers play a diversity of additional roles. They serve as models for the type of playing (e.g. posture, phrasing, expressiveness, rhythm), they mentor students in the planning of their career, they occasionally act as personal counsellors, and they often open doors to professional performance opportunities or recording contracts once their protégés are ready to embark on their professional careers. They possess this special ability, often based on their own personal experience as musicians, to project a sense of what the future might hold for the young MP. Again, we can assume that such roles could vary to some extent from one student to the next, depending on their needs and personal dispositions, but there is little indication that there are significant disparities between MPs and their older highly talented peers.

Our downward reassessment of the impact of parenting on children's musical talent development extends to the parallel relationship between professional music teachers and their MP students. In other words, we asked ourselves to what extent we should endorse the common SSSM-inspired interpretation that these master teachers play a "crucial" role in the blooming process of young musical prodigies. Is it possible, as proposed by Harris in the case of parents, that we could shuffle around these professional music teachers without significantly modifying the end result? Recall that these master teachers show exceptional pickiness when examining the qualities of candidates for their professional services; they need to protect their reputation as producers of international soloists. Their renown allows them to be very selective in their admission criteria and literally pick the *crème de la crème* (the best of the best). This preoccupation opens the door to an alternative explanation of their success, which involves the "two-way street" interpretation we introduced when discussing parent-child relationships. Thus, could it be that the most renowned master teachers—or prestigious music schools—graduate so many of the best young musicians not so much because of the quality of their teaching, but because of the quality of the chosen students? In the same way that we say "garbage in, garbage out" when talking about computer operations, could it be, at least partly, "diamonds in, diamonds out" in the case of famous master teachers and prestige music conservatories?

3. Peer group influences (EIP)

To what extent do peers contribute to—or hinder—the growth of the talents of our musical prodigies?

Theoretical considerations When we examine the anecdotal literature, it looks as if the MPs described here did not have any significant peer relationships, or at least none that appeared worth mentioning as significant contributors to their talent development. This seems strange for two main reasons. The first concerns a core aspect of Solomon's (2012) book on his ten groups of marginal individuals. At the very beginning, he places the peer group at the centre of his thesis by insisting that all his interviewees were trying to acquire a *horizontal* identity, for lack of a *vertical* one. Here is how he distinguishes these two concepts:

Because of the transmission of identity from one generation to the next, most children share at least some traits with their parents. These are *vertical* identities. Attributes and values are passed down from parent to child across the generations not only through strands of DNA, but also through shared cultural norms. ... Often, however, someone has an inherent or acquired trait that is foreign to his or her parents and must therefore acquire identity from a peer group. This is a *horizontal* identity.

(Solomon, 2012, p. 2)

Harris (1998) similarly argued that, much more than parents, same-age peers acted as a crucial reference group in most children's socialization process: "Children in developed societies are socialized in a group of children. This is the group they see as being 'psychologically significant' for them, the one to which they 'relate themselves subjectively,' the one from which 'they take their rules, standards and beliefs about appropriate conduct and attitudes' " (p. 144). As mentioned earlier, this view stands at the core of what she calls her "group socialization theory". How can we reconcile these two viewpoints with the almost total absence of peers in the MP vignettes used as our background information?

First, short vignettes needed to focus on the essential, namely the prodigies' early exploits, as well as the pre-teen phases of their musical talent development; there was little room left to explore side avenues like youthful peer relationships unless they bore directly on the core subject. Second, the extreme exceptionality of the young MPs made it virtually impossible for them to meet similarly talented peers. In other words, Solomon's theory of a search for "horizontal" identity might apply to deaf or dwarf children who will join eponymous organizations early in life, but it cannot apply to musical prodigies, simply because they are virtually alone in their community. On the other hand, they could easily enjoy satisfying peer relationships with other children who do not possess their musical giftedness, but with whom they could share many other interests. We have found no specific documentation on this particular aspect of their youth. But as soon as they enter an advanced music school they join a large peer group of other highly talented young musicians. These new peers need not be age peers; even older, but similarly talented, music students can constitute a relevant peer group.

Music talentees as peers Even in a learning environment where the schedule of activities reserves many hours to solitary practice, many hours still remain, in classes and public spaces, to create and strengthen friendships. Friends and peers can have a positive influence, especially if the prodigy is interacting with other similar-minded friends within an environment in which competition among them is supportive and does not undermine motivation. Many of the highly involved talented students interviewed in the study by Evans and McPherson (in press) mentioned that such friendships provided a sense of purpose and focus. On the other hand, such environments create a potential for competitive animosities, since many students will be participating in the same music competitions, will apply for the same scholarships, or will audition for the same positions in orchestras. Summarizing her young pianists' group experiences, Sosniak (1985) states: "The 'group' of young pianists provided exciting comradeship and frightening competition" (p. 64). So, there is potential for very difficult situations as much as very enriching ones. And how will age differences affect the balance of positive and negative experiences? That difference will

constantly stand out since the rarity of musical prodigies ensures that there will be no more than one or two in any given institution at a given time; at least, this is our present guess because of lack of prevalence statistics that, as we said earlier (see Part III-C), would be relatively easy to obtain. Do MP students sometimes meet other MP students with whom they can exchange thoughts on the daily vicissitudes created by their marginal situation? Could this environment foster what Solomon called the building of a “horizontal” identity? Do their older peers perceive them as more—or less—menacing professionally? Do they have more difficulty than others in adapting to this very competitive environment? Are the advanced schools of music challenging environments where only the fittest survive? And if not, to what extent do music schools cater to the personal and emotional needs of their students? These are just a few of the many fascinating questions that currently remain unanswered.

C—Resources (ER): The *educational* dimension

The third environmental subcomponent brings together a diversity of themes. Of course, we find at its heart curricular resources (ERC), in terms of both content and instructional strategies; we also find all the administrative resources that surround the curriculum. In gifted education, these may include part-time or full-time grouping practices (e.g. elite teams, after-school clubs, weekend or summer “camps”, cluster groupings, honors classes, special schools), as well as accelerative measures (e.g. early entrance to kindergarten or first grade, grade skipping, merged grades, advanced placement). The music world has always taken for granted these two types of administrative measures, still very controversial in general education. Consequently, these diverse administrative measures cannot serve to differentiate the educational services offered to MPs as opposed to their less exceptional learning peers. A third important thematic area concerns all forms of financial resources other than those from parents or the talentees themselves; they mainly include scholarships, sponsorships, or paid public performances. Are there resources that benefit musical prodigies more specifically? We do not believe so, since all MPs attend the same music schools as other highly talented music students. They also have access to the same parallel services, like accredited public or private schools or approved home-school environments for their general education. We must remember that all major music institutions around the world have extensive application and audition processes that make them extremely selective. Even so, only a tiny percentage of those admitted would probably be labeled musical prodigies.

Music schools will sometimes make exceptional efforts to attract MPs. At the Curtis Institute in Philadelphia for example, Lang Lang went from virtual poverty in his hometown of Shenyang to a luxurious environment that he described as follows:

Curtis paid for everything—tuition, private lessons with Gary Graffman, living expenses, and an English tutor. . . . The school had even sent a car to the airport to bring us into the city. When the driver dropped us off at a high-rise building in the heart of the city, I felt as if I had stepped into a Hollywood set . . . an immaculate one-bedroom apartment with central heating, central air-conditioning, our very own bathroom, and, most amazingly of all, a seven-foot Steinway B piano in the living room.

(Lang Lang with Ritz, 2008, pp. 165–6)

Such extravagant resources for prodigies at a critical part of their development are rare, but even so some of the most prestigious schools of music provide generous financial aid, access to master teachers who are dedicated to the prodigy's personal and professional development, access to resources that enable their development, and opportunities that are not typically available elsewhere. Similarly, we might reflect on the learning environment of Michael Jackson and Stevie Wonder (Solis, this volume, Chapter 32; Warwick, this volume, Chapter 33) whose early

experiences enabled access to recording studios with the finest musicians and exposure to the very latest musical trends.

