Chapter 14

Developmental Trajectories of Giftedness in Children

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Abstract Our article focuses on the development of giftedness in children. First, we outline demands for a model that wants to describe giftedness development and introduce the Munich Dynamic Ability-Achievement Model. Second, we summarize and review current approaches that explain how giftedness in children develops, e.g., genetic psychology, cognitive psychology, expertise research, or research with focus on interest, personality, family, or learning environment. The genetic approach for instance shows that there are various interactions between innate aspects and environmental factors. Expertise research on the contrary concentrates on practice. Other approaches try to identify factors of the child like motivation, attribution, or curiosity. Special attention will be directed at gender differences. One problem is that giftedness in girls is more often overlooked. Reasons like different expectations from parents and educators or different performances by boys and girls shall be explored. Finally, we shortly point out some ways to promote gifted children.

Keywords Children · Development · Expertise · Gender · Giftedness model · Influences on giftedness development

Introduction

Since Terman (1925) and Terman & Oden (1947) marked the beginning of giftedness research a major aim in this field is the prognosis of later extraordinary achievement in specific domains. While society is interested in the identification of individuals who have high potentials for later excellence, parents are more interested in information on environmental factors which foster an optimal development of the abilities of their children. From both points of view it would be highly welcome to be able to identify or foster the respective children as early as possible.

However, there are disappointing few studies which investigated the development of gifted pre-school children. Most longitudinal studies start with primary school children or – as Terman states – even later (see e.g., Heller, Mönks, Sternberg, & Subotnik, 2000; Subotnik & Arnold, 1994). Apart from general problems to collect samples in pre-school age or even earlier (in Germany, for example, most pre-school teachers are a little hostile to empirical investigations using quantitative methods), there are many problems from the issue itself which make research in (probably) gifted pre-schoolers troublesome and difficult: Above all, the low stability of personality and ability factors in early age causes lots of methodological problems, therefore research in gifted pre-school children is either impossible or extremely expensive (see Perleth, Schatz, & Mönks, 2000).

In this chapter we first try to sum up our rationale on the early and later development of gifted children. Therefore, we will introduce the Munich Dynamic Ability-Achievement Model (MDAAM) which is characterized by the integration of different aspects of giftedness and a developmental focus. Then we discuss findings on factors that determine the development of gifted children and give a short outlook on the role of gender for the development of gifted children.

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L.V. Shavinina (ed.), *International Handbook on Giftedness*,
DOI 10.1007/978-1-4020-6162-2_14,

A Comprehensive Model for the Development of Giftedness and Achievement

Demands for Such a Model

During the last decade of the 20th century there was an intensive discussion dealing with exceptional achievement between two antagonistic streams of psychological research. While giftedness research emphasized that important contributions to society are made by individuals who must have exceptional gifts, expertise research stressed that this could be done by any individual or by individuals with a wide range of ability who, however, are willing to concentrate on a long- and hard-learning and practice process.

A major attack from expertise research was conducted by Ericsson (Ericsson & Charness, 1994, 1995) who strictly denied the traditional giftedness assumption that it is necessary to have exceptional levels of talent for high achievement. The main argument for Ericsson and colleagues was (and is until today, see Ericsson, Nandagopal, & Roring, this volume) that (innate) giftedness or intelligence is totally unimportant for exceptional achievement. Instead the role of experience is stressed, in the terminology of Ericsson "deliberate practice," which involves task commitment, motivation, and self-control. These competencies are regarded as key characteristics for the development of the expertise that is needed for exceptional achievement. Gardner (1995) defended the traditional giftedness conceptualization and counterattacked the Ericsson position (see also the discussion during the symposium of the CIBA foundation in Bock & Ackrill, 1993).

A closer analysis, however, shows that there is a considerable overlap between giftedness and expertise conceptualizations. These two approaches result from different accents and not from unbridgeable opposite standpoints. Perleth (1997; 2000) points out that expertise and giftedness represent different aspects of the same reality from different points of view. And no giftedness researcher would deny that deliberate practice is a prerequisite for extraordinary achievement.

Which elements should be taken into account when constructing a model of giftedness that can integrate relevant findings from diverse fields of psychology? Expertise as well as giftedness researchers agree for example that the analysis of giftedness and achievement has to be done in a domain-specific manner. Models such as the Munich Model of Giftedness and Talent (Heller, Perleth, & Lim, 2005; Perleth & Heller, 1994) or the Gagné model (Gagné, 1993) stress this point explicitly. The following criteria have to be considered when constructing a model for giftedness development:

1. Extraordinary performance has to be conceptualized as domain specific

As can be seen from Fig. 14.1, the Munich Dynamic Ability-Achievement Model stresses the domain specificity of giftedness and achievement factors as well as the role of personality and environmental factors that moderate the relationship between ability and achievement.

2. The model must show that the development of extraordinary achievement needs long periods of practice

Giftedness and expertise researchers agree that an extraordinary achievement level can be reached only if one is ready to undertake a long, laborious, aim-related learning process with the aims always in view. This long phase of deliberate practice explains why most individuals produce extraordinary achievement in only one domain. With the exception of Gagné's (1993) model that stresses learning processes in school, most models of giftedness do not reflect this demand.

3. Separation of knowledge and general competencies

Expertise as well as intelligence research shows that a rich domain-specific knowledge is a central prerequisite for exceptional achievement. Reflecting this demand, Perleth and Ziegler (1997) modified the Munich Model of Giftedness and Talent (Perleth & Heller, 1994) by explicitly referring to the long time that is needed to acquire specific knowledge and competencies.

4. The quality of the learning process

A decisive prerequisite for reaching a high level of expertise is the maintenance of an active and aim-related learning process ("deliberate practice" sensu Ericsson) over a long period of time. Exceptional achievement demands an active learner who is permanently ready to overcome barriers hindering the acquisition of the next expertise level. Such achievement requires the individual to push himself to his limits. Expertise and giftedness researchers agree about the fundamental importance of personality characteristics for individuals who want to reach high levels of performance.

