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Statement

Socialisation in early childhood

Biological, psychological, linguistic, sociological and economic perspectives

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Biological, psychological, linguistic, sociological and economic perspectives

Foreword

Creating conditions that best foster the development of each individual's potential to the fullest is a fundamental socio-political objective. Not least because this approach ensures that a society as a whole is best able to achieve its own potential.

Debating the details of these conditions is a matter of societal, political, as well as scientific debates. One recurrent topic of public discussions has been the role of genetic influences and the significance of the environment in early stages of human development. Another issue moving to the center of attention of German politics and society in recent years has been the question of childcare and early education.

This position statement, issued by the German National Academy of Sciences Leopoldina, the Union of German Academies of Sciences and Humanities, and the National Academy of Science and Engineering (acatech), brings together extensive research on early childhood from multiple disciplines, condensing it into an intelligible form and highlighting the conclusions that may be drawn from it.

Taking this body of interdisciplinary research as a starting-point, this position statement outlines socialisation in early childhood and confirms the immense significance of this period and the developments completed within it for later life, while vividly illustrating interactions between genetic predispositions and environmental experience.

We wish to express our heartfelt thanks to the authors, who have spent many hours in conclave working on this paper over the last two-and-a-half years. It is the academies' hope that this statement can provide a well-founded summary of current knowledge on socialisation in early childhood which will be of use to both social and political actors as well as any other interested party.

Halle (Saale) and Berlin, July 2014

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Preamble

Within a society, economic success and social cohesion depend decisively on the degree to which individuals can develop their cognitive, emotional and motivational potential. The conditions under which children grow up are fundamental to this development. In each case, the environment defines the extent to which hereditary predispositions are expressed, and whether potential is tapped and fostered or is in fact hindered in its development.

Determining how and when specific personal characteristics are formed is of material importance both for each individual and society as a whole. Not least because the resources slumbering in an individual can only become available to the community if they are developed in full. Accordingly, making use of the potential available in a society requires the successful fostering of the intellectual and emotional abilities of each and every child in accordance with its developmental needs.

Over the last 50 years, research within biology, psychology, sociology and economics has shown that the "groundwork" for an individual's entire later life is laid in particular during socialisation in early childhood. In the first years of life, certain time windows exist in which certain environmental factors must exert their influence for functions to develop adequately. This applies in equal measure to fundamental perceptual functioning (such as vision and hearing), cognitive abilities (e.g. speech and action control), and to socio-emotional behavioural characteristics (e.g. coping with stressful situations or interacting with other people).

Interpretations of the ways in which cognitive, emotional and social abilities develop have direct consequences for policy-making. One notable conclusion derived from research findings is that support provided in preschool years and in the first years of schooling – such as fostering language skills or self-regulation competencies – offers the best initial environment for successful later development and integration.

The importance of targeted support activities is all the more important the lower a child's socioeconomic status is. Even under advantageous socioeconomic conditions, a child's innate talents must be encouraged and fostered by an adequate environment. Interventions are most effective when they are offered at an optimum stage in a child's development. While later corrective measures are not ineffective, they are many times more complex, more effortful for the individual and more costly for society. In general, a person reaches his/her full potential in terms of intellectual and social capacity only if favourable environments for learning and experience are available throughout development– which starts before birth and continues until death. The more successful development was in early phases, the more substantial the potential for subsequent lifelong learning and thus, ultimately, for "successful ageing".

To date, public debate has failed to take in these fundamental insights – a fact revealed to no small degree by the at times heated discussions concerning the causes for individual differences, poor integration or educational inequality. Many of the arguments they advance are scientifically indefensible. By giving more weight to scientifically established facts, such debates could be conducted with far greater objectivity, and expedient policies presumably implemented more rapidly and more profitably.

With the above in mind, the German National Academy of Sciences Leopoldina, the Union of German Academies of Sciences and Humanities and the National Academy of Science and Engineering (acatech) jointly resolved to develop a position statement that would, by summarising the current state of scientific knowledge, offer a basis for deriving recommendations to guide political decision-making. Such decisions affect the specifics of implementing measures within intervention programmes and the potential funding of projects targeting shortcomings in research.

As a first step, an interdisciplinary working group was assembled from recognised experts in the fields of psychology, linguistics, medicine, biology, educational science, sociology and economics. The facts were compiled by members of this working group in multiple symposia and evaluated in comprehensive discussion sessions. The result was a jointly-authored position statement written in German.

Prior to publication, the statement was presented for review to an independent panel of experts drawn from a range of academic disciplines. The panel's recommendations were then incorporated into the version published. The present version is the translation of the original text. Note that the terminology refers to the German educational system unless stated otherwise.

We would like to thank the members of the working group for our fruitful collaboration, the members of the expert panel for their eminently helpful comments and suggestions, as well as PD Dr Stefan Artmann, Dr Daniel Schad, Dr Stefanie Westermann and Dr Constanze Breuer for their constructive support during the project. Many thanks go to Dr Julia Delius who carefully copyedited the English translation of the text.

Hamburg, July 2014 Frank Rösler, Brigitte Röder

Contents

Summary

Neurobiology, psychology, linguistics, sociology and economics are consistent in showing how early childhood experiences have a long-term influence on a person's later developmental trajectory. The effects of these early experiences – both positive and negative – can be traced into adult life. There are two reasons for this:

(1) Hereditary predispositions and environmental influences always work in tandem to determine the structure and workings of the nervous system – and thus both behaviour and experience. Neither the structures of the nervous system nor behavioural traits develop automatically: instead, "compatible" environmental influences are required for predispositions to manifest themselves. The reverse is also true: favourable environments can positively influence development only in cases where susceptible hereditary predispositions are available. This close interaction between genetic makeup and environment applies throughout life, yet especially in early childhood.

(2) In early childhood, critical and sensitive periods exist, in which the individual must make certain environmental experiences. Only then can key structures within the nervous system and associated behavioural patterns develop to their full capacity. If these critical phases are not fulfilled by the necessary environmental influences, neuronal development remains incomplete and certain types of behaviour can be acquired only to a limited extent – or not at all. Such deficits are irreversible. They accompany a person throughout life, and even when specifically targeted by training in later life can rarely be entirely compensated for and are sometimes intractable.

Seen from the perspective of lifelong development, funding early childhood education is thus a particularly advisable strategy. While this applies to the development of all children, it is particularly relevant for children who are born with sensory impairments or raised in disadvantaged environments (precarious familial circumstances, insufficient childcare, poorly educated parents, etc.). Such radically unfavourable environmental conditions must be recognised early on, since compensatory programmes must act at an early stage and thus before the end of sensitive phases.

Investment in high-quality educational and childcare programmes *in early childhood* is especially profitable both for the individual and for society at large, since it ensures favourable conditions for further developmental steps. Such funding should thus be secured and expanded over the long term.

While recent research findings attach particular importance to early childhood educational programmes, one should not overlook the need for later educational programmes catering to adolescents and young adults. Since subsequent experiences always build on earlier ones, however, the effectiveness of later investments will depend on the favourable conditions achieved by earlier educational programmes.

Since genetic makeup and environmental factors are inextricably in-

tertwined, genetic dispositions must be actively addressed and fostered in all children. This does not apply solely to children from less favourable environments: children from favourable backgrounds also need encouragement and active support appropriate to their predispositions. Only in this way can the intellectual and social resources available within a society develop to their fullest potential.

Content, aims and scope of this position statement

This paper opens by presenting some basic psychological and neurobiological insights into maturational and experience-dependent changes of the brain (sections 1 and 2), thereby explaining the close interaction between hereditary predispositions and experiential development processes. These insights lay the groundwork for the treatment of specific socialisation and developmental phenomena in the following sections, namely in the domains of *language* (section 3), *basic cognitive abilities* (section 4) and *emotional and motivational competencies* (section 5). Section 6 discusses the *educational consequences – in economic and sociological terms* – that may result from differing socialisation processes and interventions with varying degrees of success. Section 7 summarises *recommendations and current gaps in research*. Using a tabular form organised by section, Section 8 then *contrasts myths with facts and offers conclusions* on the topic of socialisation.

The position statement draws on empirically derived results from which *recommendations* can be derived for political decision-makers. A further aim is to communicate a set of current, empirically derived findings to the wider public in order to provide information about the basic principles of normal development and socialisation, and to contribute to reducing misconceptions and prejudice. The position paper does not discuss medical and clinical investigations into developmental and psychiatric disorders that occur in childhood and adolescence, and which require targeted strategies of intervention.

The statement does not offer parents or educators working in the field any direct, practical instructions for tackling specific scenarios. The approach chosen to implement the recommendations – in didactic guidelines, curricula or proposed legislation – must be elaborated by the relevant decision-makers in close consultation with the persons and organisations affected, while taking account of funding, human resources and planning issues.

This position paper is based on a set of scientifically sound findings, i.e. results that have been reproduced on multiple occasions and which currently form part of the body of knowledge on socialisation research in the neurosciences, psychology, linguistics, sociology and economics. Expressly excluded from this paper are findings that have not found their way into peer-reviewed journals and which are thus typically considered to lack sufficient evidence for their claims.

Recommendations

Language competence

The development of language in early childhood follows a biologically predetermined sequence of sensitive periods, in which certain kinds of linguistic experience must be acquired. Only if this experience is gained, can competence be achieved at the level of a native speaker. Educational programmes can and should be used to support the developmental process – which can be guided but not undone.

Where children grow up in families in which German is not spoken as a native language, access to German spoken by native speakers should be provided as early as possible, i.e. no later than preschool. Otherwise full linguistic competence in the German language will most likely not be achieved.

To allay their fears, parents whose native language is different from that spoken in the society where they live should be made aware that early contact with a second language will not hinder a child's development of its parents' language of origin. Early bilingual competence does not lead to impairments of linguistic or cognitive capacities. If a child is likely to be making its home in a society for the foreseeable future where their mother tongue is not spoken, acquisition of "two first languages" should begin as early as possible, i.e. before the child's fourth birthday.

Even children from monolingual households should begin learning a second language as early as possible, so as to enable the acquisition of a very high degree of competence. Ideally, the acquisition of a second language should begin at preschool age and no later than primary school where possible, since children's language learning capabilities start to worsen considerably at the age of 8–10 years. The successful early acquisition of a second language requires an adequate investment of time, however, coupled with the availability of preschool educators with high competencies for the language to be learned.

Techniques to determine levels of linguistic competence must be applied early on – possibly during routine postnatal visits to the paediatrician or paediatric audiologist. Initially, the focus must be on the phonological aspects of the language. Only in this way can deficiencies affecting normal language development be identified early on and compensated for by taking appropriate action.

Basic cognitive abilities

The basic cognitive abilities collectively referred to as "general intelligence" – i.e. language proficiency, problem-solving abilities and memory capacity – develop by means of interaction between genetic predispositions and environmentally-dependent learning processes. The level of intelligence a person can achieve is not written in stone at birth but is also dependent on the environment, which crucially influences the elaboration of genetic predispositions. Positive environments boost – and negative ones hinder – the development of intelligence. Accordingly, genetic predispositions mark out the boundaries within which basic cognitive abilities can develop.

Children should be challenged and supported so that they can attain their maximum possible level of cognitive functioning. Challenges and support signifies that programmes should demand neither too little nor too much of the respective child's predispositions.

Properly utilising the intelligence inherent in children and adolescents drawn from across the population depends not only on satisfying basic physical needs in early childhood, however. Steps must be taken to ensure that children are raised in an emotionally supportive, cognitively stimulating environment, and acquire a society's dominant language and cultural techniques as a result of natural interactions with other children and adults.