D—Biological underpinnings of E catalysts

The presence of this section may seem strange: how can we ally biology and environmental influences? Yet, an important specialty in the field of behavior genetics looks at the genetic underpinnings of popular measures of environmental characteristics. It has been “variously called gene–environment covariance, gene–environment correlation or genetic control of exposure to the environment” (Kendler & Baker, 2007, p. 616); many scholars commonly refer to it as “the nature of nurture” question. Its basic thesis states that the genotype partly influences individual differences on most environmental measures, which artificially inflates their contribution. For example, Scarr and Carter-Saltzman (1982) demonstrated that the teaching abilities of mothers, a clear environmental influence on a child’s development, were strongly (0.62) correlated with their intelligence level. Rowe (1994) gave many additional examples of the genotype’s influence on so-called “social” measures, including child-rearing styles, a variable that received special attention in section VII-B. Kendler and Baker (2007) systematically reviewed the behavioral genetics literature for studies on the heritability of environmental measures commonly discussed in the psychiatric epidemiology field. They aimed to question the traditional interpretive model according to which “the relationship between individuals and their environment is unidirectional, from environment to person” (p. 615); this brings back our discussion of Harris’s nurture assumption at the beginning of section VII-B. The authors summarized their methodology and results as follows.

We identified 55 independent studies organized into seven categories: general and specific stressful life events (SLEs), parenting as reported by child, parenting reported by parent, family environment, social support, peer interactions, and marital quality. Thirty-five environmental measures in these categories were examined by at least two studies and produced weighted heritability estimates ranging from 7% to 39%, with most falling between 15% and 35%. The weighted heritability for all environmental measures in all studies was 27%. The weighted heritability for environmental measures by rating method was: self-report 29%, informant report 26%, and direct rater or videotape observation (typically examining 10 min of behavior) 14%.

(Kendler & Baker, 2007, p. 615)

Note that two of their categories target variables we examined in sections B (parenting and family environment) and C (peer interactions). The authors concluded: “genetic influences on measures of the environment are pervasive in extent and modest to moderate in impact. These findings largely reflect ‘actual behavior’ rather than ‘only perceptions.’ Etiologic models for psychiatric illness need to account for the non-trivial influences of genetic factors on environmental experiences” (p. 615).

In summary, there is little doubt that many variables included within the DMGT’s environmental catalysts possess significant biological and genetic underpinnings, which clearly attenuates their interpretive power as “environmental” influences. But beyond this short introduction, we leave to others a more extensive exploration of this phenomenon as it might affect the talent development of musical prodigies.

E—Summing up

In the politically most delicate part of this chapter, we confronted head on the strict environmental interpretations of the SSSM model. It meant explaining why we were significantly reducing the causal role of these influences in all three subcomponents: Milieu–EM, Individuals–EI, and Resources–ER. We first briefly mentioned in the “Milieu” (EM) subcomponent some historical

(role of Europe) and cultural (role of Jews) distal influences. We also discussed the limited impact of social family characteristics, especially issues related to socioeconomic status (SES) and family structure, which we differentiated from psychological family dynamics (EIF).

We began our analysis of EI influences by introducing Harris's (1998) controversial anti-SSSM theory, which basically substitutes peer influences for parental influences. She bases her position, among other scientific results, on (a) the behavior genetic observation that family influences contribute almost nothing beyond genetic effects to sibling personality similarities, (b) the fact that parent-child interactions work both ways, with child effects as important as parent effects, and (c) a peer pressure role that is much more significant than commonly assumed. We showed how parenting styles and behaviors varied enormously among parents of MPs, thus negating a prominent role for any particular style. We transferred that theoretical position to interactions with music teachers, especially the select group of master teachers that most young MPs encounter as their exceptional talent grows. We hypothesized that, because of their renown, these master teachers could select the *crème de la crème* among candidates for their teaching; it suggested that the intrinsic qualities of their students could contribute as much, if not more, to the excellent results observed in most cases. In other words, "diamonds in, diamonds out". With respect to peer influences, we were unable to find a differential causal input on their part. As Sosniak (1985) pointed out: "The group of young pianists provided exciting comradeship and frightening competition" (p. 64).

With respect to educational resources, it was clear from the outset that MPs share the same schools as other less exceptional young pianists, thus canceling out the potential differential role of these resources. There might be some "perk effect" based on various advantages (e.g. lodging, scholarships, lent instrument) that some prestigious schools are better able to offer. Finally, we brought up the subject of the demonstrated genetic underpinnings of most classic measures of environmental influences, what is commonly called "the nature of nurture". We showed how these significant effects contribute to artificially increasing the causal contribution of these environmental influences.

VIII—Becoming a musical prodigy: which DMGT facets make a difference?

In parts IV–VII we identified a large number of potential causal contributors to musical prodigiousness. Our final task consists in selecting from them a restricted group of more promising sources of influences, and then ranking them in terms of their explanatory power. In other words, which of the various gifts, developmental processes, personal characteristics, and environmental influences play a more crucial role in favoring by their presence—or hindering by their absence—the initial appearance and then progressive flowering of exceptional and precocious musical talent? This is the task—shall we say the challenge—that the first author (Gagné, 2004) has summarized under the catch label "What makes a difference?" (WMD).

A—Importance of the WMD question

Although we briefly noted in Part I-D the "Holy Grail" symbolism associated with the WMD question, it is worth examining its importance in more detail because of its key role in this penultimate part of the chapter. So, why make it our conceptual apotheosis? Beyond its unmistakable theoretical value, there are undeniable practical implications, not only for improving identification of the most promising candidates for a given talent development program, but also for better targeting the most appropriate curricular and administrative support resources for these exceptional students. Underneath these rational motives, we observe a deep human interest in

discovering the developmental paths of eminent or otherwise notable individuals. Note how the WMD question underlies most biographies, in-depth interviews, and case studies of politicians, film idols, notorious killers, and famous athletes.

1. Implicit and explicit theories

Human interest may have very deep roots. It first brings to mind the concept of “need for closure” (NFC), first introduced by Kruglanski (1990). Individuals high in dispositional NFC “prefer order and structure in their lives ... they also prefer predictability, desiring secure and stable knowledge (Roets & van Hiel, 2011, p. 90). We all experience to varying degrees this interpretative curiosity—or deeply felt need to reduce anxiety. That need might have an even deeper evolutionary root. Shermer (2011) analysed the need for humans to create deep-held beliefs that resist scientific evidence. He argues that because humans have evolved a “theory of mind”, that special ability to read other people’s minds, they practice “agenticity: *the tendency to infuse patterns with meaning, intention, and agency*” (p. 87). That “agenticity” is a powerful generator of beliefs, and, once any of them is adopted, we tend to maintain it with resolute determination despite contradictory evidence. He even defends its hard-wired insertion in “believing neurons” (p. 111). These profound temperamental dispositions lead automatically to an accumulation of personal or implicit theories about most phenomena that come to our consciousness. In the case of talent development, every person creates implicit theories of “what makes a difference” in becoming highly talented; and these “theories” will vary from individual to individual. Indeed, as you browse through this volume, you will find dozens of instances of personal “interpretations” concerning the sources of the musical prodigiousness of the eminent musicians presented. This is precisely why the second author used the term “interpretations” in the subtitle of this edited volume.

Such is the importance of the WMD question that it has given rise to all kinds of explicit theories, most of them associated with a particular field of talent. In the case of academic talent development, some of these theories give prominence to one particular causal agent (e.g. Ericsson’s deliberate practice, Goleman’s focus and concentration, or Duckworth’s concept of grit), whereas others propose broader theoretical conceptions (e.g. Gagné’s IMTD (this chapter); the WICS theory (Sternberg, 2005; the actiotope theory (Ziegler & Philipson, 2012)). Some accept biologically anchored natural abilities while others deny their existence (e.g. Ericsson, Roring, & Nandagopal, 2007; Howe, Davidson, & Sloboda, 1998). This search for the best precursor signs of future excellence manifests itself most actively in sport, with efforts to identify as early as possible the young boys and girls who could one day reach the highest summits in a particular sport. Nations, as well as major league sports teams (e.g. baseball, basketball, cricket, football, hockey, rugby, soccer), invest tens of millions of dollars each year in identification procedures, hoping to find the few Olympic needles in junior league haystacks! It is also a major preoccupation of admissions officers in selective high schools and universities (Finn & Hockett, 2012). Finally, to bring us back to our subject, music teachers at all levels of the talent development path keep in mind the WMD question as they search for the best candidates for an advanced class, a place in a music conservatory, or a scholarship in a prestigious music school. Recall that we mentioned that specific question when discussing the dilemma master teachers face as they follow their own implicit theories to determine which among a group of young exceptionally talented candidates offer the best chances of reaching the highest professional levels (see Part VII-B).

2. Planning the discussion

To complete this important task we will follow three consecutive steps.

- (a) Extract from Parts IV–VII in synthetic form all the causal variables recognized as potential contributors to the emergence and growth of musical prodigiousness.