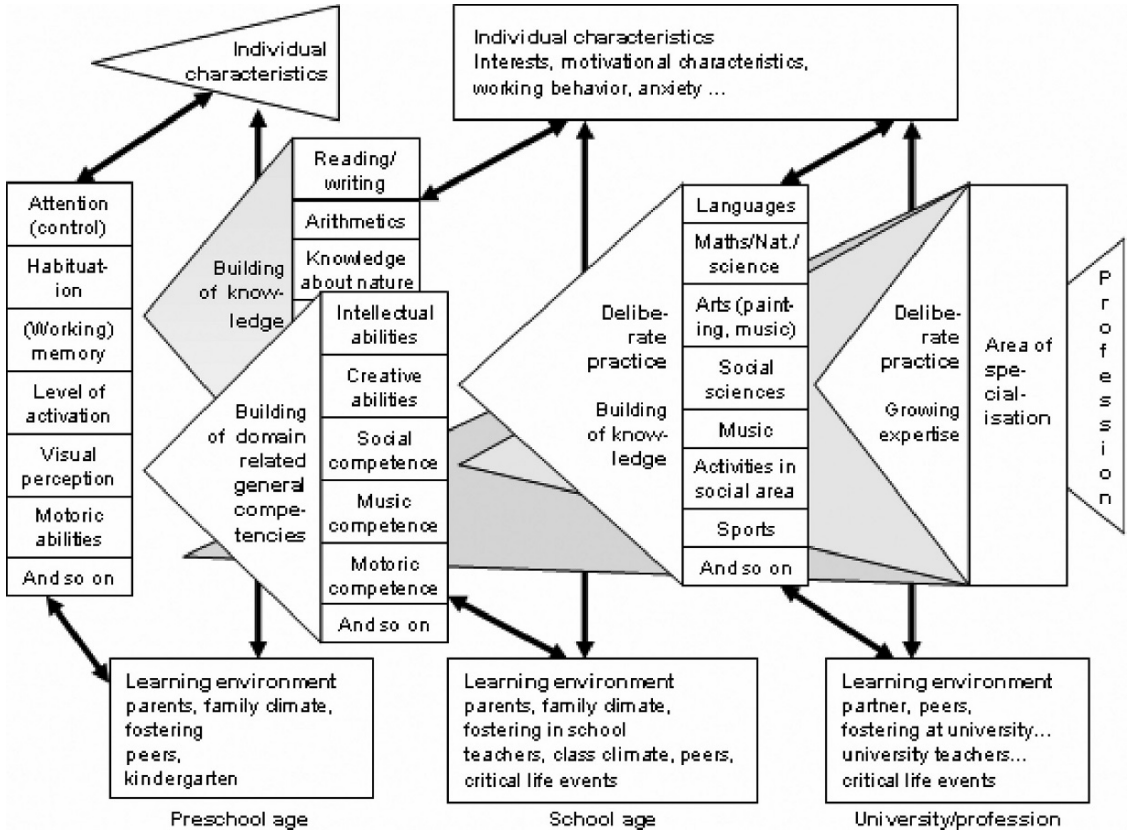

Fig. 14.1 The Munich Dynamic Ability-Achievement Model (MDAAM) (Heller & Perleth, 2004; Perleth, 1997)

5. Giftedness as a dynamic construct

Ericsson and Charness (1994) claim that intelligence tests measure nothing than learned knowledge. Even if one does not agree, it is clear that good achievement in intelligence tests requires a solid knowledge base. In other words, experiences are important for the development of both intelligence and giftedness. From this perspective we have to differentiate between giftedness factors (in the sense of traits) as prerequisites for achievement and innate dispositions (see next point).

As already pointed out even extreme expertise researchers accept the importance of motivational personality characteristics: A high level of expertise can be achieved only after a long and partly laborious activity in a specific domain, for which a high degree of motivation and a positive attitude toward achievement are necessary (Ericsson, Krampe, & Tesch-Römer, 1993; Gruber, Weber, & Ziegler, 1996). Therefore, excellence has to be regarded as a product of giftedness and personality factors as well as personality characteristics and characteristics of the learning environment.

6. Taking into account innate characteristics

An integrative model of giftedness and achievement cannot ignore the recent findings of genetic psychology. Plomin (1994) provides convincing evidence of the interrelations between genetic gifts and learning environment. Scarr and McCartney (1983) and Plomin (1994) describe three types of this interrelation:

a) Passive correlations between gifts and environment are found because children and parents share genetic and environmental influences. If, for example, a child inherits some musical ability from his parents, it is also likely that musical parents will provide a family environment in which music plays a prominent role (e.g., the family of Mozart).
b) Correlations because of reactive gifts–environment–relationships occur when the

environment (namely, teachers in school or other adults) reacts to the gifts of the children and offer learning opportunities in which the talents can be developed (e.g., Gauss, the son of a poor cobbler, whose teacher detected his extraordinary mathematical ability and recommended the boy to the Duke of Brunswick).

c) Finally, active gifts–environment–relationships are caused by the fact that gifted children actively shape their environment according to their wishes and needs by seeking out friends with similar interests (e.g., musical children choose friends who prefer musical activities).

The Munich Dynamic Ability-Achievement Model (MDAAM) as an Integrating Framework for Giftedness Research

Perleth (1997; 2000; 2001a) attempted to bridge the gap between the more process-oriented fields of cognitive research and expertise research in the development of the Munich Dynamic Ability-Achievement Model (MDAAM). This model is presented in Fig. 14.1; it attempts to integrate the above-discussed important perspectives of expertise and giftedness research and to put them into a common and consistent framework. Even if at the first glance the model might produce an opposite impression, it is meant to hold an appropriate level of complexity so that it is convincing to teachers as well as parents of gifted children and youth (fulfilling one of Sternberg's, 1990, criteria for a good definition of giftedness). The seeming complexity is due to the examples that were chosen to illustrate the different groups of variables. (No examples for the expertise domain were given because no selection seems adequate with respect to the nearly unlimited possibilities.)