Cognitive development should not be taken for granted. It requires targeted stimulation and continual gains in knowledge that permit the solving of increasingly sophisticated cognitive problems. Proficiencies and items of knowledge gained later always build on what has been learned before. The stronger the foundation, the more rapid and effective the learning processes it can support. The knowledge and cognitive bases to the domains of written language, mathematics and the natural sciences learned before a child's tenth birthday are therefore of particular importance for his/her educational choices and later development at school.

Targeted support programmes are especially likely to succeed if they are able to reach children from disadvantaged social backgrounds. Yet fostering the intellectual potential in certain groups – i.e. improving their average performance – does not imply that all children and adults can achieve an identical level of competence. Even with beneficial training and schooling programmes in place, inter-individual differences in cognitive functioning will still tend to persist.

As a consequence, a society should not act solely to promote the development of intelligence, but should also provide career choices that can be taken by individuals with varying levels of cognitive functioning.

Social, emotional and motivational competencies

The development of social/emotional and motivational/volitional skills is crucially dependent on the formation of a secure attachment with primary caregivers in early childhood. These are usually the parents themselves: their sensitivity and warmth creates positive, culturally appropriate conditions for socialisation. Secure attachment is essential for the child to form a positive and realistic self-concept, and to develop proficiency in self-regulation and the ability to cope with stress.

Such self-regulation skills express themselves in emotion regulation and both behavioural and inhibitory control, i.e. they enable the individual to make goal-oriented decisions between conflicting behavioural choices and inhibit impulsive behavioural tendencies, e.g. when choosing to delay gratification. Empirical studies show that the degree of proficiency in self-regulation observed in childhood reliably predicts the course of later development in adolescence and adulthood in terms of academic and career success, social adjustment, physical and mental health, socioeconomic status and prosperity.

Groups at high risk of developing inadequate self-regulation skills include children without a reliable primary caregiver, children of overburdened parents, children of impoverished and poorly-educated parents, and children who experience domestic violence or a lack of parental care and support, or who grow up in socially-disadvantaged neighbourhoods. For these risk groups, particular commitment must be shown – in the shape of active support programmes to encourage the development of self-regulatory competencies.

Longitudinal studies have shown that the experiences of early childhood have far-reaching implications for the later development of social, emotional and motivational competencies. Appropriate interventions aimed at fostering executive functions and skills in self-regulation should therefore take place as early as possible – i.e. for those attending preschool – and not solely for disadvantaged children. Institutional programmes should be used to actively promote support for individual socialisation. Awareness should be raised among both parents and teachers of the need to identify and promote self-regulation and, equally, to recognise and foster its corollary social, emotional and motivational competencies.

Consequences for educational policy

Attendance at a preschool educational facility supports a child's development in terms of both socioemotional and cognitive/performance-related aspects. Longer-term positive effects will depend primarily on teaching being of a high quality.

The educational quality of day care facilities is defined above all by the process quality, i.e. the direct support processes available within the facilities themselves. Structural quality characteristics influence these processes, and these latter processes can be changed and improved by policy frameworks. In this context, key items to address will include making group sizes smaller, reducing the number of children cared for by each preschool educator, and improving basic/further training and continuing professional development for the facility's teaching staff. Note that the criteria in each case will vary by the children's age group.

An active support programme at the preschool stage, e.g. in day care, does not necessarily imply formal schooling. Actively supporting children's cognitive and emotional socialisation creates ideal educational opportunities for them at an early stage. This does not imply that these children are being moulded to serve economical goals but, on the contrary, that individual chances can be seized. A common prejudice against nursery teaching often stems from misconceptions about playful and situated learning. Education in early childhood has little in common with conventional learning in the classroom. For example, encouraging multilingualism in nurseries does not mean that preschool children should start being given language classes. The presence of native speakers in a day care facility is quite sufficient to ensure children acquire a different language by (playful) interaction with one another.

The efficiency of educational investments can be increased by targeting their deployment, as long as segregatory effects can be avoided. Children from disadvantaged families in particular can benefit from education and care that is of a high quality. Accordingly, the German system of day care must also tackle the issue of providing enhanced support that is focused on specific target groups and/or urban districts.

Stronger involvement of families in educational/support programmes outside the home can boost the efficiency of these interventions. Evidence for high efficiency is demonstrable above all for educational programmes where parents are firmly "on board". One option for Germany might be the targeted expansion of day-care facilities into "Family Centres" or "Parent & Child Centres".

Educational choices are determined not only by differences in ability and performance due to a child's social background, but also by class-specific decision-making behaviour resulting from different values being placed on the costs and benefits of educational options. These factors need to be addressed by policy interventions. On the one hand, day-care facilities, full-time schools etc. should act to balance out a lack of potential for parental caregiving and support. For migrant populations, such interventions could make a major contribution to reducing linguistic deficiencies and establishing a level playing field for entry into the educational system. On the other hand, interventions should be funded to cut educational costs for low-income families and to raise awareness of the prospects for success offered by educational options.

Prevailing institutional conditions materially influence the educational options available to children and thus the reproduction of social inequality by the education system. More open – i.e. more porous – systems offer better chances of acquiring a higher level of education. More rigid systems involving early selection act to curtail the chances available to weaker social groups in particular.

Research desiderata

Current research shows that longitudinal studies organised over as long a period as possible provide an indispensable basis for understanding the complex, temporal interdependence of early experiences and behavioural characteristics in later life.

In contrast to work conducted by researchers in the UK and US, Germany has provided few representative longitudinal studies to date that are capable of mapping out the developmental trajectories of children into adolescence and adulthood, and which are available to the wider national and international scientific community. Recent years have seen the addition of new panel studies capable of filling this gap over the medium to long term. Several existing studies have also greatly expanded their childhood research focus. Nonetheless, on account of the specific methodological approaches to the respective data collection, these projects permit only limited statements to be made. They are therefore unable to replace further research on other specific topics.

While many questions about the relationship of early childhood experiences to individual development can be researched using epidemiological studies and the long-term collection of data, it should nonetheless be emphasised that convincing causal links and a clear understanding of the underlying processes is only possible by carrying out dedicated experiments. Since experimental interventions involving human subjects operate within very narrow bounds and must observe the most rigorous ethical standards, research must also consider the use of animal models. This is true in particular for research conducted on bases for development within molecular biology, genetics, neurophysiology and neuroanatomy – and their role in the expression of behavioural characteristics.

Desirable areas for research include the following:

- Fundamental research drawing together psychology and the neurosciences with the aim of discovering the link between brain development and cognitive abilities, social skills and the development of personality.

- Investigation of development-driven neuroplasticity and the molecular-biological basis of sensitive and critical periods in development.
- Longitudinal studies aimed at achieving a scientifically sound estimate of the efficacy of interventions and programmes that are intended to actively support the development of linguistic, cognitive, emotional/motivational and self-regulation competencies in early childhood. Evidence-based decision-making is conditional on such studies being available. They must be initiated early on and accompany corresponding interventions and programmes continuously.
- Investigations into the significance of prenatal experiences and potential sensitive periods on the development of cognitive, socio-emotional and motivational competencies.
- Investigations into the impact of intrauterine and postnatal environmental factors (physical, physiological, psychological) on the expression of individual genes or gene combinations in the sense of epigenetic effects.
- Investigations into the influence of specific boundary conditions on the efficacy of interventions, such as genetic typing, traumatisation, parenting style.
- Investigations into methods of correcting atypical development processes with negative repercussions, as well as demarcating the relevant learning and training conditions.

1 Aims and scope of this position statement

- An individual's *socialisation* comprises his/her cognitive, emotional and social development, and is closely associated with maturation- and experience-dependent changes of the brain.
- An individual's development and social integration, and the degree to which she/he achieves his/her innate development potential have direct consequences for the harmonious social cohesion and prosperity of a community.
- The biological anchoring of socialisation processes on the one hand and their repercussions for society on the other necessitate a wide-ranging, interdisciplinary approach that takes into account insights from neurobiology, genetics, educational science, psychology, sociology and economics.
- The aim of this position paper is to summarise the current state of knowledge on socialisation in early childhood from a range of disciplines and set out the consequences that this work implies.

Career success, physical and mental health, and social integration are the primary indicators of flourishing human development. The better able society is to put people in a position where they can realise their individual potential, the larger will be their contribution to social intercourse, to prosperity and to the success of the community as a whole. Successful individual development and societal welfare are mutually interdependent.

In public discussions of these issues, differences in intellectual and social development are generally ascribed to mutually exclusive conditions. The reasons for differences in a person's character traits and intellectual abilities are either viewed as constitutional – i.e. derived from genetic makeup – or having their origins in upbringing. These views are accompanied by claims that differences are either biologically hard-wired or are the result of social inequality. The last 50 years of research has provided convincing evidence that such simplistic either–or arguments are false. Research findings from a wide range of disciplines, including psychology, biology, neuroscience, sociology, economics and educational science, consistently show that the development of individuals can be understood only as a process of continuous interaction between genetic and environmental factors. For all people, and at all stages of their lives, there is thus no "either x or y" but always a "both x and y". For each individual, both brain and behaviour develop as a co-construction shaped by biological and cultural influences. Equally, societies develop from the interplay of the individual genetic predispositions of their members occurring under social and historical conditions (Baltes, Reuter-Lorenz, & Rösler, 2006).

One notable conclusion derived from research findings is that early support in particular, beginning no later than preschool and the first years of schooling, offers the best foundations for successful later development, as interventions are most effective when they are offered at an *optimum* stage in development. This applies in equal measure to fundamental perceptual and motor skills, to language and cognitive functioning, and to self-regulatory competencies. While later corrective measures are not ineffective, they are considerably more effortful for the individual and more costly for society (see section 6). This does not mean that only early active support strategies are necessary and advisable. A person reaches his/her full potential in terms of intellectual and social capacity only if optimum learning environments are available *throughout his or her development*. And development is lifelong: it starts before birth and continues until death.

Targeted support strategies are particularly important if environmental stimuli are lacking – especially at an early age. Targeted support is often absent for children from families with a low socioeconomic status (Chong & Whitelaw, 2004). Moreover, parents and children from this section of the population make less use of support measures. Knowledge about developmental trajectories of cognitive, emotional and social abilities – and how this development can be fostered – thus has direct relevance for political decisions.

The aim of the present position paper is to summarise the current state of knowledge about educational pathways, social participation and the conditions for successful development from a range of disciplines. In the following, the term *socialisation* is used to describe the topic of this position statement. This focuses our attention on the integration of the individual into society from an economic and social perspective. Among other things, successful socialisation is characterised by adequate and complete use of individual abilities in professional life, health, life satisfaction, and quality of life across the lifespan. Socialisation is successful if it also offers chances for development to children from poorly-educated backgrounds and lessens negative consequences within a society, such as youth/long-term unemployment or – in the worst case – criminality.

The position paper's objective is to tease apart the particularly labyrinthine "cat's cradle" of facts and interactions between biological and social factors that influence the socialisation of the individual – and thus society as a whole (figure 1-1). Yet the intention is not to construct daring hypotheses designed to encourage – yet another – reckless reform of the education system. On the contrary: the objective is to present a critical, integrative review of findings from the various disciplines, and to discuss which recommendations can be made to bring about individual and social change. Last but not least, the intention is to clear up the misunderstandings that all too easily result from a superficial treatment of isolated findings.

The facts reported by this paper comprise empirically derived findings from a range of scientific disciplines. These facts are taken from a broad spectrum of sources, including the fields of genetics, developmental neurobiology and developmental psychology, the biology and psychology of learning, sociology, educational science, and both micro- and macroeconomics. The state of knowledge thereby achieved is then used to fuel deliberations on how educational programmes targeting early childhood can be designed and improved, so as to facilitate successful socialisation. Research shortfalls are also revealed: these must be overcome in order to derive reliable facts from initial, provisional observations.