- (b) Identify within the pool of causal variables a restricted number of more effective influences, offering a “why” answer for both the chosen and the rejected.
- (c) Rank the members of the restricted list with respect to their relative predictive power.

B—Survey of potential causal contributors

We will proceed sequentially through Parts IV–VII; we will maintain an open mind, deferring the WMD question itself to the next two steps.

1. Part IV: The G component

We found interesting musilinked aptitudes in three natural ability domains (cognitive-GI, perceptual-GP, and motor control-GR), from which we extracted seven distinct elements. In the case of cognitive abilities, the literature suggests a significant but modest relationship between measures of general intelligence (GIG) and measures of both musical aptitudes and musical talent (Schellenberg & Weiss, 2012). But these results have their origin in samples from individuals with mostly average musical aptitudes and competencies. If there is a significant degree of covariation, does it mean that high intelligence would go hand in hand with exceptional musical talent? Indeed, a recent study (Ruthsatz & Urbach, 2012) argues strongly for such a causal influence. With so few empirical studies to borrow from, it would not be sensible to ignore this result, even if the sample is very small.

The perceptual domain, more specifically its auditory (GPA) facet, contains most of the classical tests of musical aptitudes (Hallam, 2006); we extracted from that domain four distinct musilinked aptitudes. Despite their perceived limited predictive power, we decided to retain classical audiation measures, like tone, pitch, rhythm, loudness, or timbre discrimination. We felt a similar hesitation towards the phenomenon of absolute pitch, seemingly overrepresented among MPs, but judged of doubtful causal power in some music literature (Mandelman & Grigorenko, 2013). On the other hand, we highlighted two natural abilities that have received limited attention from music researchers: (a) mimicry and (b) long-term declarative memory. In our view, mimicry (Solomon, 2012) belongs essentially to the auditory domain (with a probable cognitive component); it allows young music students to pick up and reproduce easily subtle technical nuances in their music teachers' examples. It needs to be coupled with the motor dexterity necessary to perform these imitations successfully; again, students need to control aurally the faithfulness of their reproduction. One form of long-term memorization targets the auditory and visual dimensions of a complex melody—thus the “declarative” label given to them. Exceptional long-term memorizing aptitudes are so commonly mentioned in most MP vignettes that we found difficult to understand their disregard by music psychometricians.

Finally, the motor control (GR) domain appeared to us rich in potentially influential sources of rapid progress as a musical performer. We first highlighted manual dexterity (GRM), and especially the precise coordination of movements from both hands; it plays an important role, not only to ensure perfect technique, but also to convey expressiveness. This ability also appears to be undervalued (Hallam, 2006). Finally, we identified within this same facet a second type of memorization: the procedural long-term memorization of complex sequences of fingering allowing an accelerated mastery of new musical pieces.

2. Part V: The D component

We selected from the D component two potential sources of causal influence. We first identified an unavoidable characteristic, namely amount of practice (DIT); as the saying goes, “practice makes perfect”. Differences in practice time impact musical progress from the very beginning of systematic musical learning (McPherson, Davidson, & Faulkner, 2012) to the highest levels of musical

expertise (e.g. Ericsson, Krampe, & Tesh-Römer, 1993; Macnamara, Hambrick, & Oswald, 2014; Hambrick, Altmann, Oswald, Meinz, & Gobet, 2014). But practice time is not enough if it is not used efficiently, which means with deliberate concentration and effort (DIE); this second source of influence corresponds to the “deliberate” qualifier in Ericsson’s construct of deliberate practice (Ericsson, 2006). This energetic investment can even translate into a reduction of the practice time necessary to master a unit of music curriculum (Gagné, 1999b; Sloboda & Howe, 1991); thus it would contribute to an accelerated pace of progress.

3. Part VI: The I component

As described at length in Part VI, the I component revealed itself to be a rich source of causal influences. We have extracted from that discussion no less than seven potentially significant causal influences: (1) emotional hypersensitivity to music (IPS); (2) attention to detail (IPD); (3) autonomous monitoring of talent development activities; (4) rare but strong *coups de foudre* (IMP) as initial manifestations of (5) a long-term passionate commitment to music and to a specific instrument (IMP); (6) ambition as a complementary extrinsic motivator; and (7) willpower and perseverance as key volitional characteristics. We decided not to include possible biological sex differences in musilinked aptitudes because of their very hypothetical status as well as their main impact on the differential prevalence of male vs. female prodigies.

Within the IP subcomponent, we find three distinct temperamental or personality characteristics. The first one, hypersensitivity to music (IPS), appears recurrently in the short biographies examined for this chapter; we believe it could underlie and support the high level of intrinsic motivation observed in the MP population. The second element is attention to detail (IPD), one of just a few empirically supported differentiating characteristics between MPs, in fact all prodigies, and their less exceptionally talented peers (Ruthsatz, Ruthsatz, & Ruthsatz-Stephens, 2014). This personality trait could influence the level of concentration (DIE) that contributes to effective and efficient practice sessions. We finally chose to extract from the IP subcomponent the capacity, even at a very young age, to monitor one’s talent development activities, not only the choice of the music repertoire, but more importantly the efficient management of practice schedules. These capacities concretize that precocious trait Winner (1996) popularized under the expression “marching to one’s own drummer”.

The last four sources of influence belong to the merged pair of motivational (IM) and volitional (IV) subcomponents. The potentially most powerful and long-lasting influence belongs to love of music, an intrinsic source of motivation that manifests itself most strongly as passion; it can appear very early, as our anecdotal sources have shown time and again, in the form of a literal *coup de foudre*. Yet, the intensity of intrinsic motivation does not rule out the complementary presence of extrinsic motivations, with ambition as the most significant in the present context. Again, many anecdotal vignettes confirm the relevance of this source. Finally, we cannot ignore the crucial role of willpower as a strength that ensures continuing involvement and perseverance through boredom and unavoidable setbacks during the long years that lead to full-blown MP status.

4. Part VII: The E component

We carefully re-read Part VII to determine which environmental influences we would select as potential causes in the development of musical prodigiousness. We were facing two opposite theoretical perspectives, the powerful SSSM environmentalist credo on the one hand, and the “heretical” Harris thesis on the other. To respect the “survey” goal of this section, we chose an intermediate approach and extracted all sources that might play “some” role in the accelerated talent development process of MPs. First, we decided to put aside more distal sources, like large geographic, cultural, or socioeconomic influences, even though any children who possess exceptional musical

aptitudes and personal dispositions, if born and raised in Africa, the Middle East, and most Asian countries, have minimal chances of seeing these potentialities recognized and developed. But such distal influences have little immediate impact on the learning process itself. Moreover, making music education more available in these countries would not affect the MP phenomenon substantially; there is no reason to imagine that we would find in these countries a higher ratio of MPs.

As our first “environmental” source of influence, we judged it important to include a generally overlooked variable, namely the parental genotype received by all children. Recall that we added at the end of Parts IV–VII a section devoted to the biological underpinnings of the characteristics mentioned in each particular part. We stated in the DMNA part of the IMTD (see Part II-B) that both natural abilities and personal dispositions have a genetic component. And where does that genetic infrastructure originate? It comes of course from the parents. Consequently, it makes sense to include that parental “gift” as a potentially significant source of influence on the talent development process of our musical prodigies. We identified in the EM subcomponent two proximal influences related to the family environment, namely the family’s financial resources and the level of musical culture in their daily lives, including the professional musical involvement of parents or siblings. We kept both of them despite clear contrary evidence, for instance the financial hardship of some MPs’ parents (e.g. Lang Lang), or Sosniak’s (1985) observation that the familial musical culture of her eminent pianists did not differ significantly from that of average Americans.

Within the EI subcomponent, we chose to respect our theoretical leanings and put aside the controversial area of parental styles and behaviors, especially in view of the large diversity of observed styles among the parents included in our sample of MPs. We selected for inclusion in our preliminary list only one EIF characteristic, parental differences in their values concerning the support to be given to their children’s dreams of high level musical excellence; we thought they might underlie the level of their commitment to make the sacrifices needed to help their children achieve their dream (or sometimes the parents’ dream!). We had similar hesitations with respect to the second most important group of significant individuals, the music teachers (EIT), and more specifically the select community of master teachers, but decided to include them at this point. Finally, we did the same in the case of prestigious music schools that seem to welcome and train a majority of MPs. We will examine the pros and cons of the extent of their causal impact more closely in the next section.