Individual characteristics or traits such as aspects of attention and attention control, habituation, memory efficiency (speed of information processing), aspects of working memory, level of activation, perception, or motor skills can all be seen as innate dispositions or prerequisites (left side of the model). Perleth et al. (2000) regard these characteristics as representing the basic cognitive equipment of an individual.

The model distinguishes between three or four stages of achievement or expertise development that are related to the main phases of school and vocational training: pre-school, school, and university or vocational training. These stages can be roughly characterized by the classification Plomin (1994) uses to distinguish passive (pre-school age), reactive (primary school age), and active (adolescence and older) genotype–environment relations. The fourth phase of professional activities is only indicated in the model and has to be completed by conception (see Ackerman, 1988). Surely it has to be expected that deviations from this sketched "normal" development will occur, especially with gifted individuals.

There are different learning processes attached to each of these stages. They serve the buildup of knowledge and competencies and are symbolized by the grey triangles. These triangles open to the right which indices growth of abilities, knowledge, or competencies. The left corner of the triangles shows when the respective learning process begins (different tones of grey are used to make the figure clearer):

- During pre-school years the formation of general domain-related competencies is assumed. These are abilities or talents that are depicted in the model as giftedness factors. Examples are intellectual or creative abilities, social competencies, and musical or motor abilities. The development of these competencies is contrasted even in this early age by the accumulation of knowledge (nature, reading, writing, calculation).
- During school years the formation of knowledge in different areas is predominating, and this knowledge has to be acquired in active, goal-oriented learning processes ("deliberate practice").
- The stage of university or vocational training is the phase of increasing specialization and the development of expertise in a domain. Depending on the domain, this specialization can also start considerably earlier. Professional musicians or high-performance athletes, for example, often begin to occupy themselves with their domains as early as pre-school or primary school years (symbolized by the respective long triangles in Fig. 14.1).

The model not only identifies ability factors and knowledge domains as well as the respective learning processes but also highlights personality (motivational) characteristics that are important for the development of achievement and expertise. As shown in the model, these traits develop during pre-school and the first years of primary school (see also Helmke, 1997),

and they are conceptualized as being relatively stable later on.

Finally, aspects of the learning environment are emphasized in the model. Different factors for the three main stages of development are specified for the development of achievement and expertise (see Fig. 14.1 for more details). All in all, the influence of the family dominates in the first years, and then the characteristics of the school's learning environment gain more and more influence (e.g., extra courses for the fostering of the gifted, school and class climate, and extracurricular activities). At the same time, the importance of friends and like-minded fellows increases. A more detailed description of the model is provided by Perleth (1997; 2001a).

Influences on the Development of Giftedness

Different and sometimes directly opposed approaches try to explain how giftedness in children originates and develops (see also the chapter of Moltzen, this volume). We focus here on the five most common approaches to explain the development of giftedness: genetic psychology, cognitive psychology, expertise research, research with focus on interest and personality, and research with focus on family and learning environment.

Genetic Psychology Approach

During the past years genetic psychology has given interesting new impetus and enriched the field of giftedness research. It is in the first place the work of Plomin (1994) that convinces with a sophisticated view on the interactions between genetic dispositions and environmental factors. His approach goes far beyond the last decades' simple attempts to estimate percentages of genetic dispositions and environment. Following Scarr and McCartney (1983), Plomin (1994) described three types of disposition–environment correlation: passive, reactive, and active interaction between dispositions and environment (see above).

Most scientists agree that perceptional, cognitive, and motoric characteristics of the individual are inhered (see Perleth, 2001b). These innate determinants of intellectual functioning do hardly respond to practice; they constitute, as it were, the hardware of our mental system. These are among others (see Perleth, Schatz, & Gast-Gampe, 2001 for the following sections):

- *Memory efficiency* which refers to the velocity of cognitive processes. This speed of information processing can be compared with the clock speed of a computer.
- *Processing capacity* applies to the amount of information an individual can deal with simultaneously. This would be the random access memory (RAM) in our computer analogy.
- *Memory capacity* is the amount of information that can be stored in the long-term memory or, in computer language, the hard disc storage unit.
- *Activation level* refers, in technical terms, to the working voltage of an individual. Gender differences in childhood for example such as differences in aggressive behavior can be explained with different activation levels of boys and girls.
- There are different *perceptional channels* like vision, hearing, olfaction (sense of smell), or tactile sense. How precise the perception with these different senses works and how good one can calibrate information from different perceptual channels is important for giftedness development.
- *Attention* and *attention control* also contribute to giftedness development. Is the attention concentrated on a wide array of environmental cues or on a limited field? It is a vantage if the attention can be zoomed in on a broader or narrower section of the environment depending on the demands of a task. A narrow field of attention (like a telephoto lens) is useful with strongly restricted tasks such as memorizing a poem whereas a wide field of attention ("wide angle lens") is useful with tasks that require paying attention to as much information as possible (e.g., driving a car).
- *Habituation* means how fast children adapt to novel stimuli and how quickly they recognize familiar stimuli. Consequently habituation can be regarded as an indicator for learning speed. In recent years researchers tried to measure habituation in very young infants and to predict later giftedness. However, this prediction is quite limited as the research results show. Correlations with developmental tests in later

infancy are rather low and long-term predictions until school age nearly impossible.
- Finally, aspects of the *motor function* are inhered as well, such as muscles, bones, and nerve tracts and can influence giftedness development.