One particular concern of this statement is to underline the fact that certain biological and social circumstances have direct consequences for childhood socialisation and the later development of the person, and accordingly have repercussions for society at large.

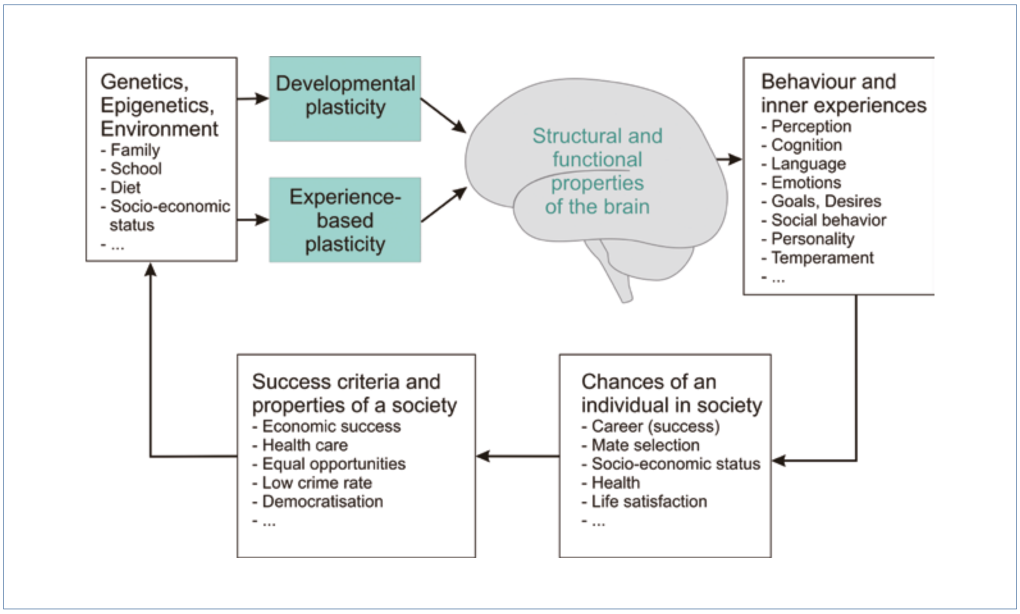


Figure 1-1 (Frank Rösler). Socialisation: influencing factors and consequences. Structural and functional properties of the brain determine an individual's behaviour and inner experience (top right). This is expressed in perception, language, cognition, emotions, goals and desires, social behaviour and temperament. The properties of the brain–mind system develop on the basis of two mechanisms: functional and structural changes in the brain (plasticity), a process due to maturation and experience. These two forms of plasticity are dependent on genetic, epigenetic as well as environmental factors. The lower set of connections in the diagram indicates how an individual's behaviour determines his/her chances in society (bottom right) and how, at the same time this, and the interactions between individuals, influences the characteristics of an entire society (bottom left). In turn, these societal and cultural characteristics then influence the maturational and experience-based plasticity (top left).

Only limited meaning can be attached to individual research findings. Only careful evaluation of their applicability and the integration of findings from an entire field of research allow balanced statements and recommendations. The present position statement is offered solely as scientific expertise. It provides no patent recipes or cure-alls derived from isolated findings. On the contrary: it explains the complexity of the subject area considered, indicates which interventions are likely to produce certain effects, highlights potential courses of action, draws attention to research shortcomings and attempts to clear up misunderstandings held by laypeople that are often based on patchy or one-sided knowledge of the facts.

1.1 Connections between different observational levels

The relationships presented in figure 1-1 mark transitions between different observational levels and disciplines, such as psychology, biology, economics, educational science, etc. The differences here involve the topics of research investigated in a particular discipline (and especially those attributes that can be influenced or which reveal changes), their linkages, and, ultimately, the frames of reference that can be derived from them for scientifically justified social interventions. How can one create relationships between findings from such diverse fields of research?

Psychology asks why people think, how they think, why they feel, how they feel, and why they act as they do. To this end, it applies a broad spectrum of methods, one such method being targeted intervention. Both spoken language and behaviour are recorded, whereby utterances also provide access to emotions, motives and highly subjective aspects of inner experience. Experiments involving humans are strictly regulated – not least for ethical reasons. While observation is able to confirm the insight that innate and acquired factors contribute to the expression of a characteristic, the tools of psychology alone are not able to provide sound mechanistic explanations. For this reason, disciplines such as neurobiology are employed to record brain activity metrics directly: these permit precise temporal location of complex thought processes – including those that do not lead to observable behaviour. Debates about the origins of behaviour and individual differences both in psychology and (especially) the public sphere are based explicitly or implicitly on concepts from genetics and neurobiology.

Neurobiology researches the processes and changes that take place within the building blocks of the nervous system. Examples of such research include investigating how new nerve cells are created during development and via environmental interaction, how their connections change or how the expression of genetic predispositions varies according to environmental influences. For example, the regions of the brain responsible for vision require interaction with the environment to develop and the properties of neurons depend on the environment in which the organism is raised (Blakemore & Cooper, 1970). In addition, this "imprinting" of nerve cells – i.e. the acquisition of basic filtering capabilities – can take place only during finite periods of time (LeVay, Wiesel, & Hubel, 1981). While psychology also observes effects due to development and learning in similar situations, its focus is on variances in behaviour, i.e. a child's success at distinguishing between different sample stimuli or the point in development at which three-dimensional objects can be recognized and distinguished as separate entities. Results of such work have shown that children born with a congenital cataract, and thus initially unable to fully process visual information, suffer a permanent loss of function for certain perceptual distinctions. Moreover, such losses of function can still be observed in adulthood, i.e. many years after a successful operation (Putzar, Goerendt, Lange, Rösler, & Röder, 2007). Such observations of people with congenital visual impairments impressively demonstrate that the development of specific capabilities in humans depends on specific sensitive periods, coupled with neural changes. If an early operation is able to rectify the cataract, the conspicuous behavioural ramifications can be lessened or avoided entirely. Both branches of investigation, neurobiology on the one hand and psychology on the other, provide evidence of very similar, convergent effects, thus granting us an insight into a fundamental phenomenon of development. We see something similar to the basic principles of learning. Eric Kandel received the Nobel Prize for his ground-breaking work on the cellular mechanisms of learning and memory, performed on the Californian sea hare *Aplysia californica*, a very simple organism with an extremely limited behavioural repertoire. Yet these cellular mechanisms also apply to humans. There, they occur in a far more complex context, however, and a full study of their expression also requires the application of other methods.

Despite the presence of convergent findings, one must not lose sight of the fact that a complete stepwise mapping of the findings and terminology of one descriptive level (e.g. molecular neurobiology) onto those of another (e.g. psychology) is currently not (yet) entirely possible. This does not represent a fundamental challenge to the research results, however, since convergent findings from separate scientific disciplines can be used to derive hypotheses concerning cause-and-effect relationships as well as desirable interventions.

For example, many psychological and educational investigations have shown that the environment of early childhood – and above all the way the mother treats her child and the social status of the family in which the child is raised – can have long-lasting effects on the child's cognitive and social competencies (Noble, McCandliss, & Farah, 2007). Favourable conditions in childhood can positively affect a person's resistance to stress and openness to new experiences for a lifetime (Caspi et al., 2003a). From a biological perspective, such behavioural effects are closely associated with genetic expression patterns and functional changes in certain brain regions (Zhang & Meaney, 2010). Both economic and sociological studies have provided evidence that an increase in the socio-economic success of a society goes hand in hand with an increase in the average level of intellectual competence achieved by the younger generation. Furthermore, such studies also show that the average intellectual performance of school leavers is also a factor deciding a society's economic success – as expressed in gross domestic product, for example (Jones & Schneider, 2010). Although the investigative methods used initially seem very different, their integration permits the inference of generalised interdependencies, and probable cause and effect mechanisms. Findings suggest the following process: higher social status coupled with favourable economic conditions in the family facilitate improved use of intellectual resources, leading to an increase in the economic success of a society and thus – in the form of a positive feedback loop – to an improvement in the economic conditions of each individual family, thus benefitting the next generation. While the transitions between the various observational levels are not generally substantiated by precise chains of cause and effect but are often merely correlations, such convergent findings nonetheless strongly support the use of interventions with which, for example, both an individual's intellectual resources and those of an entire society could be best activated.

1.2 Interventions: effects on the individual and the group

The core concept informing many studies is to examine the effect of a specific intervention on a performance measure within a group of test subjects. For example, the question of whether basic cognitive abilities can be improved by targeted training in early childhood has been widely studied. While such investigations frequently demonstrate significant effects for the group, the same is not necessarily true for its members. Figure 1-2 shows a constructed but nevertheless typical pattern of results. The diagram shows how an intervention has increased the group's average performance from 97.5 to 105. Changes in scores for individuals (A, B, C, D) do not necessarily follow this average trend, however. This fictitious example shows how progress from one measurement to the next increases in proportion to the initial score (the "Matthew effect": "For unto every one that hath shall be given" Mt 25:29 (KJV)). The higher the initial score, the greater the individual's benefit from the intervention. While the individual with the highest initial score (D) benefits the most, the lowest scorer (A) does not benefit at all.

As such, proven changes within a group do not always permit conclusions to be drawn for *all* of its members. A specific course of training in early childhood – such as foreign language tuition in a phase critical for language development – can significantly increase the performance of a group of people of the same age, improving their chances in later life and thus also producing an indirect macroeconomic benefit. Indeed, comparatively minor effects of this type can have profound consequences. According to estimates, increasing the average intellectual competence of a nation by a mere handful of IQ points could actually add a few percentage points to the annual gross national income and/or average wage level (Jones & Schneider, 2006; Jones & Schneider, 2010). This must be understood as referring to the statistical mean for the society as a whole: as figure 1-2 illustrates, it naturally does not imply that each individual benefits equally from such an intervention.

When evaluating the results of research into socialisation, we must therefore distinguish consistently between the consequences applying to the group – e.g. in the sense of an improvement across the board – and the conclusions that may be drawn from these results for the individual. Improvements in developmental conditions generally lead to greater educational equality and an increase in prosperity. Yet this does not imply the elimination of differences from person to person. Changes in an average value do not result in the elimination of variance between individuals!

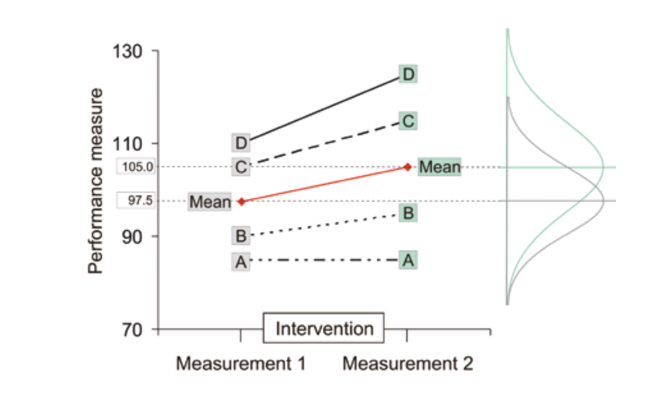


Figure 1-2 (Frank Rösler). Fictitious data illustrating intervention-driven change within a group and for its individual members. An intervention improving performance occurs between measurements 1 and 2. For the experimental group shown here, this led to an increase in the average performance of the group as a whole, i.e. in the mean value from the first to the second measurement, while for a control group without intervention (not shown) the mean value remained unchanged from the first to the second measurement. Benefits from the intervention were not the same for the four individuals shown, however. The larger the initial value at the time of the first measurement, the greater the benefit. Person A did not benefit, while person D benefitted the most. The fictitious frequency distributions for various values at each measurement interval are shown on the right. As we can see, the score for some people after the intervention was lower than the average score for the group before the intervention. Equally, the score for some people even before the intervention considerably exceeded the group's average score after the intervention. Accordingly, the intervention not only raises the average performance level within the group (group mean value) but also magnifies the differences within the group (variance).