5. Synthetic visualization

Table 1.4 lists the 22 variables from the four causal components of the DMGT that summarize our extraction process from Parts IV–VII. It includes the facet code and a brief description of each variable. The data in Table 1.4 confirm the complexity of the MP phenomenon’s origins; we are far from shortcut explanations that reduce the causal process to just two or three variables! This table will serve as our point of departure in the next step of our effort to determine which variables make a difference in the emergence of musical prodigiousness or exceptional expressions of musical talent.

C—Selecting and ranking key causal influences

As we enter the crucial two parts of this search for “What makes a difference?” we need to make a few methodological comments that will better circumscribe the focus and limits of our search.

1. Methodological precisions

Individual versus group outlook The WMD question automatically casts aside the study of individual talent development stories, simply because individual paths activate strictly personal

Table 1.4 Potentially significant causal influences of musical prodigiousness

#	DMGT facet	Description
G component		
1	GIG	General intelligence, or “g”
2	GPA	“Audiation” (hearing) abilities: pitch/rhythm/timbre discrimination.
3	GPA	Absolute pitch
4	GPA	Mimicry (auditory; includes feedback from motor activity)
5	GPA (m)	Long-term (declarative) auditory memory for melodies
6	GRM	Manual dexterity (e.g. synchronization, rhythm, pressure control)
7	GRM (m)	Long-term (procedural) motor memory for fingering sequences
D component		
8	DIT	Time investment in practice (hours/weekly or monthly)
9	DIE	Energy investment (focus, concentration, “deliberate” practice)
I component		
10	IPE	Emotional sensitivity to music
11	IPD	Attention to detail
12	IPA	Autonomy, self-determination, “marching to one’s own drummer”
13	IMP	<i>Coups de foudre</i> as a rare initial passionate manifestation
14	IMP	Long-term passionate involvement with music
15	IME	Ambition as extrinsic motivator (+ DPP feedback loop)
16	IVW	Willpower, perseverance, Winner’s “rage to master”
E component		
17	EIF (b)	Parental biological “gift” of genotype
18	EMF	Familial financial resources
19	EMF	Familial musical culture and professional involvement
20	EIF	Parental commitment to support child’s maximal development
21	EIT	Access to master teachers
22	ERS	Resources offered by prestige music schools

dynamic interactions between the IMTD (but mostly DMGT) components, subcomponents, and facets. A case study is just that, a case study; recall Harris’s comment that the plural of anecdotes is not data. On the other hand, the comparative analysis of a large sample of case studies can suggest interesting hypothetical causal variables through the recurrent appearance of specific causal events in a series of case studies. We did just that in Parts IV–VII, extracting interesting hypotheses (e.g. declarative and procedural memorization, *coups de foudre*) from dozens of biographical vignettes in Kenneson’s (1998) book, Solomon’s (2012) chapter, and chapters within this volume. This approach cannot adequately substitute for the results from dozens of empirical studies, each one examining the comparative predictive power of multiple causal agents on our target dependent variable. This is precisely the type of analysis that the first author applied to studies of the predictors of school achievement (Gagné, 2004), leading to his proposal of a G–I–D–E decreasing

hierarchy in the case of academic excellence. Unfortunately, the field of music has not yet accumulated an equally rich research database, forcing us to rely on case studies as our main source of evidence.

The dependent variable The choice of the dependent variable is straightforward—musical prodigiousness. In other words, we do not need to worry about the professional future of MPs, whether they leave the field of music during adolescence or make a safe transfer into adult exceptional musical talent. But how should we operationalize musical prodigiousness? Should we use outcome measures of musical proficiency, like the grade level attained in the music curriculum? If we do so, we must take into account the length of training, a precision explicitly included in the DMGT's definition of talent through a required membership in the top 10% of *learning peers*. By so doing, we would in fact be adopting our proposed MPQ index (see Part III-C.1). In other words, our real dependent variable would become *individual differences in pace of progress*, with MPs representing the upper end of that continuum. We could consequently rephrase the WMD question as follows: "Among talented young musicians, which causal variables have a more significant impact on individual differences in pace of progress (MPQ), including its highest levels achieved by MPs?" We have just described an ideal operationalization of the dependent variable. Unfortunately, no MPQ-based comparison studies yet exist! Thus we have little choice in the present context but to compare acknowledged MPs with other groups of music students or professional musicians.

The control group(s) If researchers used MPQ indices, there would be no need for a control group since the continuum of MPQ values would act as an implicit control group. Significant correlations of independent variables with that quantitative variable would reveal predictive power. Again, only one study (Ruthsatz & Urbach, 2012) offers some degree of comparison with general population norms. However, we have access to an interesting comparison group, namely the 21 eminent adult American pianists studied by Sosniak (1985). According to our understanding of her text (see III-B), we judged that only one of her pianists might have deserved the label of musical prodigy, a label Sosniak never used in her analysis of their professional growth. Moreover, her description leaves no doubt that her pianists would have obtained MPQ indices well below the 200+ levels we have estimated for musical prodigies. Yet, already in their youth, their initial music teachers definitely judged them musically gifted: "they responded well to the teachers' directions, and were quickly able to translate newly acquired knowledge into action" (Sosniak, 1985, p. 37). But she summarizes their level of talent after 2–4 years of music lessons as follows.

They were clearly the best pianists in their families. A few were the best by virtue of their age. ... The pianists were perhaps the best in their neighborhood, even in their town, for their age. Yet if these children ... had been in competition with one another, or just with a larger group of children their own age who also studied the piano, few would have looked very special.

(Sosniak, 1985, p. 39)

Even if Sosniak's study does not address many of the questions we surveyed in Parts IV–VII, confronting MP achievements with those of that group represents the best available comparison base. In fact, even if we are targeting two groups who both belong to the highest levels of performing excellence, well beyond the top 1%, and thus cannot manifest much variability in terms of their musical talent, we have a unique opportunity to take advantage of a situation of maximal between-group differentiation: the members of one group *all* manifest musical prodigiousness—even though we cannot assess it precisely—whereas *virtually no* members of the other group achieved that extreme pace of progress, yet still reached eminence as professional pianists. Such a between-group disparity very rarely happens in the social sciences.

2. Step 2: Choosing the key causal influences

We will again proceed component by component through the list given in Table 1.4, selecting the variables we believe to account much more than others for the lightning learning progress of MPs. As we have said repeatedly, exceptional pace of progress, ideally represented by the highest MPQ values observed within a group of young music students, corresponds to the best available operationalization of musical prodigiousness.

Predictive G variables We chose to target this chapter on one specific type of musical prodigiousness: performing on an instrument, especially keyboard or strings. Let's face it: performing is first and foremost a complex motor activity, even judged "athletic" by Solomon (2012, p. 419). This inescapable association has brought us to select first among the seven G elements the GRM pair, which includes manual dexterity, especially the synchronization of both hands, and the procedural memorization of complex sequences of fingerings. The quality of this motor activity requires constant monitoring, mostly auditory, which brings into action a second pair of qualities mentioned by Solomon that belong to the auditory perception facet (GPA): mimicry and the declarative memorization of increasingly complex melodies. Finally, we need to include a fifth natural ability, judged very influential by Ruthsatz and Urbach (2012), namely general intelligence (GIG).

Predictive D variables We saw in Part V that most MPs do not hesitate to devote at least two hours daily to their musical practice. Just on the strict basis of time involvement (DIT), they diverge strongly from Sosniak's young pianists; indeed, she points out "that practice time during the early years was enforced, either by a parent or a teacher, often with an eye more to the clock than to the keyboard. One hour of practice time per day was likely to be a required minimum, with only a secondary emphasis on musical objectives" (p. 35). Assessing the efficiency of that practice time through level of concentration is not an easy task in the present circumstances. But the above quote suggests that Sosniak's young pianists showed wavering concentration. On the other hand, the lightning progress of MPs would tend to confirm an extremely efficient use of both lesson and practice times on top of other qualities. So, if we wish to explain our dependent variable, namely exceptionally rapid pace of progress, we need to take into account both the amount of practice time (DIT) and its more efficient use (DIE). However, if we had to keep only one of them, we would choose without hesitation the DIE facet; very steep MPQ curves within a few months of beginning music lessons argue in favour of exceptional efficiency.