It is worth noting, however, especially in the context of giftedness development in pre-school age that innate attributes can be influenced. We can take the perfect pitch as an example. The psychologist and expert for musical talent John A. Sloboda and his colleagues assert that more children than expected can develop the perfect pitch (Sloboda, 1991, 1996). We understand by perfect pitch the ability of an individual to exactly determine the tone pitch of a heard tone. A person with perfect pitch can clearly distinguish between different notes. Children with perfect pitch (and good memory for melodies) are able to intone a melody in exactly the same pitch as heard before. It was without controversy for a long time that this rare ability is inhered. But Sloboda and colleagues found that pre-school children who had musical instruments available at home (especially keyboard instruments like piano) developed a perfect pitch more often. We can assume therefore that this special musical talent only develops in children if certain innate auditive characteristics and memory aspects concur with beneficial learning stimulation in the family environment.

That a psychological characteristic is innate does not mean that it is unchangeable. In contrast, in modern genetic psychology nobody argues if child development depends on environment or genes. Scientists like the psychologist Robert Plomin rather try to find out how genetic dispositions and social environment interact during the mental development. We can conclude that even if abilities and temperaments are determined by genetic dispositions they are malleable and can be affected by socialization and education. The learning opportunities that are provided in the environment of the child are crucial for giftedness development.

Cognitive Psychology

As an example for a cognitive intelligence model we want to introduce the model of Campione and Brown (1978) because it is most useful to explain performance development in children, even if it was originally derived from research with retarded children. According to the authors the identification of problems learning-disabled children face can raise our awareness of important but otherwise overlooked aspects of giftedness. Contrary to other researchers the authors do not assume that intelligence can be defined by one single factor.

The basic concept of Campione and Brown's model is the differentiation between the architectural "hardware" level and the higher "executive" system. Whereas the "hardware" is neither changeable nor trainable developmental processes underlie the executive system, therefore it can be improved by training measures.

The *hardware level* consists of a three-storage space memory model (sensory register, short-term memory, and long-term memory, see Wessells, 1984 for a summary). The characteristics of these memory parts (capacity, duration, and efficiency) do not underlie developmental processes; therefore, they are not malleable and not related to intelligence. The operative efficiency of the cognitive system on the contrary, that is, the speed of information processing and retrieval, does correlate to parameters of intellectual functioning (see Swanson, 2006).

The components of the *executive system* can also be influenced by practice. These components are for instance knowledge base, rules and strategies, or executive meta-cognitive control processes. Meta-cognitive control processes are used in the regulation of memory tasks, comprehension processes, or complex problem solving.

Following Campione, Brown, and Ferrara's (1982) practice generally plays an important role for the development of intelligence. Intelligence could even be defined by learning speed or the ability to transfer knowledge to other areas. While Campione and Brown (1978) originally developed the model for retarded children, Borkowski and Peck (1986) modified it in a way that conclusions can be drawn about the characteristics of gifted children. Comprising research literature and own empirical studies they found that gifted children outclass their peers in various components of the model (for cognitive characteristics of gifted children see also Gross, this volume).

An important difference between gifted children and children with average intellectual abilities seems to be the superior knowledge base and the higher information processing speed of gifted children. In contrast,

the findings with respect to meta-cognitive components as well as learning and problem-solving strategies are unclear. While some researchers found indicators for superior strategies of gifted children in these areas (Borkowski & Peck, 1986; Kurtz & Weinert, 1989), others did not (see Perleth, 1994). Nevertheless the approach of Campione and Brown (1978) seems convincing for various reasons. First, the authors succeeded in establishing a link between giftedness and expertise research by highlighting the importance of the knowledge base. Reading or calculating in young age can be explained very well by the model. Second, they differentiate between inhered aspects of intelligence which are not malleable and parameters that can be changed by practice. Finally, the approach can be considered as an attempt to get a clearer picture on how exactly a gifted child becomes an expert.

Expertise Research

In the 1990s a novel approach, expertise research, disturbed the traditional giftedness research by partly radically denying the importance of intelligence and talent for performance development. Trying to comprise various definitions, Gruber (1994) defines an expert as an individual who permanently excels in a given area. Beyond question the most radical position in expertise research in the last years is adopted by Ericsson and colleagues. On the basis of the controversy between Ericsson and Charness (1994; 1995) and Gardner (1995) we want to elaborate the positions of the expertise approach.

It is important to note that Ericsson and Charness (1994) explicitly focus on individuals with high performance or extraordinary expertise level. On the basis of their literature review the authors conclude that there is no evidence that high performance or expertise in various areas like chess, sports, and music or manual tasks such as typing is determined by talent in the sense of innate dispositions (see also Ericsson, Nandagopal, & Roring, 2005). In contrast, it is important to recognize that even basic determinants of cognitive functioning like extent and speed of perception, motoric parameters, reaction times and also physical characteristics like the size of heart and lung, the strength of bones, or flexibility depend on practice. Therefore, giftedness characteristics (in the traditional psychometric sense) have no predictive validity for high performance; this is especially true for the relevant psychometric tests that measure giftedness. According to the authors these measures for (innate) abilities pose significant methodological problems because they inextricably mix up cognitive dispositions and acquired knowledge, they conclude that these tests measure mainly acquired knowledge. Elaborating on these statements Ericsson and Charness (1994) say that with the usual tests performance can be predicted at best in a restricted area (including school performance) and over a short period of time, but in either case before achieving a high expertise level. However, the reasoning of Ericsson and colleagues falls back on a rather simple and very traditional understanding of intelligence when equating talent or intelligence with general intelligence.

To strengthen the case against the effects of disposition on performance and expertise development, Ericsson and colleagues argue with the exceptional performances of young experts or child prodigies. These children excel in very early life in areas like chess or music. Following Feldman (1986), Ericsson and Charness (1994) say that these children pass through the same developmental learning stages like other children but the relevant stages faster and in younger age. In contrast it could be shown that the performance level of precocious children is directly related to intensive promotion from teachers and parents. Most adults who show high expertise were not labeled precocious as children but engaged early and intensely in their later area of expertise.