A similar rule applies in other areas, e.g. when assessing risk on the basis of genetic or environmental factors (see section 2.5, "Genetics"). Here, too, a distinction must be made between the outcomes for the individual and for the group.

1.3 A look ahead at the topics and scope of this position statement

Section 2 presents a number of fundamental psychological and neurobiological insights into maturation and experience-based brain changes, while also discussing the close interaction between hereditary predispositions and experience-related developmental processes. These insights lay the groundwork for the treatment of specific socialisation and developmental phenomena in the following sections, namely in the domains of *language* (section 3), *basic cognitive abilities* (section 4) and *emotional and motivational competencies* (section 5). Section 6 discusses the *economic and sociological consequences* that may result from differences in the success of individual socialisation processes and interventions. Section 7 summarises *recommendations and current gaps in research* while section 8 offers a tabular overview of false ideas and conjectures contrasted with the facts and conclusions.

The aim of this position paper is to present empirically derived findings from socialisation research conducted within the neurosciences, psychology, sociology and economics, from which recommendations for political actors can then be derived. A further aim is to communicate these empirically derived findings to the wider public, with the intention of informing this group about the basic principles of normal development and socialisation, and make a contribution to tackling misconceptions and prejudice.

To be included in this paper, findings must be robust: they are reported only if the authors have been able to substantiate them with detailed research, have already been replicated in multiple contexts and are since viewed as part of standard knowledge. Expressly excluded from this paper are findings that have not found their way into peer-reviewed journals and which are thus typically considered as lacking sufficient evidence for their claims.

The position paper does not discuss medical and clinical investigations into developmental and psychiatric disorders that occur in childhood and adolescence, and which require targeted strategies of intervention (e.g. medication, psychotherapy).

The position statement does not supply parents, preschool educators or teachers working in the field any purpose-built, practical instructions for tackling specific scenarios. While such practical recommendations – including didactic advice – are generated almost unavoidably from general guidelines, they must always be adjusted to take account of the relevant constraints, which typically involve the availability of funding, human resources and planning. The concrete approach chosen to implement the recommendations – in didactic guidelines, curricula or proposed legislation – should therefore be worked out by the relevant decision-makers in close consultation with the persons and organisations affected.

2 Development, learning, neuroplasticity, genes and the environment

- Learning and the associated brain changes, i.e. neuroplasticity, are possible throughout a person's entire life.
- The development of specific functions is tied to sensitive or critical periods, in which individual structures of the nervous system are especially receptive to environmental experiences.
- If a function should lack adequate environmental stimuli during such critical periods, its development may be impaired and in fact never attain its full potential. This applies not only to basic sensory functioning (such as vision and hearing) and language but also to the development of intelligence and personality traits.
- Atypical development patterns resulting from biological or social constraints can be changed by behavioural interventions. That said, the "late learning" of functions or proficiencies not gained by the close of their relevant critical periods is considerably more time-consuming and often incomplete, while also achieved with brain structures other than those involved in the course of normal development.
- Development is the result of causally inseparable interactions between genetic predispositions and environmental experiences. As a result of experiencing the environment, epigenetic mechanisms work to either activate or block the expression of genetic information. Accordingly, neither genes nor environmental factors are solely responsible for the formation of behavioural patterns.
- Epigenetic effects – i.e. changes in genetic expression due to environmental factors – occurring either before birth or in early infancy remain active over an individual's entire lifespan and may also have consequences for successive generations.

When the conversation turns to learning, schooling, socialisation and development, the two sayings we are most likely to hear are "You can't teach an old dog new tricks" and "It's never too late to learn". The contradiction apparently constructed by these opinions is resolved by a closer look at findings from research in the neurosciences – and psychology and neurobiology in particular. These findings tell us that not all learning is equal. Some abilities can be acquired only during narrowly-defined development time windows (in critical periods) whilst others are most effectively acquired at a certain stage in life (during sensitive phases). A further class of skills and abilities can be learnt or modified over a lifelong timescale. To better classify these differences, one must take a closer look at what is meant by learning and the underlying biological factors associated with it.

Learning, knowledge acquisition, conditioning, training: all of these are terms that describe behavioural changes. They highlight the fact that organisms store experiences as memories and are able to use these to adapt their behaviour to achieve an optimum response to altered environmental conditions. The behavioural changes triggered by learning are multifaceted. They may include:

- the acquisition of entirely new behavioural patterns and skills;

- the more rapid and precise execution of actions and skills learnt previously;
- changes in behavioural preferences; or
- the elimination of undesirable patterns of behaviour.

This broad spectrum of adaptation can be observed in all areas of behaviour, namely:

- during the most basic kinds of conditioning (e.g. those important for toilet training or the acquisition of eating habits);
- during the acquisition of motor skills (e.g. walking, cycling);
- during the acquisition of complex pieces of knowledge (e.g. learning a language or the comprehension and use of mathematical formulae); and
- while gaining competencies in self-regulation (e.g. that one does not always aim to achieve immediate and easily-attainable goals but also those that are harder to attain and lie further in the future).

In neurobiology, the psychological model of learning as behavioural change equates to the concept of "neuroplasticity" (often shortened to just "plasticity"). Neuroplasticity describes the basic property of nervous systems to adapt their functional and structural organisation to accommodate altered requirements. Such plastic changes affect the various levels of organisation of the nervous system (molecules, neurons, neuronal networks), whereby changes at these levels of organisation are mutually interdependent.

One might suppose that the behavioural changes, as described by psychology, and their biological foundations, which are the domain of neurobiology, are related to each other in a similar way as the software and hardware in a computer. Yet this is incorrect. The demarcation between hardware and software familiar to us from computers does not exist in the brain. Whether in early childhood or later life, the learning process always means that changes in behaviour and inner experience are accompanied by changes of the nervous system – i.e. the connectivity and cell properties in the brain. Whereas in a computer we can distinguish between system structure (components) on the one hand and system functionality (programs) on the other, no such distinction exists in the brain–mind system. Behavioural changes corresponding to a functional change are accompanied by changes in the neuronal architecture: signal pathways are changed, new neurons are accommodated and the properties of existing neurons are modified. Functional changes in the brain are thus necessarily linked to structural changes – and vice versa. Accordingly, when describing the components and the functional properties of the brain–mind system, experts in the field now tend to use the term "wetware" rather than talking about hardware and software. The term describes the neurons of the brain, their molecular and biological properties, and their electrical and chemical interactions. They determine both structure and function of the overall system. *To understand childhood development and lifelong learning and use interventions to guide them along a positive developmental trajectory, it is therefore also necessary for us to study the biological foundations of learning and development, and to take into account the ways in which they operate.* This is particularly important in light of the fact that some developmental behavioural changes are linked to specific, critical periods that are especially favourable for changes in the "wetware" (see boxes 2-1 and 2-2).

While learning at the behavioural level is always accompanied by a plastic change in the central nervous system, the same is not necessarily true for the reverse direction. Changes in the brain can – but need not – manifest themselves in the form of observable behaviour. Sometimes, behavioural changes are delayed until a certain amount of time has passed. Described as “latent learning” by psychology, this is also termed a “sleeper effect” in neurobiology. At the cellular level, however, each and every structural change necessarily implies a functional change and, vice versa, each and every functional change is accompanied by a structural change – even though this change may be very minor. Structure and function are inseparably bound up with one another.

2.1 “You can’t teach an old dog new tricks”

Many studies that have compared learning in childhood and learning as an adult have demonstrated differences between these stages in life. Learning during early development ultimately produces a higher level of achievement, and the person learns both faster and more efficiently (i.e. the same training results in greater progress). Taken together, these findings speak in favour of the proverb “You can’t teach an old dog new tricks”. Yet saying that young children are better learners than adults, i.e. that learning skills deteriorate non-specifically over a person’s lifetime, is to risk oversimplification. More accurately, there are *developmental time windows* or *sensitive phases* within which experience has a much stronger effect on the functional and structural organisation of the brain. Moreover, a special form of these sensitive phases also exists – the *critical period* – in which a certain environmental input is needed before a typical course of development can even commence. If this input is not present, some functions may develop either inadequately or not at all. Once this critical period is over, brain changes that have occurred as a result of non-typical experiences can no longer be reversed. Equally, the typical manifestation of individual functions can then no longer be achieved subsequently, even in a “normal” learning environment.

In humans, evidence is especially strong for the sensitive phases and critical periods for elementary sensory abilities required for vision and hearing (box 2-1), and in language acquisition (see section 3). Numerous experimental studies conducted on a wide range of species permit one to draw the conclusion that such sensitive phases also govern development of other functional areas, such as the development of emotional stability, the formation of stress resistance (Zhang & Meaney, 2010), the development of self-regulation (Bakermans-Kranenburg & van IJzendoorn, 2011) or the development of the immune system (Coe, Kramer, Kirschbaum, Netter, & Fuchs, 2002) (box 2-2).

2.2 Brain development and the role of experience

The functional and structural development of the central nervous system involves processes of differentiation, selection and growth. For humans, the basic structure of the central nervous system is already formed at the time of birth. Most neurons are formed before birth. Only in certain regions of the brain important for the formation of memory do new neurons form from stem cell division, in a process that continues after birth and lasts well into adulthood (adult neurogenesis, Kempermann, 2011). In both adult and prenatal nerve cell formation, the first stage in all cases is the formation of an excess of nerve cells. The long-term survival and formation of connections between the nerve cells that ultimately survive is regulated by activity and experience.

These development processes occur at different points in time for different brain regions and functions. Appropriate environmental experiences are *vital* in bringing about these neuronal processes of selection, growth and differentiation. To ensure the best-possible ad-

Box 2-1: The significance of sensitive phases and critical periods, illustrated by looking at congenital and acquired disorders of the visual system

Congenital and acquired blindness

Those blind at birth necessarily undergo atypical experiences. They can assess the spatial properties of their environment only via touch and hearing. In such individuals, the neuronal system adjusts to match these altered conditions. The plasticity of this system also enables compensatory improvements in other abilities. For example, blind people develop an improved auditory short-/long-term memory for ambient noise and voices, can locate sounds more precisely and exhibit a faster auditory response in speech perception. All of these changes in ability are associated with specific alterations within neuronal systems. For instance, the regions of the brain that handle vision in sighted individuals can take on other tasks in those blind from birth (Röder, Rösler, & Neville, 2002). If blindness is acquired later in life, after the neuronal systems have already been formed by visual input, the system cannot change as radically as it can in the congenitally blind. Thus, late-blind individuals exhibit only minimal improvements in long-term memory compared to those who have been blind from birth (Röder & Rösler, 2003).

That said, one often observes comparable compensatory abilities in blind people, independently of the time of onset of blindness. Both the congenitally blind and late-blind individuals improve their ability to localise sounds, for example. Initially, one might conclude that the neuronal systems responsible are also able to adjust to blindness later in life. This is not the case, however. While the ability observed in the congenitally blind and late-blind individuals is the same, it stems from a reorganisation of entirely different neuronal systems (Fieger, Röder, Teder-Salejarvi, Hillyard, & Neville, 2006). This can be proven using neuroscientific methods that measure brain activity directly (e.g. electroencephalography and functional magnetic resonance imaging). Accordingly, the same or similar behaviour can be produced by the interplay of different neuronal systems.