Predictive I variables Choosing the best predictors among the seven I catalysts listed in Table 1.4 is not an easy task. We must keep in mind that catalysts, contrary to natural abilities, do not build the high level competencies that define musical prodigiousness; they just support that process (see Part I-D). Figure 1.1 shows that they act most of the time through the developmental process, more specifically on the DI facets of practice time (DIT) and practice efficiency (DIE). To better understand their action, we can use the simple metaphor of a running car, in which natural abilities represent the motor, and practice the motor's energy that creates the car's forward progress toward its desired destination. To operate, the motor needs fuel, and it will receive its fuel, its source of energy, from both intrapersonal and environmental catalysts. Although far from perfect, this analogy underlines the importance of catalysts in the talent development process. Indeed, it is interesting to note that Ericsson et al. (1993), staunch defenders as they have been of the causal influence of deliberate practice, not only acknowledged that there was more to achieving expertise than just deliberate practice, but even recognized that some of these additional sources of influence could have genetic bases. For instance:

It is quite plausible, however, that heritable individual differences might influence processes related to motivation and the original enjoyment of the activities in the domain and, even more important, affect

the inevitable differences in the capacity to engage in hard work (deliberate practice). . . . Individual differences in emotionality and general level of activity are also likely influences on the capacity to engage in sustained practice as well as on the preference or dislike for this type of isolated activity.

(Ericsson et al., 1993, p. 399)

This quote—and no doubt many others—implicitly supports our “fuel” metaphor. Keeping this metaphor in mind, which among our seven I candidates offer the best sources of fuel for the pursuit of an intense regimen of musical practice? We first decided to put aside extrinsic motivators (IME), especially ambition, because of the young age at which future MPs begin developing their musical competencies; ambition might appear later, when prodigiousness comes into bloom, but most of the progress will be completed. The biographical vignettes also contain many more examples of strong intrinsic as opposed to extrinsic motivation. In the case of emotional hypersensitivity (IPE), just like any other emotional expression, it acts indirectly through intrinsic motivators by increasing their strength; the more intense these emotions, the stronger the level of attraction towards the perceived source of these emotions (Isen, 1993). We can also hypothesize that attention to detail (IPD) also acts indirectly, probably by influencing the efficacy of the mimicry process, which will in turn increase practice efficiency (DIE). Only four intrapersonal catalysts now remain: intense intrinsic motivation expressed as (a) rare *coups de foudre* and (b) long-term passionate involvement, (c) willpower, and (d) autonomy or self-determination, what Winner labeled “marching to one’s own drummer”. Despite their intensity, *coups de foudre* represent once in a lifetime emotional events that last just a few moments, and then transform themselves into a deeper and quieter long-term love of music and the chosen performing instrument. It is that passionate musical involvement that stands out as a key differentiating catalyst when we compare the MPs we have described in this chapter with Sosniak’s sample of young non-MP pianists who eventually became eminent professionals. With respect to the other two, it is beyond our analytic capacities, in view of the lack of reliable empirical comparative data, to determine which we would retain if forced to choose. Consequently, we will keep both of them among the key causal influences of exceptional musical pace of progress. Let us point out that the first three catalysts in this group are usually confounded under the common umbrella label of “motivation” (see Part I-C) in almost every explanatory model of talent development (Gagné, 2004).

Predictive E variables As we look at this last group of potential influences, it is worth restating the operational definition of our target dependent variable: a pace of progress that exceeds in speed the pace of any other music students, even the most talented ones. What we are trying to pinpoint is the precise source(s) of such lightning progress that lasts about half a dozen years. Among the six E catalysts placed in Table 1.4, there is no doubt that the combined parental genotypes contribute to this extremely rapid development through a causal chain described in the DMNA (see Part II-B); it begins with their child’s genetic baggage and continues to the biological underpinnings of the natural abilities and intrapersonal catalysts we have already selected as their respective component’s most significant contributors to musical prodigiousness. But, as we did with some intrapersonal catalysts, we will exclude this “environmental gift” from our final list because of its distal and indirect impact on the learning process itself. But we can keep it at the back of our minds as a kind of *éminence grise* that affects the biological foundations of G, I, and even E facets.

Which of the remaining five characteristics can we save for the final list? The little information we can rely on does not indicate that the two elements from the EM subcomponent, family finances and family musical culture, differ between the MP population and the members of Sosniak’s sample in any way that could explain the large differences observed in terms of pace of progress. A similar lack of significant differences in parental commitment or availability of master

teachers, the two elements from the EI subcomponent, leaves us with the inescapable decision to exclude them from our final list of significant influences as well. Indeed, members of both groups benefited, on average, from parents committed to making the necessary sacrifices that helped them reach their high excellence goals; they also had access to recognized master teachers, if at different ages during their development process.

Comment on the exclusion of E influences Before moving to the last task, we judged it essential to introduce additional explanations for the absence of E variables in our restricted list of the ten most significant predictors of MP emergence. Not only does this absence go totally against common sense, it also opposes an interpretative orientation probably shared by almost all participating authors in this volume! Without repeating the arguments we defended as we expressed our general endorsement of Harris’s (1998) anti-SSSM thesis, let us introduce—or recall—the following clarifying points.

1. Although we did not retain that variable in our short list because of its distal and indirect impact, the parental genotype constitutes a major source of environmental influence. Our multiple comments and quotes in the final biologically oriented sections of Parts IV–VII confirm the significant role of these environmental “gifts”.
2. Our comparison situation has played an important role in limiting the causal influence of environmental influences; we did focus on two groups of very talented musicians who differed mainly by the presence versus the absence of musical prodigiousness. We can easily understand that the members of both groups did benefit from all the necessary environmental support, including influential individuals (EI), to achieve their respective high levels of musical excellence, albeit at different points in the course of their talent development. Even if we had the opportunity to open the analysis to all music talentees (top 10%), using MPQs as our index of talent level, we are confident that we would observe this hypothesized very modest causal impact of environmental influences. Note that even though the suggested sample of talentees appears very restricted, it would still be large enough for MPs and quasi-MPs to represent no more than a 1:100 or even a 1:1,000 ratio.
3. Recall finally Rowe’s (1994) comment (Part VII-B) concerning the fact that, except for very marginal familial situations, most families offer sufficiently appropriate parental environments to allow their children to develop adequately their own individual aptitudes and personalities.

In brief, there is no lack of convincing motives to explain a final choice of the most effective predictors that does not include variables from the E component.

3. Step 3: Ranking the key causal influences

From the original 22 facets presented in Table 1.4, we have now brought the list down to what we believe to be the ten most significant causal influences; they appear in Table 1.5. Our final task consists in ranking them according to their *decreasing predictive power* of individual differences in pace of progress.

Methodological cautions We are facing a difficult task for at least three reasons. First, our selection process has reduced the pool to influences that differ much less in causal power one from the other. If we pick almost any pair, we cannot instantly place one in front of the other. Second, as we have mentioned repeatedly, we have at our disposal few empirical data on which to base our judgment; we lack especially the results of studies that would compare the relative predictive power of a certain number of causal influences, giving us helpful statistical indices to operate our ranking. Third, four of the five natural abilities we have included in this reduced list do not yet possess psychometrically valid measuring tools; in fact, we did not have time to create proper operational definitions for them. Thus we are feeling our way through a dark room, guiding ourselves on little

Table 1.5 The ten most significant causal predictors of musical prodigiousness

#	DMGT facet	Description
1	GIG	General intelligence, or "g"
2	GPA	Mimicry (auditory; includes feedback from motor activity)
3	GPA (m)	Long-term (declarative) auditory memory for melodies
4	GRM	Manual dexterity (e.g. synchronization, rhythm, pressure control)
5	GRM (m)	Long-term (procedural) motor memory for fingering sequences
6	DIT	Time investment in instrument practice (hours/weekly or monthly)
7	DIE	Energy investment (focus, concentration, "deliberate" practice)
8	IPA	Autonomy, self-determination, "marching to one's own drummer"
9	IMP	Passionate involvement with music, <i>coup de foudre</i>
10	IVW	Willpower, perseverance, Winner's "rage to master"

more than a few empirical results, a lot of anecdotal landmarks, and strong convictions; we will need to identify convincing logical arguments to give at least temporary value to our proposed ranking. Consequently, readers should not expect much more than a structured set of hypotheses which could guide future research.

A crucial role for natural abilities According to the basic DMGT credo, talented competencies result from the progressive transformation of outstanding natural abilities into the equally outstanding knowledge and skills that define a field of human activities. During that long process, catalysts will play a supporting role, influencing learning involvement, essentially the DIT and DIE facets. This dynamic developmental law gives a central role to natural abilities because they are the building blocks, literally, of the competencies to be mastered by young talentees as they progress through the music curriculum. Our reduced list includes five of these building blocks, all members by definition of the G component. The ease and speed with which young learners utilize their domain-related (GI, GP, GR) building blocks determines to a significant extent the speed with which they will master their musical skills, in other words the effectiveness of their lessons and practice sessions. Of course, individual differences in skill mastery also reflect the complex contributions of all four causal components, not just natural abilities. But having achieved a talentee level means that individual differences in intrapersonal dispositions and environmental conditions have been significantly reduced, thus automatically increasing the *relative* causal role of individual differences in musical aptitudes.