The experience gained during the learning process is according to Ericsson et al. the fundamental motivation for the development of expertise. However, not every experience leads to expertise but the learning has to be active and purposeful. Ericsson, Krampe and Tesch-Römer (1993) refer to this learning process as "deliberate practice." Deliberate practice is characterized by the following criteria (see Perleth, 1997):

- *Specialization in one single area*: Examples show that knowledge in different areas grows rapidly and that there are hardly people who gain expertise in more than one domain. Therefore, Ericsson and Charness (1994) conclude that expertise refers to the specialization in one single area, an expert has to dedicate all of his time to his area of expertise.

- *Early outset and dedication of much time over many years*: The achievement of expertise on an international level needs at least 10 years of intensive engagement in an activity (10-year rule). Therefore, it is useful to engage as early as possible in an area of expertise. Though initial progress is much bigger when the engagement in practice activities starts in later age, the late beginners can hardly catch up with the early beginners because the achievement curve runs asymptotically. As Ericsson and Charness (1994) outline differences in expert performance can be explained by differences in practice extension and starting point of engagement in an activity. But it is important to notice that the correlation between practice time and performance improvement decreases with increasing performance level.
- *Deliberate practice*: Various studies show that experience cannot be accumulated in any manner but it is crucial that competent, experienced, and motivated teachers facilitate the learning process. These teachers have not only to support and guide the learners and to focus the activity on important aspects but also to give constant feedback on the performance. Deliberate practice is usually not motivating in itself but has to be considered as hard work. This work must be distinguished from ordinary work and other activities because of the following reasons:
  - It is targeted on performance improvement by overcoming present obstacles and performance plateaus.
  - Contrary to ordinary work it does not lead to immediate social or monetary rewards, the future expert must be able to delay the fulfillment of needs.
  - Most people use deliberate practice only until a certain level of performance is achieved and are not interested in further enhancement.
- *Stages toward expert performance*: According to Bloom (1985) individuals have to go through three stages to achieve expert performance (see Fig. 14.2). If we take as an example how individuals attain high expertise status in the field of music, the first stage in childhood is characterized by engagement in the domain through play. If parents regard their child as talented, they might engage a teacher and the child will engage in deliberate practice, at first on a limited scale. At this stage it is important that the parents support and motivate the child and take care that it practices regularly. The second stage is reached when after some years the young expert can increase performance only by notably intensifying efforts and engaging full time in the area of expertise. At that time the hobby turns into profession. The amount of deliberate practice is extended again and the young expert

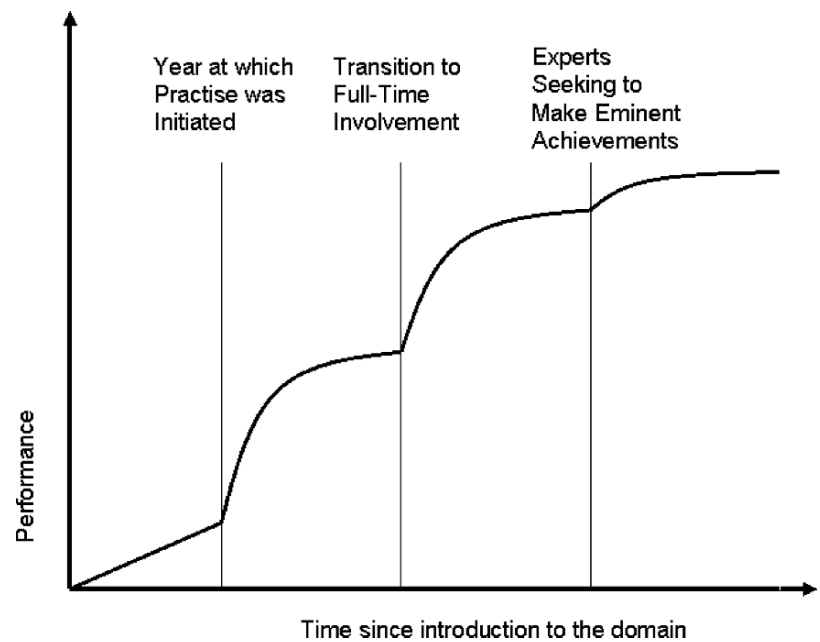

Fig. 14.2 Stages of performance development (adapted from Bloom, 1985)

will look for teachers with outstanding abilities. Finally the individual becomes an expert and professional in his or her domain. The final state which according to Bloom (1985) is not taken by every expert is characterized by the effort to advance ones performance further and contribute eminent achievements to the domain. That in turn will ideally contribute to the advancement of the area of expertise as well.

Only a few who started a promising career will finally reach the expert level or deliver outstanding contributions to their domain. Most people will have to be content with the performance level at the second stage. For this reason parents and educators are very interested to obtain indicators that allow predicting the performance of the future expert. As Ericsson and Charness (1994) highlight (see above), talent does not play a role for this prediction, the only important prognostic variables are motivation and interest.

Gardner (1995) agrees in his comment on Ericsson and Charness's (1994) article on the structure and acquisition of expert performance that deliberate practice is essential for expert performance. He argues further that the constellation of motivation, interest, and temperament that Ericsson and Charness (1994) introduce as main determinant for expertise development (together with cognitive characteristics) can be interpreted as talent as well. But Gardner (1995) disputes their suggestion that the development of expertise in a given domain does not fundamentally differ between experts and people who do not reach expert status. He says that in order to explain their "skilled memory" approach expertise research should be able to show that children can become experts in randomly assigned areas, something that has not been proven yet. Finally Gardner (1995) critically comments that it cannot be the aim of research to explain solely extremely high performances while losing sight of "normal" high performance. To focus more on the latter could even have more practical implications for the promotion of talents than the study of extreme populations.