Transient disorders of the visual system (cataracts)

Some children are born blind on account of cataracts (also known as lenticular opacities) obstructing both eyes. Typically, these defective lenses are surgically removed before the child is one year old and compensated for with glasses or artificial lenses. This population can be studied to determine which perceptual/cognitive functions can still be learned thereafter. Although deprived of visual input for the relatively brief period of just a few months, the visual system suffers massive impairment to complex visual functions such as face recognition (Le Grand, Mondloch, Maurer, & Brent, 2004). This is truly unexpected, since face recognition in healthy children continues to improve until well into later childhood and basic visual functions such as visual acuity develop relatively well even in cataract patients. Presumably, the atypical organisation occurring in early childhood manifests itself only at a later point in time.

By using cataract patients as a model, we can readily appreciate how an atypical experience not only changes the deprived system itself but also other systems with which the first system interacts. In adulthood, for example, former cataract patients find it less easy to relate what they hear to what they see. Normally-sighted individuals can significantly improve their understanding of speech by observing the lip movements made by the speaker. This is especially helpful in situations with a lot of background noise that threatens to drown out the speaker's voice. In contrast, individuals who were blind from birth for five months or longer on account of congenital cataracts do not benefit from observing these lip movements, even though they are able to recognise them (Putzar et al., 2007). Measurements of brain activity have shown that the areas in the temporal lobes in which auditory and visual input are normally processed together do not respond to visual information in persons born with cataracts (lenticular opacities) afflicting both eyes (Putzar et al., 2010). This is surprising, since the individuals concerned had reached adulthood at the time of the study and had therefore had access to visual information for as many as two decades or more. Interestingly, the regions of the brain that combine visual and auditory perceptions in sighted individuals and do not respond to visual information in cataract patients are also used more intensively by the congenitally blind than by sighted people for processing speech. In the congenitally blind, the lack of visual input therefore causes the neuronal systems used to recognise individuals to follow a different developmental trajectory. In individuals with congenital cataracts, the visual experience after the operation becomes available too late to reorganise these systems and thus reorient them back onto a normal course of development.

aptation to the living environment, these experiences must match the expected challenges in terms of their nature, differentiation and complexity. The nervous system “expects” environmental stimuli to drive the development of genetically determined structures. If such experiences are absent or exposure to experiences is limited, neuronal connectivity develops atypically: this, in turn, is generally associated with functional impairments that are at best only partially reversible, if indeed at all.

For many neuronal systems, their functional differentiation depends on highly specific experiences, to which only these distinct networks are receptive or – as is frequently the case – only during certain developmental time windows. The experience moulds the neuronal systems for the relevant environment in a specific fashion. This “moulding” causes the neurons and connections activated by the environment to become established and develop further. In contrast, non-activated neurons and connections are eliminated or inhibited.

For example, children can learn any natural language in their first years of life. The language they learn depends on where they grow up and which language is spoken around them. If the child receives no linguistic input at all – as is true of congenitally deaf children of non-signing parents –the innate ability to learn a language dwindles, because the necessary development process has not been activated. While deaf people who did not learn a sign language as infants are capable of acquiring a written language or sign language later on in life, they will not attain the level of proficiency achieved by children who were raised in a signing environment from the outset (Mayberry, Lock, & Kazmi, 2002). Their written language skills will also be poorer than those of deaf people who started learning a sign language shortly after birth.

As we can see, timely experience of natural language has a very specific impact on the language processing system. If a normally developed system comes into contact with a second language (e.g. a foreign language spoken outside the family or acquired later at school, or written language in the case of deaf people), the system shaped by the first language can apply its learning capacity to acquire the second language. If experience of language is lacking entirely, however, the learning ability of the associated neuronal systems is so atrophied that the level of language skills acquired is meagre at best (e.g. in deaf people who did not acquire a sign language in early childhood).

Figure 2-1 uses a landscape metaphor to illustrate the age-dependent plasticity of learning (Knudsen, 2004; Waddington, 1957). Experiences affect the formation of the nervous system like a ball rolling over soft terrain, sinking ever deeper as it follows a particular path. At birth, many potential patterns of neuronal connectivity are already in place. Subsequently, specific experiences cause a functional differentiation and manifestation of neuronal systems (represented in figure 2-1 by the landscape), which grow continuously more stable. Depending on the forces acting on it from the outside, the ball can initially take one of a variety of routes, i.e. the nervous system has many possible manifestations. The further the ball travels, however, the more it sinks in – i.e. the more fixed the neuronal structures become. Changes are still possible, but only within predetermined limits (figure 2-1 (a)).

The landscape metaphor describes development as a process of conditional dependencies. Each further step in development is based on its predecessor. The large initial plasticity of the nervous system permits an optimal adjustment to the respective environment, while the abatement of plasticity during development maximises functional excellence within the existing environment. Equally, the reduced level of plasticity in adulthood can thus be understood as a positive adaptation, since it enables the stabilisation of the relationships of exchange maintained with the social and physical environment. Atypical experiences in early receptive phases can cause a very different manifestation of the nervous system and, as a corollary, alterations to function. The ball follows a different route and thus "carves out" a different path of development (figure 2-1 (b)). Studies focusing on extreme cases – such as individuals born blind or deaf, or who lacked dependable caregivers in the first few months (or years) of life – can powerfully illustrate such atypical courses of development (box 2-1; Pavani & Röder, 2012).

Sensitive phases or critical periods in human development also mean that an atypical experience in the mother's womb or after birth prevents normal experiences from fully reorganising the system to exhibit "typical" structure and function – at least not in cases where development has already progressed beyond a critical point in time (figure 2-1 (c)). In humans, such atypical and irreversible developments can be exemplified by individuals who have been exposed to atypical environmental experiences for a limited period of time after birth on account of a congenital anomaly. Such individuals include children born with a cataract. While these children are operated on at a relatively early age and are then exposed to normal visual experiences, significant deficiencies in a number of visual abilities and other perceptual functions can nonetheless be confirmed in such persons even in adulthood (see box 2-1). A similar situation applies to individuals who acquire a second language only after the 4th to 6th year of life (e.g. children of migrant populations). For such individuals, a lack of proficiency in processing complex grammatical structures can be detected even in adulthood, and even though the test subjects believe themselves to be completely fluent in the non-native language (Clahsen & Felser, 2006; see box 3-2).

In recent years, evidence has also been presented for the pivotal role played by early childhood experiences in the development of personality traits such as anxiousness, anti-social behaviour and depressive tendencies. Unfavourable surroundings – including domestic violence, abuse, the ignoring of children's needs, the withdrawal of the mother or the primary caregiver and neglect – can lead to permanent alterations in developmental trajectories. In adulthood, this can be detected both in behavioural characteristics and by looking at physiological indicators such as the responsiveness of the immune system (see box 2-2).

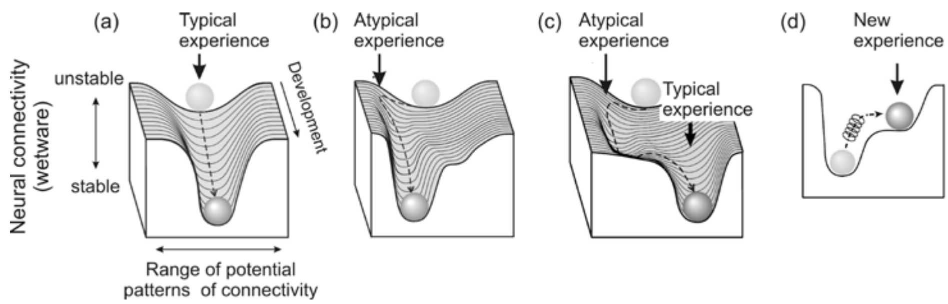


Figure 2-1 (adapted from Knudsen, 2004). Courses of development illustrated using the metaphor of a ball that follows a path through soft terrain.

Many scientific observations have provided evidence that childhood development comprises sensitive phases and critical periods. These findings bring into focus a *general principle of brain and behavioural development*. Nonetheless, a series of misconceptions exists: every once in a while, these are used to cast doubt on the existence of sensitive phases in humans. The continued presence of learning capacities in adulthood for domains is taken as evidence against sensitive phases, for example. Yet the existence of such phases does not preclude lifelong learning ability. These sensitive phases facilitate especially rapid and resilient learning, however. Learning outside these phases is less efficient, requires more time and effort, and the maximum level attainable is also lower. This proficiency is also achieved in a qualitatively different manner, i.e. the same proficiency originates in other brain structures, often not specialised for this task (see box 2-1, comparison of congenitally blind and late blind people).

2.3 Can developmental trajectories be changed?

Any intervention that enables complete restoration of function even after the end of the sensitive phase would have to reinforce normal experiences and re-orient the brain-mind system onto a "normal" developmental trajectory (cf. figure 2-1 (d)). At first glance, a generally increased level of plasticity capable of correcting atypical developmental trajectories seems desirable. Yet it is also associated with certain risks. The pronounced learning capacity of individual neuronal systems during the sensitive phases and critical periods is switched off at the end of this period by genetically predetermined mechanisms (Bavelier, Levi, Li, Dan, & Hensch, 2010). There are good reasons for this: if it did not happen, the neuronal systems would not stay hard-wired and adapted to a specific environment but would suffer continuous destabilisation and change. Accordingly, the effects of any "plasticity pill" that bypassed these mechanisms would need to be extremely specific. At the heart of the matter is the "stability–plasticity" dilemma, which applies to all nervous systems able to "learn". If too much stability is present in the network, nothing can be learnt, since learning is conditional on plasticity. If plasticity is too high, however, the network can keep learning but cannot retain anything, since each new piece of information overwrites the information acquired previously.

If one imagines the development of brain and behaviour to be like the construction of a house – which begins with the foundations and ends with the roof –a pharmacological intervention that caused the mortar to disintegrate would bring the whole building crashing down. Even if the intervention destabilised only the foundations, the house would still collapse, even though the intervention was specific in action, as intended. Both interventions would thus have grave consequences for any kind of acquired knowledge. Accordingly, *an intervention that elevates or stimulates neuroplasticity must be more than merely functionally specific. Steps must also be taken to ensure that the rest of the system is not degraded and destabilised*. Since developing drugs that meet these specifications precisely will be difficult (Hills & Hertwig, 2011), behavioural interventions that exploit plasticity mechanisms throughout life seem to be the safest and also the most promising approaches at this moment in time.

Psychology draws on a broad repertoire of methods for behavioural intervention, whose successes have been demonstrated in neurorehabilitation (e.g. after strokes, Rüsseler & Schneider, 2009), behavioural therapy (in the treatment of anxiety and other disorders, e.g. Margraf & Schneider, 2008), language teaching and rehabilitation (e.g. Huber, Poeck, & Springer, 2006) and educational science

Box 2-2: The significance of sensitive phases and critical periods for the development of personality traits and resistance to stress

Sensitive and critical time windows have also been delineated for the development of personality traits (Caspi, Roberts, & Shiner, 2005; Kreppner et al., 2007). Within such phases, the negative experiences undergone by a child can have a lasting impact on behaviour, neurophysiology and the immune system. Corresponding observations were first made in well-controlled animal experiments (Zhang & Meaney, 2010; Newman et al., 2005). These investigations subsequently encouraged research into comparable effects in humans using epidemiological studies.