These arguments initially led us to attribute the first five positions in our final ranking to natural abilities. We then reconsidered that initial choice, judging that future empirical measures of these variables would probably reveal significant covariations among them, forcing us to decide which variable(s) would receive the lion's share of that overlap. We hypothesized that "g" (GIG) plays a more distal analytic role, essentially enhancing the effectiveness of the four other natural abilities. We also concluded from the limited research results available (Ruthsatz & Urbach, 2012; Schellenberg & Weiss, 2012) that its raw causal impact on pace of progress would probably be smaller. For these reasons, we reduced its causal significance, deciding to re-examine its position after ranking the D and I variables.

Now, how should we rank our four main G abilities? We defined competence in Part I as the mastery (through long-term memorization) of a structured set of (declarative) knowledge and (procedural) skills. Because of our focus on musical *performance*, it seems logical to consider

skill acquisition—as opposed to knowledge—as *proportionally* more important during the first years of musical training. Is it not why students sit at the piano or have their instrument on hand during most music lessons? This argument would suggest giving more importance to manual dexterity (GRM) and its associated memory processes (GRM (m)). On the other hand, the quality of the fingering probably depends enormously on constant auditory monitoring activities, which brings into action mimicry processes. Unfortunately, the lack of relevant empirical data makes it impossible to assess relative prominence. Consequently, we decided to cautiously avoid undue controversy and place them on an equal footing (see Table 1.6). We also initially judged that the two abilities related to long-term declarative or procedural memorization played a subordinate role with respect to their “parent” abilities; without good mimicry or dexterity there would be little content of quality to memorize! In other words, we believed that these two building blocks follow, in time and importance, their purveyor of relevant content. But, without valid supportive data, we opted to maintain an equal ranking for all four.

Ranking D and I variables Pursuing our ranking process, we now faced a decision between causal influences from either the D or the I component. In continuity with our earlier vehicular metaphor, we judged that the intrapersonal “fuel” that feeds the “practice” motor should receive priority. Among the three I subcomponents, we did not hesitate to give predominance to levels of intrinsic motivation. This choice followed clearly from the numerous examples of precocious passionate involvement and frequent early *coups de foudre* among our MP musicians compared with Sosniak’s pianists. In the case of the two DI facets, we did not hesitate to follow Ericsson’s position and give more importance to the efficiency of practice time (DIE) than to the simple accumulation of hours of practice, although we feel that at such high levels of learning, individual differences in practice efficiency will largely overlap with parallel differences in practice time. We then judged that the two other I catalysts, autonomy (IPA) and willpower (IVW), should receive some priority because they had been highlighted by Winner (1996). However, unable to determine a relative ranking, we placed them on equal footing in seventh and eighth positions. The last two variables, GIG and DIT, were also placed on equal footing at the bottom of the ranking.

As shown in Table 1.6, our ranking gives top ranks to the G component, then to the I component, and then to the D component. The absence of the E component in the final list relegates it to fourth and lowest rank. Recall our earlier mention of the first author’s similar ranking of the

Table 1.6 Ranking according to hypothesized decreasing predictive power of the ten most significant causal influences

Rank	DMGT facet	Description
2.5	GPA	Mimicry (auditory; includes feedback from motor activity)
2.5	GPA (m)	Long-term (declarative) auditory memory for melodies
2.5	GRM	Manual dexterity (e.g. synchronization, rhythm, pressure control)
2.5	GRM (m)	Long-term (procedural) motor memory for fingering sequences
5	IMP	Passionate involvement with music, <i>coup de foudre</i>
6	DIE	Energy investment (focus, concentration, “deliberate” practice)
7.5	IPA	Autonomy, self-determination, “marching to one’s own drummer”
7.5	IVW	Willpower, perseverance, “rage to master”
9	GIG	General intelligence, or “g”
9	DIT	Time investment in instrument practice (hours/weekly or monthly)

four components when examining predictors of academic achievement (Gagné, 2004). We hope that future research will provide confirmation or rearrangement of this very tentative hierarchy.

An overrepresentation of G sources? Many music scholars will no doubt object that our final selection, which includes five natural abilities, and our ranking, which places four of them at the top of the hierarchy, are overly influenced by our ideological bias (at least the first author's bias!) in favor of natural gifts instead of environmental influences. We have already taken pains to explain our choices and rejections in a preceding section. We did in fact consider reducing the number of variables belonging to the G component; for example, we could have merged the two GPA (mimicry) and the two GRM (manual dexterity) elements. But we explained in section IV-C.2 that the two distinct memorization processes, declarative and procedural, not only represent distinct natural abilities, but also differ from their "mother" abilities—mimicry and manual dexterity, respectively. In other words, when reliable and valid assessment instruments for these four abilities become available, we expect to observe only moderate correlations among them. For example, some talents could show exceptional dexterity without a corresponding high ability to memorize these procedural sequences, or vice versa.

Note also that the G component's central causal contribution has its source in our target dependent variable, namely an extremely fast pace of progress that no other young music talents can achieve. Musical prodigies literally represent what we labeled in section III-B as "the tip of the tip of the music performance iceberg." We could not imagine *any* environmental variable, even Howe's God-like parents, *any* intrapersonal disposition, even the most passionate involvement, or *any* amount of practice, even the most deliberate practice, that could account for the mastery by MPs of so many musical competencies in a matter of months or just a year. This is what we argued passionately to counter the denials of Antinats (see Gagné, 2009), citing the lightning developmental pace of Sarah Chang and other well-known MPs. Here is another typical example. Solomon (2012) reported that the 11-year-old Jonathan Floril from Ecuador "who had studied piano for less than six months, was accepted into the fifth year of the Rodolfo Halffter Conservatory [in Madrid]" (p. 444). Young Jonathan had certainly not accumulated more than two or three hundred hours of lessons and practice when "within three months, the piano teacher told Jaime [Jonathan's father] that Jonathan had a talent [read "gift"] too significant for Ecuador and needed to train in Europe" (pp. 443–4). How many times do music teachers reach a diagnosis of such exceptional potential after just a few weeks of teaching a new music student? Readers will find throughout this volume dozens of similar examples of very short practice times that translate into lightning progress, confirming the probably modest *relative* contribution of the D and I components to musical prodigiousness.

This priority given to "gifts" has been confirmed in education through hundreds of studies (Gagné, 2009; Macintosh, 2011); only irreducible "Antinats" deny that cognitive giftedness best predicts high academic achievement, at least before students complete their high school education. So, our transposition of that priority role to music receives clear empirical support.

4. Interpreting the WMD results

How can we properly interpret the differentiated impacts and dynamic interactions within our proposed hierarchy of causal influences? There are many potential misinterpretations; lack of space prevents examining many of them. But here is one interesting example. Solomon (2012) quotes Ms Yoheved (Veda) Kaplinsky from the Juilliard School of Music as follows: "If the talent ['our' giftedness] is there, it's ten percent of the package. If the talent is not there, it becomes ninety percent, because they can't overcome the lack of it. But just having talent is really a very minor part of what is necessary in order to make it in music" (p. 451). First, she makes a very common

error by using Manichean (all or nothing) definitions of causal variables. Musilinked gifts—or any other variable appearing in Table 1.4—are never “there” or “not there”; they express themselves quantitatively with a large continuum of degrees. Love of music has degrees, willpower has degrees, parental resources have degrees, mimicry certainly has degrees, self-determination has degrees, and so forth.

Second, if we try to account for a pace of progress as steep as the one we observe by definition with MPs, we need very high levels of good predictors. In the case of estimated MPQs at the 200+ level, any good predictor whose intensity level drops below the 90th percentile level of expression will seriously jeopardize the blooming of musical prodigiousness. Recall that the prodigies in the study by Ruthsatz and Urbach (2012) all had memorization scores above the 99th percentile. So, when Ms Kaplinsky says: “if talent is not there, it becomes ninety percent”, she should have concluded instead that any intensity level under the 90th percentile will probably cancel any chances of ever reaching MP status. This conclusion differs enormously from “not being there!” It might be the reason why Sosniak’s pianists did not manifest in their youth that extreme pace of progress; their gifts were somewhat too low, but still high enough that additional deliberate practice allowed them eventually to reach adult professional eminence. In the case of other predictors, like those in the D or I components, we could probably observe significantly lower thresholds in a group of MPs, but probably not below the 60th or 70th percentiles. In other words, we need exceptional predictors to account for such an exceptional outcome as musical prodigiousness (see section D below for an innovative hypothesis).