Schneider (1992) acknowledges that various studies in the context of expertise research support the importance of deliberate practice for expert development. But this does not allow concluding that basal intellectual abilities are not important for performance development. Schneider (1992; 1993) summarizes in his threshold model his view on the relation of talent, practice, and performance:

- High basal abilities are neither sufficient nor necessary for expertise performance development.
- If the basal abilities exceed a certain threshold or limit than noncognitive learning, prerequisites such as commitment, perseverance, concentration, and success orientation as well as factors of the family and school environment will determine what performance level will be achieved.
- This threshold must not be in the realm of high ability (normally more than two standard deviations above average) but can sometimes be at a surprisingly low level.
- The relevance of basal abilities seems to increase with growing complexity of the domain.

Gruber (1994) agrees that differences in expert performance cannot be explained without factoring in abilities based on dispositions. He proves this with the noticeable performance differences some years ago between the best chess players in the world, Kasparov and Karpow, and the other international grand masters. It is not likely that these performance differences are due to practice differences. And even with intensive practice not every person succeeds in becoming a chess expert.

Interest and Motivational Characteristics

As research shows certain motivational and personality characteristics of the child can be beneficial for giftedness development. These are for instance curiosity, special interests, certain attribution styles, achievement, and intrinsic motivation (see Howe, 1990; Johnson & Beer, 1992; Rost, 1993). In children, even in young age, curiosity and interests manifest itself in exploratory behavior (as described in the paragraph on expertise). During the cognitive development exploratory behavior becomes more and more elaborated.

The assessment of motivational variables in young children is difficult because interest and motivation develop little by little and consolidate not until primary school age. Besides it is difficult to find tests that reliably measure these traits in young infants (see also Perleth et al., 2000). Consequently more results are available for children in primary school age. Rost (1993)

found in his longitudinal study on gifted children (Marburg Giftedness Project) that gifted children positively differ from children with average abilities with regard to achievement motivation, causal attribution, and dealing with failure (see also Perleth et al., 2000). At the end of primary school gifted children have been found to show higher intrinsic motivation (Gottfried & Gottfried, 1996). Compared to high-achieving peers gifted middle school students had higher general self-concept and attributed (social) success more on ability and effort (Bain & Bell, 2004). Pruisken (2005) reanalyzed the data of the Marburg Giftedness Project with regard to interest differences between gifted and primary school children with intellectual abilities in the average range (control group). While she found massive gender differences (in both groups), there existed nearly no differences between gifted and control students. The only exception of the eight interest domains explored (e.g., music, construction, biology, or arts) was the greater interest of gifted children in mathematics and languages/reading, however, the effect sizes of these differences were rather small. Furthermore the gifted children possessed significantly more books than their peers from the control group (irrespective of the socio-economic status of their parents) and spent more time on reading.

The superior exploratory skills and curiosity of the child are favorable in dealing with complex information in unstructured play situations, in the long run they are advantageous for the development of cognitive abilities and the building of a complex knowledge base, better problem solving and meta-cognition (see the model of Campione and Brown above or Perleth et al., 2000). Since curiosity and exploratory behavior are important for giftedness development the social environment of the child (in the first place parents and teachers) should seek to satisfy the child's curiosity and make room for exploratory behavior. Research shows that meta-cognitive strategies such as dealing with obstacles during problem solving or the modification of strategies are acquired during the interaction with significant others. Therefore, it is crucial in which manner parents and educators react on the child's curiosity. Especially helpful for the acquirement of meta-cognitive strategies are verbal and nonverbal cues from interaction partners. If these cues are appropriate for the child and comply with the child's abilities, the child can adopt these strategies. Mothers of gifted children have been found to promote the development of meta-cognitive strategies by pointing out to the child important relations between problem aspects ("A piece of the puzzle is missing here, that has at least two tabs"). Mothers of less-gifted children in contrast seem to give more often direct advice in order to solve a problem ("This piece fits in here").

Family Environment

Giftedness development strongly depends on the good interaction of individual characteristics and environmental factors. Families provide learning experiences and opportunities that are crucial in order to transform gifts and talents into achievement. When the child gets older, not only parents but also teachers, other mentors, or gifted peers serve as role models (see Perleth et al., 2000).

Certain characteristics can be seen as typical for families with gifted children:

- *Socio-economic background*: Children identified as gifted often stem from wealthy and intellectual middle and upper class families (Birx, 1988; Howe, 1990). These families provide the children with the monetary as well as intellectual resources for giftedness development.
- *Social family variables*: Howe (1990) found that successful scientists (e.g., Nobel Prize winners) came from intact families and reported a happy childhood. Other research indicates that gifted children were planned children and pregnancy and birth went without difficulties (Berger, 1984).
- *Educational style and family climate*: These variables are inextricably tied to the before mentioned socio-economic and family variables. An educational style that favors motivation development has to balance freedom and pressure. A medium level of control and discipline has to be compared with high positive emotional regard (Perleth et al., 2000; for contrary findings see Rost, 1993). Dwairy (2004) compared the family climate in families of gifted and adolescents not identified as gifted (control group) and found that parents of gifted adolescents were more authoritative and less authoritarian. Furthermore, an authoritative parental style was positively correlated with the mental health of the gifted and the students of the control group.

An authoritarian style on the contrary was only for gifted students negatively correlated with mental health. In contrast, Schilling, Sparfeldt and Rost (2006) did not find differences in family climate, parental style, or intellectual–cultural orientation between families of gifted German adolescents and the respective control group of students in the middle range of the distribution (up to one standard deviation below and over the mean).