In New Zealand, a longitudinal study began in 1973 that examined a large cohort of 1,037 children that was representative in terms of social status and parental educational background. This group received regular medical exams and psychological evaluations. Data were first collected when the children were 3 years old. The most recent collection of data to date was when the participants were over 30 years of age. Issues examined included the consequences of stress, abuse and violence in early childhood. Severe abuse in early childhood was responsible for causing a significant increase in antisocial behaviour in adulthood, this effect also being further amplified by a particular genetic predisposition (Caspi et al., 2002).[1] The study also showed that a high incidence of stressful experiences in early childhood increased the risk of developing depressive symptoms in adulthood (Caspi et al., 2003b). The influence of a genetic predisposition was also seen in this context.[2] Finally, the same random sample demonstrated that the magnitude of stressful experiences in early childhood due to domestic violence is a factor that influences immune response in adulthood (Danese, Pariante, Caspi, Taylor, & Poulton, 2007).

Other investigations were able to show that even stressful experiences undergone by the mother in the last months of pregnancy (e.g. domestic violence) are able to exert an influence on the formation of the child's personality and the development of its immune system (Coe et al., 2002; Radtke et al., 2011).

Equally, other epidemiological studies and experimental intervention studies have observed that positive experiences in early childhood can trigger lasting positive effects – particularly in the case of children on a negative developmental trajectory as a result of less favourable child-raising environments (Ellis, Boyce, Belsky, Bakermans-Kranenburg, & van IJzendoorn, 2011; Bakermans-Kranenburg & van IJzendoorn, 2011). For example, it was shown that proactive behaviour on the part of the parents (support and emotional care on the one hand, coupled with establishing clear-cut boundaries on the other) led to more socially acceptable behaviour in precisely those children showing severe externalising behavioural problems – i.e. those who were aggressive, disobedient and hot-tempered (Denham et al., 2000).

[1] In individuals with genetically caused low MAOA (monoaminoxidase A) activity, the reactive adaptation of neurotransmitter systems to stressful situations is less pronounced. For these individuals, the correlation between abuse and socially maladaptive behaviour was stronger than for individuals with higher MAOA activity.

[2] The correlation was observed only for individuals also characterised by having a gene-related lower serotonin reuptake.

(e.g. Hofmann & Löhle, 2012). Experimental studies suggest that the efficacy of behavioural interventions aimed at rectifying developmental deficiencies depends on satisfying three criteria (Bavelier, Green, & Dye, 2010): (1) The intervention must be self-reinforcing; (2) it needs to capture attention (3); and it must be content-rich and multifaceted.

The reason for the prime importance of these criteria was initially shown in well-controlled studies using animal models. These investigations also isolated a number of neurobiological bases for these criteria. For example, both reward and success induce the release of certain neurotransmitters (dopamine), which in turn "unlocks" the mechanisms for neuroplasticity in several regions of the brain (Schultz & Dickinson, 2000; Li, Cullen, Anwyl, & Rowan, 2003). The term "success" is to be understood very generally here as the fact that an expected target state has been achieved (or overachieved) by an action. *Accordingly, functional or structural changes in the brain resulting from experience occur preferentially in* *cases where the "reward system"* signals success (Rösler, 2011, chap. 5).

These lab findings can be used as a context within which one can then interpret less well-controlled studies in humans. An example: patients suffering from strabismus in early childhood frequently develop impaired vision (amblyopia) in one eye. To avoid this, the healthy eye is repeatedly covered (occlusion therapy) for a period of time during very early childhood. This temporarily gives the neuronal structures connected to the affected eye a much greater volume of visual input. As a result, the visual system can develop almost normally. If such a therapy was omitted, these children are generally assumed to be untreatable. A recent study provides evidence to the contrary, however. In this investigation, adult and late adolescent test subjects played video games for a time while the healthy eye was covered up and only the eye with impaired vision could be used (Li, Ngo, Nguyen, & Levi, 2011). Results showed that particularly addictive, and thus self-reinforcing, video games had an especially positive effect on a wide range of visual functions (e.g. on depth perception, a function that is particularly limited in strabismus sufferers). One finding from the study was that substantial improvements in performance are easiest to achieve in cases where positive reinforcement (= reward) is present, and attention can be captured and held ("it has to be fun" and "you've got to be completely absorbed in the task at hand"). The study also highlights the fact that atypical developments in neuronal systems are receptive to at least rudimentary correction by suitable interventions with behavioural training.

2.4 "It's never too late to learn"

The evidence for sensitive phases and critical periods seems to contradict everyday wisdom that claims we can continue to acquire new knowledge in later life. Nor can it be denied that both neuroscience and psychology have impressively documented lifelong plasticity – and thus the capacity to learn – in humans. This enables sensory functioning and cognitive abilities to be trained and further improved up into old age (Lövdén, Bäckman, Lindenberger, Schaefer, & Schmiedek, 2010). This applies equally to simple skills, foreign languages, orientation in new environments and other kinds of knowledge. The recovery of functionality following brain trauma (e.g. after a stroke) and the development of compensatory functioning on the loss of a sensory modality (e.g. patients with late-onset blindness or loss of hearing) also impressively substantiate the assertion that lifelong learning is possible (Pavani & Röder, 2012). Studies from psychology and neuroscience research on learning in adulthood and the restructuring of the brain following trauma therefore provide convincing empirical evidence for the proverbial "It's never too late to learn."[1]

Notwithstanding the above, losses of performance and limitations on learning ability are also an undeniable corollary of old age. Indeed, the first signs of brain ageing can already be seen in early adulthood. One is a steady fall in the concentration of the neurotransmitter dopamine. Other signs include a reductions of synaptic connections, a decrease in the volume of grey matter and a drop in white matter functioning. Changes in the cardiovascular system also affect brain ageing. All of these physiological losses lessen the transmission accuracy of neuronal signals and the system's ability to distinguish neuronal representations.

1 Yet lifelong plasticity can also have negative repercussions. For example, most amputees complain of phantom pain following the operation. Similarly, people who have suffered acoustic trauma damage to the inner ear also report hearing noises inside their ears (tinnitus). Studies from psychology and neuroscience research have shown that both phenomena are based on the kinds of cortical reorganisation that also play a role in adaptive learning (Flor, Nikolajsen, & Staehelin-Jensen, 2006).

The effects of brain ageing on the development of intelligence in adulthood are not uniform, however, since "fluid" intelligence is affected much more strongly than "crystallised" intelligence (see section 4 for details of this conceptualization of intelligence). "Fluid intelligence" describes the speed, accuracy and coordination of elementary processing steps such as those required in learning about novel circumstances or in dealing with several tasks at the same time. In contrast, crystallised intelligence draws on the wealth of experience gained in the course of a lifetime and includes professional expertise and general knowledge as well as strategies, heuristics and skills. While fluid intelligence diminishes – first gradually and then with increasing rapidity – from age 30 onwards, crystallised intelligence accumulates during adulthood, only declining gradually in old age and then accelerating later in life. Nevertheless, the brain ageing and intelligence trajectories of different adults can deviate considerably from these average courses of development. Furthermore, individuals exhibit vastly differing levels of performance on entering adulthood. As a result, there are many 70-year-olds whose fluid intelligence exceeds the average scores of 20-year-olds.

For plasticity research, the primary focus of interest is the question of whether cognitive abilities related to fluid intelligence can be improved by targeted training of both the mind and body. The first step in answering this question requires us to distinguish between *skills* and *abilities*. The word "skill" is used to describe specific, learned actions, such as the practised application of a memory technique to word lists. In contrast, we use the word "ability" to describe a general type of proficiency, such as our overall memory, for example – and even in cases where our learned skills (such as the aforementioned memory technique) *cannot* be used. Despite promises to the contrary from suppliers of "brain workout" programmes, there is very little empirical evidence to date that targeted training is in any way capable of boosting cognitive abilities in the specific area of fluid intelligence in adulthood. The most impressive data so far was produced by a study in which the test subjects trained for over 100 days in 12 challenging tasks involving cognition, memory and reaction speed for over one hour per task every day (Schmiedek, Lövdén, & Lindenberger, 2010).

In this context, one surprising insight is the strong interrelation of physical activity and basic cognitive ability. A wealth of diverse studies substantiates the idea that physical fitness and mental fitness are associated with one another. Endurance training in particular – distance running, cycling, etc. – is reflected in improved mental performance (Hötting & Röder, 2013; Kempermann, 2012). This reciprocity is likely to have a basis in evolutionary biology, which argues that brains evolved in the first place as a means of controlling movement, i.e. only by directing movement can brain activity communicate with the environment. Language also involves movement, such as the larynx's vocal musculature or – in the case of sign language or writing – the arms and hands. It is therefore likely that movement offers adequate feedback to the brain that cognitive challenges are to be expected. Those moving around in the world experience a great deal. In animal models at least, physical activity has been shown to promote synaptic plasticity and adult neurogenesis directly. Data from studies involving humans have also demonstrated that physical training can lead to neuroplastic changes in specific regions of the brain in just a few weeks or months. This also includes the region that is fundamental for learning and memory formation (the hippocampus). Yet physical activity alone does not seem to be capable of effecting long-term neuroplastic change. Other forms of cognitive stimulation are also required.

Summing up, we can state that people are capable of learning a wide range of new skills throughout adulthood, and that this in itself is powerful evidence of the lasting, experience-dependent plasticity of the brain. Evidence for training-dependent physiological changes – e.g. in the volume of individual regions of the brain or in structures that link both hemispheres or other areas with one another – has been provided by studies with younger and older adults. Furthermore, an active, challenging lifestyle is also linked with a high level of cognitive functioning (Hertzog, Kramer, Wilson, & Lindenberger, 2009). Last but not least, there are some initial indications that the ageing brain is still sufficiently plastic to permit the improvement of both skills and cognitive abilities. Ultimately, however, the gains are much smaller and more laboriously achieved than commercially-interested parties would often have us believe.

2.5 Genetics, epigenetics and the environment

A person's qualities – such as physical constitution, susceptibility to certain diseases, temperament and intelligence – are determined by his/her genetic makeup and the experiences undergone over an entire lifetime. Often, this is formulated as the dichotomy "nature *vs*. nurture", one of which is then used to argue the corner for genetic determinism with the pessimistic message, "If behaviour is inherited, options are fairly limited". The other option heralding environmental influences leads to the optimistic message, "Since the environment is decisive, no limits can be placed on behavioural malleability".

Yet research has shown that the "nature vs. nurture" dichotomy is based on myths that are scientifically untenable. To say a characteristic is "inherited" does not imply it is immune to environmental modification – nor is the transformative power of an "environmental influence" itself infinite. The restrictions placed on learning ability by specific sensitive phases and critical periods during development have been discussed in previous sections. This section addresses the other side of the equation, namely that genes do not determine everything immutably.

The realisation that environmental factors can exert a profound and long-lasting influence on a person's physical and mental characteristics is not a modern one. While championing Mendel's principles and the "laws" of inheritance during the first half of the 20th century, researchers in genetics already knew that the formation of many phenotypical traits did not follow these rules and required more sophisticated, "multifactorial" theories. In the second half of the century, it became clear that the information encoded by desoxyribonucleic acid (DNA) is responsible for genetically-driven predispositions for such trait complexes. The manifestation of this multifactorially caused trait complex – such as a schizophrenic disorder, for example – is not solely due to the genetic makeup of the individual person afflicted, however. While a person's personal genetic profile may indicate a predictable, increased risk for a certain medical disorder, the environment in which she/he lives also influences his/her chances of actually falling ill. An innate, deterministic specification of a person's phenotype by his/her personal genome would make no sense from the perspective of evolutionary biology: the ability to adapt to changing environmental conditions is a strong selective advantage.