Third, she compares the contribution of “talent” (natural abilities) as one constituent member in a very large ensemble of causal influences, namely “what is necessary to make it in music”. There are certainly many more influences that contribute to adult professional eminence as a performing musician than those involved in achieving our more modest goal, that of MP status. So, it is important to keep in mind the exact nature of the dependent variable to be “explained”. With respect to the emergence of musical prodigiousness, because we attributed the first four causal ranks to facets from the G component, we were attributing to that component a crucial causal significance *as a predictor of that specific outcome*. In other words, gifts are much more than “ten percent of the package” when we try to understand the MP phenomenon. The predictive role of natural abilities certainly decreases when they are introduced to predict “making it in music” as opposed to reaching MP status; but we still believe in a contribution at least twice as large as her “ten percent” estimate. On the other hand, if Goldsmith’s (2000) very pessimistic statistics about the proportion of MPs who “make it in music” were verified, it would certainly give more validity to her statement. The future will tell.

D—Could MPs represent an emergenic phenomenon?

As we were writing Part VIII, we became progressively more intrigued by the almost total absence of musical prodigies among Sosniak’s young eminent pianists, as well as their significantly slower pace of progress than any MP. Why had they still reached in early adulthood an eminent status in their performing field? What could be so different in the case of musical prodigies? Could there be some unique source for that incredibly rapid progress? Suddenly, an idea emerged. Could we be witnessing the rare instance of an *emergen*ic phenomenon?

1. The nature of emergensis

According to Lykken (2006), one of the “fathers” of this theoretical proposal, a majority of human traits are *polygenic-additive*, which means that they owe their level of expression to multiple (poly) genes whose contributions add up to produce the individual differences observed in the target

behaviors. Lykken (2006) points out: “pairs of relatives resemble one another on the given trait in proportion to their genetic similarity” (p. 306). Consequently, the correlation on a trait between monozygotic (MZ) twin pairs will be about twice as large as that of dizygotic (DZ) pairs, since MZ twins share 100% genetic similarity as opposed to 50% on average in the case of DZ pairs, or pairs of ordinary siblings. But there are behavioral traits for which the MZ correlation remains quite high, whereas the DZ correlation is close to “0”. Lykken interprets this abnormal gap by proposing a *multiplicative* combination of genetic effects instead of the more common additive one: “The distinctive feature of emergence is the notion of configurality, which implies that a change of any one component may result in a qualitative, or a large quantitative, change in the emergent trait” (Lykken, McGue, Tellegen, & Bouchard et al., 1992, p. 1569). In his view, these genes act “rather like workers on an assembly line each of whose contributions may be qualitatively essential to the final product” (Lykken, 2006, p. 306). Said differently, if just one of the “workers” (or genes) does an imperfect job, it will result in a much less effective product.

2. Emergenesis and MPs

Let us apply that emergent hypothesis to our MP situation, using the four main natural abilities (see Table 1.6) as our analytic tool. Let us assume that for a very high MPQ to manifest itself, each of these four gifts would have to express itself at least at the 99th percentile (the top 1%). Example 1 in Table 1.7 illustrates this situation, and reveals that a *multiplicative* combination would produce a 0.96 product, a result quite close to the level of each of the four components. We could roughly interpret that product as 96% of an “ideal” pace of progress. In an *additive* situation, the sum of the action of the four genes would be 3.96 (out of a maximum of 4.00), which represents 99% of the maximum; this result is already superior to the other. This first example will serve as our baseline. Let us adopt as our minimum threshold to be labeled a musical prodigy a 90th percentile on either the Product or the Sum indices. What happens if *any one* of the four genes (or traits) expresses itself at a lower level than top 1%? In example 2, just one of the four traits (it can be any of them) expresses itself at the 90th percentile instead of the 99th percentile. Although remaining among the top 10% on that trait would be a matter of pride for most music learners, that drop is sufficient to bring the product to 0.87, *below* our adopted MP threshold. In contrast, an additive situation would keep the sum at 0.97, well above the threshold. We can already observe the more negative impact of multiplicative gene combinations on musical talent development. In example 3, we just lower the level of expression to the 95th percentile for all four traits, and the Product drops to 0.81, well below our adopted threshold, whereas the Sum remains at 0.95. The last three examples illustrate worsening Product results, down to 0.64, while an additive combination keeps the expressed performance above our minimum MP threshold. Example 4 is particularly illustrative because it

Table 1.7 Examples of various combinations of trait levels, with their multiplicative and additive impacts

Example	Trait 1	Trait 2	Trait 3	Trait 4	Product	Sum (% max)
1	.99	.99	.99	.99	.96	3.96 (.99)
2	.99	.99	.99	.90	.87	3.87 (.97)
3	.95	.95	.95	.95	.81	3.80 (.95)
4	.99	.99	.99	.80	.78	3.77 (.94)
5	.99	.99	.85	.85	.71	3.68 (.92)
6	.95	.95	.95	.75	.64	3.60 (.90)

shows how the drop of a single constitutive trait from 0.99 to 0.80, a result still well above average, brings the product far below the MP threshold.

3. Implications

Emergenesis remains a hypothesis for the time being, but an interesting one because of its explanatory power for the major difference in pace of progress between our MPs and Sosniak's pianists. With levels on our four top-ranked musilinked aptitudes equivalent to those shown in any of the last three examples, these pianists would certainly possess sufficiently high aptitudes to achieve exceptional musical excellence, but they would be forced to progress at a slower pace because of their "slight handicap" on any one, or a few, of them. An emergenic situation would also predict a very low prevalence of quasi-MPs as measured through the MPQ indices we proposed, thus reinforcing the impression of MPs forming a qualitatively distinct group. In summary, this hypothesis adds another puzzle piece to our quest for "What makes a difference?"

E—A hypothetical developmental scenario

As a concluding contribution to Part VIII, and to better illustrate the various causal influences in action, we propose painting our view of a typical developmental scenario for musical prodigies. We will use all the predictive characteristics identified in Table 1.4, with special emphasis on the set of ten variables judged more causally powerful. Beginning with occasional precursor signs of future passionate involvement in music, we will describe the young exceptional talents' meteoric developmental path all the way to its mature expression as musical prodigiousness.

1. Precursor signs of musical prowess

Future musical prodigies can appear in almost any family environment of any state or country, yet probably very rarely in less socioeconomically developed countries (EMC). Their parents can be either financially comfortable or much less so, and they may or may not surround the family environment with musical activities; there can be some families with professional musicians, others without them (EMF). When they are still very young, before beginning any formal musical education, more or less during the second or third year of life, future MPs may show distinct precursor signs of exceptional musical interest. Not all of them manifest these signs, and we have no idea of their prevalence, but it seems that we do not observe them in the early lives of highly talented musicians (e.g. Sosniak's pianists) who do not achieve MP status. What do these precursor signs look like? They appear either as an emotional hypersensitivity (IPE) to music that expresses itself in very explicit ways (e.g. delight, crying, complete attentional focus), or as an instantaneous passionate attraction, usually to a specific musical instrument, an attraction analogous to a lover's *coup de foudre* (IMP). That passionate reaction contains the same emotional component as the first precursor sign, but leads generally to "demands" made to the parents to learn to play the newly discovered musical instrument. In very rare instances, parents who have some musical training might be able to notice the presence of absolute pitch; but that natural ability does not appear specific to the population of future MPs. Some parents, either through ignorance or lack of interest, might not follow up on the child's precursor signs of hypersensitivity or passionate interest. But we will probably never know since most of the time that negative parental reaction (EIF) will stop in its tracks the beginning of a potential path towards extreme musical excellence.

2. Early accelerated pace

Most future MPs start their musical talent development earlier than learning peers, usually between the ages of 3 and 5; but late "vocations" exist, sometimes with starting points during adolescence. Remember that our MP definition stresses pace of progress rather than strict pre-teen blooming.