School Environment

As Tannenbaum (1992) pointed out, many children who showed indicators of giftedness in early years lose their head start compared to their peers until the end of primary and the beginning of secondary school (see also Hotulainen & Schofield, 2003). One reason for this development might be found in the learning environment provided by family and school.

The first important tasks of schools and their predecessors like kindergarten and play school is to identify talents. They accomplish what was described above as reactive interaction between dispositions and environment, which means the environment (in this case the teachers) reacts on the talents of the child. This is especially important for children with parents who cannot detect (for various reasons) the giftedness of their child. Furthermore, teachers and educators can contribute to the promotion and development of giftedness by mentoring gifted children, helping them to find new fields of interest, or enabling them to perform activities in their favorite domain or field of interest. Often this exceeds the possibilities the child has at home. Educational institutions, especially such with special gifted programs, can also provide opportunities to meet like-minded people and to grow into a community of excellence.

However, a barrier with regard to an adequate promotion of giftedness at school is the lack of individualization. The educational schedule is not specific enough for children's individual talents and interests. Teachers have difficulties in managing the variety of talents and learning conditions of the children and orient toward the average which leads to inadequate performance requests for both students with good and poor performance. Consequences can be motivational problems and off-task behavior of good students and self-concept problems, demotivation, and dropout of students with poor performance. In the Progress in International Reading Literacy Study (PIRLS), it was found that German elementary school teachers tend to offer high-performing students more of the same instead of offering them tasks that match the students' competence level and interests (Bos et al., 2003). Another example for sometimes quite subtle mechanisms is teachers' attribution of students' performance. Research and observations in the classroom show (e.g., Ziegler, 1999) that teachers attribute good performance of girls in mathematics or science on effort and the good performance of boys on ability. Conversely, poor performance of girls in this area is rather attributed to a lack of ability and that of boys on a lack of effort.

Gender Differences

Generally boys slightly outnumber girls in the samples of the most studies on giftedness, regardless of the method of sampling (see Benbow, Lubinski, Shea, & Eftekhari-Sanjani, 2000; Perleth & Sierwald, 2001; Rost, 2000; Swiatek & Lupkowski-Shoplik, 2000). In the Marburg Giftedness Project an unselected sample of more than 7000 primary school children was screened with respect to intelligence (Rost, 1993, 2000), here the final sample consisted of 56% boys and 43% girls. Another large German longitudinal study, the Munich High Ability Study, found at least among the very high intellectual gifted more boys than girls (Perleth & Sierwald, 2001). Furthermore, girls were more often selected as gifted because of their high music or social abilities. In the United States in the 1970s the Study of Mathematically Precocious Youth (SMPY) was started, a longitudinal study running until today (for an overview, see Lubinski & Benbow, 2006). As part of a talent search students took the SAT (mathematics and verbal). While no gender differences were found on the verbal test there appeared stable gender differences in mathematical reasoning with a ratio of 12.9 to 1 in the highest levels (Benbow et al., 2000).

This research already gives the impression that gifts and talents of boys and girls lie in different areas. Boys are found to be more spatially or mathematically gifted whereas girls' talents are found more often

in languages (see also Brody, Barnett, & Mills, 1994; Eccles & Harold, 1992; Swiatek, Lupkowski-Shoplik, & O'Donoghue, 2000). Gender differences are even more pronounced when it comes to interests and activities (see Benbow et al., 2000; Pruisken, 2005; Rost & Hanses, 1992; Schober, Reimann & Wagner, 2004). These differences always go in a traditional direction with boys being more interested in science and mathematics and girls preferring art, humanities, and languages. In this regard gifted children do not differ from their peers with average abilities.

The picture is more mixed however when it comes to gender differences in self-concept and motivational variables among gifted children. Generally differences in these variables tend to be not so large and pronounced like the differences in interests and preferences mentioned above (Finsterwald & Ziegler, 2002; Perleth & Sierwald, 2001; Rost & Hanses, 2000; Schütz, 2004). Finsterwald and Ziegler (2002) conducted a meta-analysis on gender differences in variables such as motivation, attribution, locus of control, self-concept, and anxiety. In neither of these variables a clear effect of gender could be found. More recent research shows the same picture. So did Rost and Hanses (2000) for instance report an equally high self-concept of gifted boys and girls while other research reports lower self-concept of girls as well as more effort for achievement and less-optimistic control beliefs (Dresel & Haugwitz, 2005; Hong & Aqui, 2004). Schober, Reimann and Wagner (2004) compared the self-concepts of adolescent boys and girls. While they did not find differences in actual test performance, gender differences appeared in various self-concept variables. Girls had a lower mathematical self-concept, scored higher on helplessness, and girl's parents had lower achievement expectations. While these students attended "normal" classes a second research sample consisted of boys and girls taking part in a special gifted school program. Here as well gender differences were found. Again, girls had a lower mathematical self-concept, besides and different to the first study they showed lower aspiration level and a lower motivation to succeed.

Even if gender differences in self-concept and motivational variables are found they do not always go in the same direction. The research reported so far indicated better outcomes for boys, however, some exceptions are found. Generally girls have better grades at school, gifted or not (Reis, 2002). Schober et al. (2004) found gifted girls who took part in a special gifted school program to have a higher general academic self-concept, a more positive attitude toward school, and a higher intrinsic motivation than gifted boys. Hotulainen and Schofield (2003) tested Finnish children at pre-school age and after 10 years of school. The children identified as gifted performed better at school then the children with average abilities, however, this effect was more pronounced for girls. The authors conclude that during school time gifted boys succeeded much less than girls in realizing their potential.