Not until the 1990s – and the birth of the new research discipline of epigenetics – could it be demonstrated that the activity of genes is also dependent on their chromatin packaging (see box 2-3). The genes fundamental to the development of phenotypical trait complexes – the numbers of such genes can run into

Box 2-3: Epigenetics

The starting point for epigenome research is a fundamental problem within developmental biology. All cell nuclei, from the first cell that is created by the fusion of the sperm cell and the egg cell to the many billions of cells that make up the body – and brain – of a fully-developed adult human, contain the same genetic information. This complete (known as "diploid") genome comprises two half (known as "haploid") genomes inherited from the father and the mother. In the body's cells, which fulfil a wide range of different functions (muscles, nerves, digestive tract), many thousands of genes cause highly diverse patterns of activity, despite the genome being the same. Genes showing strong activity in one type of cell may be only weakly active – or entirely inactive – in another cell type. How is this possible?

The genetic substance DNA (desoxyribonucleic acid, famous for its double-helix structure) does not exist as bare chains of molecules but forms a complex, protein-packed structure known as chromatin. The precise nature of this DNA packing, namely whether it is "open" or "closed" chromatin, is regulated specifically, and determines whether and to what degree the genes contained within it are active or inactive (see figure box 2-3). Epigenome research examines the specific factors that work to alter chromatin and thus regulate gene (de)activation.

The hypothesis that environmental factors can cause long-term changes in gene expression was first confirmed by the consequences of the Dutch famine of 1944/45. Affecting cities such as Amsterdam, the famine was caused by the German high command placing an embargo on food transports. For many people, calorie intake was reduced to less than 1,000 kcal per day. Children of women pregnant at the time recorded very low birth weights and, as adults, exhibited an increased risk of contracting Type II diabetes mellitus. The causes of this were changes to the chromatin packaging on genes involved in sugar metabolism. These changes remain effective throughout the affected individuals' lives – and continue to affect even their children (Gluckman, Hanson, & Low, 2011). Whether this transmission to the next generation is a form of inheritance, i.e. via the germ cell, or is in fact an indirect result conditional on the behaviour of the parent generation is a topic of interest within current epigenetic research. Recent investigations have demonstrated that a mother's condition of being overweight or diabetic during pregnancy can cause long-term changes in her offspring's metabolism; the effect of such changes can then also persist over an entire lifetime (Plagemann, 2011; Plagemann et al., 2010).

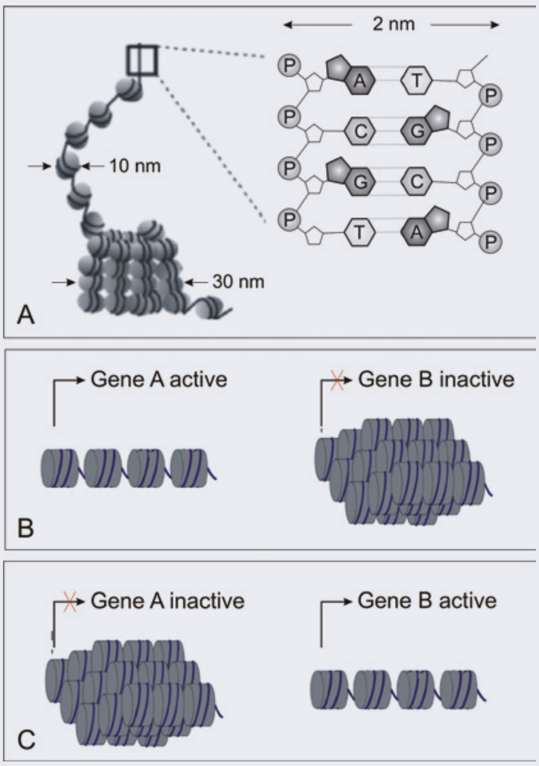


Figure box 2-3 (Thomas Cremer).
A. Structure of the DNA strand. Left: DNA strand wrapped around nucleosomes: loose structure (top), compact structure (bottom). Right: Structure of DNA strand (double helix) with the internally arranged base pairs A-T = adenine-thymine and G-C = guanine-cytosine (nm = nanometer = 10^{-9} m).
B. Normal development. Gene A with open chromatin packaging has long-term activity; gene B with closed chromatin packaging has long-term inactivity.
C. Disturbed development. Due to adverse environmental influences, gene A receives a chromatin packaging that remains closed over the long term (for decades in some cases) and is inactivated; due to chromatin opening, gene B has long-term activity. Such long-term changes in gene packaging are termed "epimutations". They cause persistent changes in gene activity without an underlying mutation of the DNA base sequence.

the hundreds or even thousands – can be "unpacked" and thus made accessible or "repacked" and thus remain quiescent (see box 2-3). Research on the "epigenome" has the aim of understanding the factors that are responsible for remodelling gene packaging (i.e. chromatin) and thus regulating gene activation and deactivation.

One ground-breaking achievement in this field has been the discovery that one cannot simply assume epigenetic changes brought about by environmental influences are always reversible: instead, they may have lasting consequences that may persist for many years – and perhaps even exert an influence on subsequent generations. One logical consequence of the above is of extraordinary importance: while "You can't teach an old dog new tricks" might not be true for all kinds of learning it is – in the case of humans – certainly applicable to some abilities required in life (see section 2.1 above). One pertinent example is the development of language competence in early childhood (see section 3). Here, adverse environmental conditions may prevent the achievement of certain developmental goals that remain unachievable despite major efforts or can no longer be achieved to the degree that would have been possible had timely support been provided. In earlier work, the English epidemiologist David J. Barker had put forward the hypothesis that deleterious influences occurring in early stages of intrauterine development lead to permanent changes in the physiology and metabolism of affected persons (Barker, 1998). Recent studies have shown that this is indeed the case (see boxes 2-2 and 2-3).

Via epigenetic effects, environmental factors also influence the developmental and experiential plasticity of the brain and its structural and functional characteristics (e.g. Meaney, Szyf, & Seckl, 2007). While current evidence for this hypothesis is less solid than that for the influence of foetal malnourishment on metabolism (outlined in box 2-3), for example, observations of this kind are now showing that the genes inherited from the parents do not predetermine all of a child's developmental options. Genetic predispositions develop only under environmental influences. Advantageous conditions play a part in ensuring that an individual's genetic predispositions are expressed as a positive adaptation to the environment. Conversely, the effects of unfavourable conditions during early development can last a lifetime and cannot simply be "repaired" in later life (Belsky, Bakermans-Kranenburg, & van IJzendoorn, 2007). The long-term effects of the epigenetic changes that can be stimulated by environmental influences throughout life make clear that even if the foetal genome could be sequenced completely, the genetic code as such would not allow reliable estimates of developmental opportunities and risks.

Poorly understood until a few years ago, the surprisingly sophisticated interaction between structural and functional genomic and epigenomic networks in the formation, maintenance and lifelong modification of phenotypical traits is now being revealed by the joint efforts of (epi) genome research and work in molecular biology (see figure 2-2 and Kendler, Jaffee, & Romer, 2011). The precise details of how the genome is packed within the several billion cells of a child is part of this child's genetic information in a wider sense. Figure 2-2 describes an individual's development from conception to death as a record of the interactions between genome, epigenome and environment. At this juncture, it is important to note the paucity of information available about the potential long-term effects of early environment-driven epigenetic changes on the subsequent course of a person's life. More insights from molecular biology are still required before detailed predictions can be made about how and when certain environmental events impact – via the mechanism of secondary epigenetic effects – a person's health, cognitive abilities and personality, and thus improve or worsen an individual's opportunities in life. As things stand, the role of epigenetic mechanisms in this context cannot be judged sweepingly. Understanding these mechanisms is a key objective for future research. That having been said, it would be irresponsible to cite current gaps in our knowledge as a reason for ignoring such positive and negative effects. While limited, the knowledge we do have encourages us to warn public and policy-makers alike of the danger of assuming that derelictions of a duty of care during development in early childhood can be simply "patched up" later on. Indeed, in case of doubt, overestimating possible long-term effects appears preferable to making light of them.

The current state of (epi)genomic research offers no grounds whatsoever on which to marginalise the significance of the human genome and its evolutionary history for human aptitude and human behaviour (Davies et al., 2011). Current investigations do reveal the complexity of the genetic contribution, however. Personality traits are clearly determined by a large number of genes and their interactions. Since there are many genes that each make only a very minor contribution to the phenotype, exact characterisation of the genetic dependency of psychologically relevant variables at the molecular level will remain an intractable problem (Bevilacqua & Goldman, 2011; Munafo & Flint, 2011). The fact that personality characteristics, intelligence or predispositions for disease, are defined not by single genes but the concerted action of thousands does not exclude the possibility of high heritability for such psychologically defined characteristics (cf. section 4). In the case of a person's height, for example, this phenotypical trait is heritable to about 80 percent, i.e. 80 percent of variance in the population's physical height can be traced back to hereditary factors. Expressed slightly differently, one can say that this proportion of variance can be predicted from one generation to another. This trait is nonetheless determined by a large number of genes, each of which is responsible for explaining less than 0.5 percent of variation in the phenotype (Gudbjartsson et al., 2008).

In addition, the fact that a trait has high heritability does nothing to lessen the probability that changes in the environment will strongly affect the quantitative expression of this trait. The pronounced increase in physical height that has occurred within the advanced economies over just a few generations shows that environmental factors still remain significant despite high heritability. Ex-

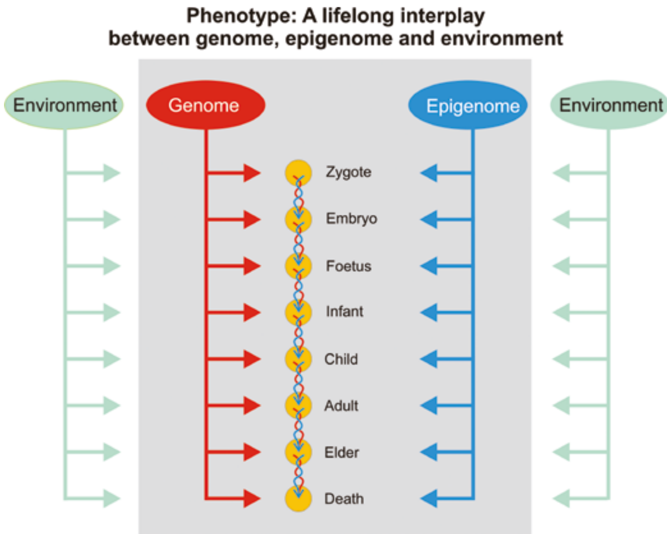


Figure 2-2 (Thomas Cremer). Impact of environmental events on the human genome and epigenome. Left-hand side: Impact of the environment on the genome. Environmental events (e.g. changes in available nutrition) can lead to short-term changes in gene expression by mechanisms that are also reversible. The information encoded in the DNA itself remains unchanged. In contrast, the effects of high-energy radiation or mutagenic substances can act to cause permanent alterations in the DNA (mutations) of cells in the body. Such alterations can lead to the onset of cancers, for example. Right-hand side: Environmental events, e.g. poor nutrition, obesity, stress experienced by the mother during pregnancy, negative factors in the first months of life, can also alter the packing of DNA as chromatin (see box 2-3) and thus modify the activity of genes for a lifetime. With these kinds of changes within the epigenome, the genetic information itself, coded as the base sequence in the DNA, remains fully intact. Recent research has clearly shown that environmental influences on the genome and the epigenome are equally important for the comprehension of normal and abnormal development, and for health and ill-health alike. The interwoven red and blue threads symbolise the intimate interactions occurring between genome and epigenome.

periments with mice have examined the question of the extent to which individuality (i.e. inter-individual differences) is created and reflected in the structure of the brain in cases where the genome is identical and the environment is kept constant. This roughly equates to a situation where monozygotic (identical) twins are raised together, yet differentiation between the two becomes more and more pronounced as they age (see section 4.2 and box 4-3). In the animal experiment as performed, gradually divergent individual behavioural patterns developed, despite the same genome and external environment. These patterns explained a considerable proportion of the variance (20 percent) in measurable brain plasticity (Freund et al., 2013). Translated into human terms, this finding points to the significance of individual activity and experience, and the enormous complexity of gene–environment interaction – a model that often appears deceptively simple.