The start of a formal music education confirms that the parents have committed themselves to help their child benefit maximally from this musical involvement, and that they will maintain as long as necessary their psychological and financial support (EIF). Young future MPs make use of their exceptional musilinked (and cognitive) aptitudes (GI, GP, GR) from the very beginning; attentive music teachers should observe within just a few weeks the exceptional effectiveness of the four natural abilities we have selected as key building blocks of early musical skills: (a) an exceptional level of ability to pick up and mimic (GPA-GIG) almost instantly the music teacher's suggestions in terms of rhythm, phrasing, or expressive detail; (b) an outstanding natural ability to memorize phrases and melodies, hear these mentally, and monitor faithfully the feeling and precision in their physical reproduction (GPA (m)); (c) an unusually nimble manual dexterity (GRM), especially in the simultaneous control of both hands and for the piano "touch" on the keyboard; (d) an easy memorization of the correct fingering of early music pieces (GRM (m)), allowing talents to move ahead much earlier to more advanced pieces. An elevated level of attention to small details (IPD) enhances the effectiveness of the learning.

Even in the absence of precursor signs, they attack the new learning challenge with intense intrinsic motivation and gusto; their love of music manifests itself with ebullience and vivacity (IMP), and makes both music lessons and practice periods more enjoyable and effective. During music lessons, they maintain almost constant focus and concentration, and will transfer that deliberateness to their practice periods (DIE). Thanks to their outstanding natural learning abilities and high attention to details, they profit enormously from each practice session. They might need some parental supervision once in a while (EIF) to maintain their practice schedules (DIT), but usually initiate them autonomously, and complete them without outside control (IPA). Often, they prefer the practice of their musical instrument to other leisure activities (IMP). At this early point in their musical talent development, they rarely need any willpower to maintain their practice schedule (IVW). In summary, the exceptional level of these young talents' musical aptitudes (G component), as well as their strong personal dispositions (I component), have a direct impact on their initial developmental activities (D component), which in turn greatly accelerate their early musical progress and open up a rapidly increasing mastery gap with other learning peers.

3. Progressing to full bloom

Everything we have described concerning the first music learning steps of future MPs applies *mutatis mutandis* with almost similar intensity to the next months and years of their talent development. Their natural abilities grow even more as talents constantly use them to master new and more difficult musical skills. Their initial exuberant passion settles somewhat into a quieter type of love for music (IMP), but continues to fuel daily learning and practicing activities (DIT). It soon becomes clear to both parents and the neighborhood music teachers that these young talents possess extraordinary musical gifts; the label "prodigy" begins to be mentioned, at first with hesitation, and then with growing conviction. As the local music teachers feel increasingly overwhelmed by their protégés' progress (EIT), they finally concede that the time has come for them to access a more advanced level of music education (ERS). From that point on, individual developmental paths will diverge to take into account more and more diversified G, D, I, and E causal influences, and respect unique environmental contexts. One certainty remains: in most cases, whatever the dynamic interactions between natural abilities, developmental activities, as well as intrapersonal and environmental catalysts, these young music students who possess exceptional musical aptitudes and exhibit the passion and willpower to face any difficulties encountered will reach that lofty goal that defines the present chapter: musical prodigiousness.

IX—Concluding comments

Musical prodigiousness is a phenomenon that most music researchers have taken for granted, in terms not only of its nature but also of its origins. This chapter offered a unique occasion to the first author to apply in an extensive way his *Integrative Model of Talent Development* (IMTD), and especially its DMGT constituent element, to a field outside general education. The various texts examined in preparation for this chapter were found to contain countless statements and interpretations that had never been thoroughly questioned, and which became the “body” under the DMGT’s analytic scalpel. To wrap up this long discussion of musical prodigiousness, here are two distinct series of comments, first a retrospective summary of the major observations and hypotheses, and then a pot-pourri of suggestions for future research.

A—Retrospective outlook

Our dissection of musical prodigiousness revealed a much more complex phenomenon than initially believed. By following rigorously the sequential framework of the theory, we first analyzed the target concept itself, defined as the dependent variable. Then the analysis moved to a search for the main sources of influence that could explain the emergence of such an unlikely (statistically speaking) expression of musical excellence. We first looked at musilinked aptitudes (G), then at the developmental process itself (D), and finally at the two large groups of catalysts: intrapersonal (I) and environmental (E). Thanks to this systematic approach, we were able to identify more than 20 significant causal influences, and then extract from that pool a restricted list of the ten most significant elements, for which we proposed a tentative ranking. This systematic procedure produced a large number of observations and hypotheses, many of which can be considered unprecedented in the field of music. They appear below, organized by component.

About the T component

1. Redefining the MP concept as a *quantitative* phenomenon, placed at the “tip of the tip” of the competence “iceberg”, with talentees comprising the emerged top 10% of that iceberg.
2. Hypothesizing the existence of “quasi-MPs”, a group of exceptionally talented musical performers who follow a somewhat slower pace of progress.
3. Proposing a *musical progress quotient* (MPQ) to assess individual differences in growth of musical talent, and using it to define a minimal threshold value for MP status.
4. Recommending the extension of the MP concept to performers and composers outside Western classical music, and classical music itself.

About the G component

5. Defending the existence of “natural” abilities or aptitudes (giftedness), which includes their biological and genetic underpinnings.
6. Redefining the concept of “musical aptitude” within the theoretical framework of the IMTD, and proposing “musilinked” aptitudes as a more appropriate substitute.
7. Restructuring aptitude categories according to the G domains, thus decreasing the predominant role given to auditory abilities in traditional musical aptitude tests.
8. Endorsing mimicry (Solomon, 2012) as a key aptitude, a combined auditory and cognitive natural ability.
9. Stressing the crucial role of manual dexterity in the mastery of musical competencies at all levels of training.
10. Building on the recent work of Ruthsatz and colleagues (e.g. Ruthsatz & Urbach, 2012) to highlight the important role of two long-term memory processes, declarative and procedural.

About the D component

11. Introducing a distinction between product-based and process-based systems of developmental stages.
12. Showing the double identity of pace of progress, as *the* quantitative index of developmental advancement, as well as an operational measure of talent level.
13. Dissecting Ericsson's deliberate practice construct into its two components of time (DIT) and concentrated focus (DIE).

About the I component

14. Borrowing from research on cognitive sex differences to suggest a biological interpretive hypothesis for an assumed preponderance of males among MPs.
15. Highlighting precocious hypersensitivity to music as a unique precursor sign of future musical prodigiousness.
16. Proposing very precocious *coups de foudre* for a musical instrument as a unique precursor sign of future musical prodigiousness.

About the E component

17. Endorsing Harris's (1998) theoretical perspective, which questions the commonly perceived primacy of EI influences, especially those of parents and music teachers.
18. Highlighting the key "environmental" influence of the parental genotype through its action on both natural abilities and personality characteristics.

About the WMD question

19. Introducing to the field of music the key analysis of relative causal influences through the "What makes a difference?" (WMD) question.
20. Identifying Sosniak's (1985) study sample of eminent young pianists as a particularly relevant comparison group because of its lack of MP individuals.
21. Proposing a carefully selected list of the ten best predictors of MP status.
22. Highlighting exceptional natural abilities as the most important differentiating causal factors between MPs and other excellent professional musicians.
23. Introducing the concept of emergence as a potential explanation if a significant MPQ gap was eventually observed between MPs and "quasi-MPs".

The contents of the above list represent of course the personal view of its authors; moreover, the level of significance and innovativeness varies from item to item. Similar variability will certainly be found within any group of readers. Future discussions will reveal how well the community of professional musicians and music researchers receives them.

B—Prospective outlook

As we repeated again and again throughout this chapter, most of the above observations and hypotheses, interesting as they might appear, have little more than anecdotal support; all of them would greatly benefit from empirical confirmation. We even went further, regularly describing research ideas that would not be very difficult to implement. We mentioned possible studies that could take advantage of both retrospective and prospective approaches. In the case of retrospective studies, the IMTD offers a unique framework for systematic analysis of biographies by coding their contents according to the dozens of IMTD facets (Gagné, 2000). The prospective approach can take advantage of the fact that, despite their rare incidence, MPs constitute one of the most important subgroups within the prodigy community; they offer a unique opportunity to assemble sufficiently large samples to follow the growth of their exceptional talent, even in the absence of direct contact. Parents, music teachers, and the MPs themselves could be invited to answer periodic questionnaires and participate in phone interviews, just as Lewis Terman's

research team did in their impressive follow-up of over 1,500 highly intellectually gifted young Californians (Terman, 1925; Terman & Oden, 1959).

Finally, as researchers proceed to enrich even further our understanding of the specific characteristics that MPs share as a group, they should always keep in mind that these similarities will always leave a shroud of mysterious uniqueness that all of them, with their specific aptitudes and personal dispositions, and within their specific environment, bring to their talent development process. If there is one thing that the complex structure of the IMTD makes very clear, it is the following:

talent emerges from a unique combination of complex interactions between multiple causal influences.

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