If gender differences exist (as with different areas of giftedness or different interests and preferences of boys and girls) research remains divided however on the question to what extent these differences are inhered. Some scientists (e.g., the American psychologist Sandra Scarr) regard hormonal influences as the main reason for gender differences in science and mathematics. Others (like the Munich research group of Heller and colleagues) see an important part of gender differences rooted in socializational and educational influences from parents and educators. Because boys are expected to be more mathematical than girls they adopt this view and develop in consequence more science-related interests. From adolescence on this is reflected in better performance in science both in school and tests (see for instance Nagy, Trautwein, Baumert, Köller, & Garrett, 2006). In primary school boys and girls perform equally well in mathematics but even then girls underestimate their mathematic abilities (Stipek & Gralinski, 1991; Tiedemann & Faber, 1995). In addition, typical games like building with Lego bricks and also climbing on trees foster the development of mathematical and spatial skills. Because of their higher activation level boys rather than girls tend to turn to such male activities (see above). This, again, shows the complex interaction of environment and dispositions for giftedness development. The superior verbal skills of girls that are found sometimes can be attributed to their stronger preoccupation with games such as role play, where manifold verbal skills are needed. This ranges from verbally establishing and settling the rules of the game to the communication during the game itself. Typical topics of these role plays are "playing house," "marriage," or reenacting stories and fairy tales.

It might be useful to have a closer look on parents and teachers expectations for boys and girls because this is the point where change can begin. While gender

differences in attributes of the children are rather small (just like gender differences in other domains, usually gender differences are smaller than differences between individuals), popular beliefs about gender differences in giftedness are quite persistent and can through parental expectations influence children's self-perceptions and performance (see Reis, 2002). This is reflected among others in the smaller number of girls who are recommended for identification measures like tests. Parents as well as teachers have such stereotyped expectations (see Busse & Dahme, 1986; Endepohls-Ulpe, 2004; Perleth & Stave, 2006; Perleth, Sühlfleisch-Thurau, & Joswig, 2004).

One reason for the strong association of giftedness with boys might be gender stereotypes and gender role expectations. Gender stereotypes are beliefs about the attributes of men and women (Ashmore & Del Boca, 1979). Following Prentice and Carranza (2002) they have a prescriptive (how men and women should be) and a descriptive (what characteristics men and women typically have) aspect. Feminine attributes such as being affectionate, sensitive, or kind are considered more typical of women; attributes such as being aggressive, strong, or logical are considered more typical of men (see Williams, Satterwhite, & Best, 1999). Even if the roles of men and women have changed in the last decades gender stereotypes have remained relatively stable (see Prentice & Carranza, 2004). From the perspective of social role theory (Eagly, Wood, & Diekman, 2000) stereotype content is rooted in the division of labor. Men's concentration in leadership and other high-power roles leads to the assumption that men have agentic characteristics (e.g., self-assertion, dominance); women's concentration in subordinate and caretaking roles leads to the assumption that they have communal characteristics (e.g., kind, supportive).

In a 5-year longitudinal study Trautner and colleagues (Trautner, 1992; Trautner et al., 2005) examined the development of children's gender stereotypes. Already at the age of 4 years children knew which behavior and characteristics are typical for men and women, this knowledge was especially pronounced for sex-typed behavior. Between 4 and 8 years this knowledge was characterized by a rigid attribution of traits; feminine traits and behaviors were considered to be typical for women, but not for men and masculine traits were supposed to be typical for men but not women. From the age of 6 years on children's stereotypes became more and more flexible, that is, the children knew that men and women can posses both masculine and feminine characteristics. The phase of rigidity concerning gender stereotypes reached its peak around the age of 6 years, from then on flexibility grew continuously.

As Geis (1993) pointed out, gender stereotypes can act as self-fulfilling prophecies. Based on their stereotypes people develop expectations (in this case about the intellectual abilities, talents, and interests of boys and girls) and behave according to these expectations. Children then might in turn adapt their self-perceptions or behavior accordingly. This can for instance result in different toy and activity preferences between boys and girls (see Maccoby, 1998; Trautner, 1995) (of course parents' expectations is just one factor to explain gender differences in play behavior). As the model of Trautner (1995) on the development of gender stereotypes pointed out, children pass through a developmental stage of rigid gender stereotypes. Especially during this stage children might be quite open-minded about and easily influenced by the gendered expectation of significant others.

Conclusions

In the beginning we gave important demands for a model that wants to describe giftedness development which were taken up and elaborated in the Munich Dynamic Ability-Achievement Model. We then described factors that influence giftedness development: innate characteristics, personality factors, and aspects of the environment. From this we can draw useful conclusion about an optimal promotion of gifted children.

Domain specificity of talent has to be taken into account. Even if there can be identified central personal characteristics as memory or speed of information processing which underlie different forms of giftedness, there is no such thing as "The gifted" but rather different areas of giftedness must be differentiated. This means that the environment should offer opportunities for children to find out where their talents lie. Furthermore, giftedness development must be seen as a dynamic interaction process between innate dispositions, personality factors (such as motivation), and characteristics of the learning environment.

It is especially expertise research that stresses the importance of competencies and personality charac-

teristics like task commitment, motivation, and self-control. Because long phases of deliberate practice are necessary to excel in an area such motivational competencies have to be fostered. Parents and educators have to be aware that for excellent achievement deliberate practice must be initiated and maintained over long periods of time. Finally, it is not just talent and practice but also rich domain-specific knowledge which is acquired in long learning processes: here the necessary learning opportunities have to be provided to acquire this knowledge. Innate characteristics must be regarded as important, however, when promoting children it has to be kept in mind that there are various kinds of interaction possible between innate characteristics and environment.

To better understand giftedness development in children appropriate methods of analyzing longitudinal data should be applied. It would be very fruitful to follow the suggestions of Singer and Willett (2003) as described in the framework of the multilevel model for change. Instead of analyzing giftedness development at group level grow curve modeling can be used to examine individual developmental trajectories of gifted children, for instance with respect to cognitive functioning or personality factors such as mentioned above. In the next step one might identify distinctive groups of individual trajectories and find out whether interindividual variation is systematically related to context variables.

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