2.6 Conclusions

- Learning in adulthood differs both quantitatively and qualitatively from learning in childhood. Learning as an adult frequently requires more effort, is possible only within narrow confines and often incomplete. The development time windows for the formation of specific abilities are spread throughout childhood. For visual functions and basic emotional response patterns, these critical periods occur very early on, in the first two years of life. In contrast, the window for acquiring full grammatical language proficiency extends to the end of the fourth to sixth year of life. From animal experiments and epidemiological investigations of selected groups of individuals (e.g. children raised in orphanages), we are also led to expect similar sensitive phases and critical periods in the normal development of a series of other functions, such as the immune system, resilience to stress and self-regulation competencies. The accurate demarcation of sensitive phases for such functions requires a multimethod approach including both behavioural measures and neuronal indicators.
- Importantly, functions that develop later always build on the foundations of neuronal systems that developed at an earlier point in time. The principle of conditional dependency therefore applies. Throughout life, neuroplasticity forms the neurobiological basis for learning and thus for all cognitive functioning. In part, the preconditions for learning and neuroplastic changes, can be fostered by non-specific measures such as physical activity. To ensure long-term structural and functional change in the nervous system, occurring via maturation or learning, however, specific environmental experiences are always necessary.
- Behavioural interventions must utilise the learning mechanisms provided by biology. Pharmacological elevation of learning plasticity with the aim of re-opening sensitive phases could be accompanied by multiple adverse side effects. Current opinion favours interventions based on behaviour, whose effects are functionally specific while simultaneously permitting multiple experiences to be gained with one domain. Such promising interventions must be (self-)reinforcing to have a lasting effect. The better intervention programmes are adapted to learning time windows, the greater is their efficacy, their efficiency and thus their cost-effectiveness.
- Genetic makeup and environmental factors should not be seen as mutually exclusive or opposing influences on the development of behavioural traits. The genetic information laid down in the genes defines predispositions for the formation of certain traits. Whether these traits actually develop, and

the form that they then take, depends on environmental experiences. From the perspective of molecular biology, this close interaction between predisposition and environment can be described by "epigenetic" mechanisms. Environmental factors cause genes to be unpacked or to remain packed and thus to either become active or remain inactive, respectively. Epigenetic mutations caused by the environment can occur even in the womb and in early infancy, and their effects then persist over the individual's entire lifespan.

- As the close interweaving of genetic predispositions and their expression due to environmental influences makes very clear, genetic makeup does not predetermine everything once and for all, nor are development trajectories arbitrarily modifiable by environmental influences and interventions. There are limits in both directions. A decisive role is played by the interaction of both influential factors and the resultant process of co-construction (Lewkowicz, 2011). While one person's genetic makeup may mean adverse environmental experiences which massively impact later development, another person's genotype may render these effects negligible. The same applies for positive experiences.

3 Language competence

- Language acquisition follows developmental sequences that are set by genetically predetermined maturation processes in the brain.
- In the course of normal language development, the regions of the brain relevant for language and their connectivity are normally formed by the age of six. A prerequisite for these neuroplastic changes in the brain is input from the native language by caretakers and peers in meaningful communicative settings.
- Closely associated with the neuroplastic changes in the brain is the acquisition of structural properties of a language –sound patterns (phonology), word formation (morphology) and grammar (syntax).
- If native competence is to be acquired, these structural aspects must be developed during early childhood, before the maturational critical period ends.
- In this critical phase, which lasts until approximately age six, it is possible to acquire native competences in more than one language, provided sufficient exposure to the target languages in communicative settings.
- Second languages can also be acquired at later stages in life. However, the acquisition of structural properties requires much more effort, and the level of competence attainable is generally lower than in the first language. Furthermore, as compared to the first language, additional brain regions are activated in second language processing.
- The acquisition of lexical knowledge, i.e. vocabulary and semantic relations, is not limited to the early critical development windows. Such competencies can be acquired and improved over the entire lifespan time

If we consider the development of language competence in early childhood by focusing on the neurobiological and psychological factors decisive for this development, we can see that this process begins very early on and follows a universal developmental pattern. Acquisition of grammatical competence is always successful in native language setting, except for cases of language (development) disorders.

The early acquisition of language implies that information about sound properties of the ambient language(s) are processed already prenatally, and that the grammatical knowledge is largely acquired in the first six years of life. The term *grammar* covers syntax (sentence structure), phonology (sound structure) and morphology (word formation). Other components of linguistic knowledge, such as vocabulary pragmatics (based on world knowledge) can still be learned later in life. In acquiring the important core properties of grammar, children proceed through a universally uniform *developmental sequence*, i.e. the various grammatical phenomena are acquired in a specific order. While learners may differ in the amount of time they require to successfully complete individual phases, the ordering of these phases is invariant. Grammatical development is *successful* to the extent that children attain native speaker competence independently of individual preconditions and learning contexts. Yet socio-psychological factors determine the development of the skills and abilities that are necessary to deploy this grammatical knowledge appropriately when using the language.

The characteristics of first language acquisition (L1) can be explained by the fact of humans possessing an inborn – i.e. genetically mediated – capacity for language and language acquisition. In fact, this ability is actually an endowment for multilingualism. Children who grow up from birth in a multilingual environment (simultaneous acquisition) are capable of acquiring multiple “first languages”. This capacity is not available for an unlimited period of time, however. Instead, it is necessary to activate it within the optimal age ranges, since neuronal maturation and other age-related changes can make access to this capacity more difficult and partially even impossible (Meisel, 2010).

3.1 Phases in language development

A child is capable of learning any language when born into this language. The auditory system is already fully formed in the last weeks before birth. A baby’s first step is to segment the underlying structure of the language and its words from the acoustic flow of speech alone.

3.1.1 Phonological development

Although stress and intonation which adults use when communicating with a baby may appear exaggerated, they are essential for segmentation. By emphasising one word in a phrase, this word is given a particular acoustic salience and is thus easily recognisable in the sentence. The beginnings and ends of sentences are also marked in the speech melody (prosody) by raising and lowering the voice.

Babies can identify the rough acoustic parameters of prosody even while still in the womb. By the time they are four days old, babies can distinguish between languages on the basis of different sentence melodies (Mehler et al., 1988) and various phonemes (Cheour-Luhtanen et al., 1995; Dehaene-Lambertz, 2000; Dehaene-Lambertz & Pena, 2001). They are also able to recognise statistical regularities (Teinonen, Fellman, Näätänen, Alku, & Huotilainen, 2009) and phonologically encoded grammatical relations (Friederici, Mueller, & Oberecker, 2011) in the language input.

Neuroscience research has shown that babies aged two months can distinguish short syllables from long syllables (Friederici, Friedrich, & Weber, 2002). This is significant, since syllable length is the most important cue for word stress. By the age of five months, infants are able to differentiate between words stressed on the first syllable and words with a second-syllable stress. Interestingly, German-speaking infants display a preference for words that have their stress on the first syllable, i.e. for words exhibiting the German stress pattern, while French-speaking infants prefer words with the stress on the second syllable, i.e. words that follow a stress pattern that is typical for French (Friederici, Friedrich, & Christophe, 2007). Once recognised, this acoustic cue can help to identify unknown words in the sentence. This is of particular importance for children who grow up learning two languages, since it enables an early differentiation between the language systems.

These types of information, i.e. prosody on the one hand and word stress on the other, are fundamental to the normal process of native language learning. In one longitudinal study, neurophysiological investigations were able to confirm the importance of processing of this information normally. Children diagnosed with major language development difficulties by the age of four years had already shown non-standard – i.e. significantly delayed –

brain responses in discriminating syllable lengths at the age of two months and in differentiating between stress patterns at the age of five months (Friedrich, Herold, & Friederici, 2009).

3.1.2 Vocabulary and sentence construction

Around its first birthday, a normally developed child is in command of all of the mechanisms necessary to learn words and recognise sentence structure. Neurophysiological investigations show that by the 14th month of life, infants can recognise whether a word that they know is a match for a corresponding picture or not (Friedrich & Friederici, 2005). This means that shortly after a child's first birthday, a neuronal system has been established that is capable of processing semantic information (see Mills et al., 2004).

By the age of about two to two-and-a-half, children have already acquired a basic knowledge of grammar. For example, German children then know that the verb is placed at the end of subordinate clauses. Furthermore, a two-and-half-year-old's neurophysiological response to grammatical features also already closely resembles that of an adult (Oberecker, Friedrich, & Friederici, 2005).

These and similar findings have led both language and brain researchers to the unanimous conclusion that the first important, fundamental phase in language acquisition comes to an end by the age of three years, followed by a second important phase from three to six years. Within this period, the knowledge acquired is consolidated while new words and sentence structures are learned, again in a specific predetermined sequence. For example, children use passive constructions – i.e. sentences such as "The girl was hit by the boy" (and not "The boy hit the girl") – only at age four and above. Investigations have shown that even training targeting the use of passive sentences during this age does not increase the incidence of such constructions in spontaneous language production. Brain physiology indicates that the acquisition and use of syntactically complex sentence structures requires the maturation of specific areas of the brain relevant for language, and, in particular, their interconnectivity (see box 3-1). This reflects the manifestation of the universal development sequence already mentioned.

3.2 The simultaneous acquisition of multilingualism

The simultaneous acquisition of two or more languages from birth enables the acquisition of a native competence in each of them. This competence does not differ qualitatively from that of respective monolinguals in the same languages (Meisel, 2004). More precisely, this means that all of the above characteristics of language development are also encountered in multilingual children – and in each of the languages to be acquired – i.e. the development of the languages follows the universal sequences and is successful in all non-pathological cases.

The decisive prerequisite for such successful acquisition is that learners are capable of establishing two (or more) discrete linguistic knowledge systems from an early age. Indeed, bilingual children differentiate their languages from very early on. As noted above, this occurs at an age as early as five months in the case of language perception. In language production, this is attested by a differentiated vocabulary as of the beginning of the second year of life and by the differentiation of the morphosyntactic systems towards the end of the second year. For example, children raised in a German-French context place the verb in German always when required before the subject ("Hier schläft sie", "Here sleeps she"), but not in French, which does not permit this word order ("Ici elle dort", "Here she sleeps").

Box 3-1: Maturation of language-relevant systems in the brain

Each of the diagrams A to F shows a lateral view of the left cerebral hemisphere. Language-relevant regions in the left half of the brain form neuronal networks via fibre bundles. In terms of function, three networks can be clearly distinguished.

Network 1 (yellow) associates auditory with (pre)motor regions in the brain. This network supports representational and comparative processes handling what is heard (auditory input) and what is spoken (motor output) and thus early language acquisition, especially in terms of phonological processes. In babies (A), this network is already fully developed (Perani et al., 2011).

Network 2 (green) associates the regions in the temporal and frontal lobes that are responsible for semantic processing of meaning within words and sentences. While this network is also present in babies, it develops prodigiously over time as the child matures into an adult (D, E, F). (Brauer, Anwander, & Friederici, 2011; Perani et al., 2011).

Network 3 (blue) This network connects areas of the brain in the temporal and frontal lobes that are responsible for the processing of grammatically complex sentences. Absent in babies (A), this network is present but not fully developed in children aged seven (B), where its development is noticeably less pronounced than in adults (C) (Brauer et al., 2011).

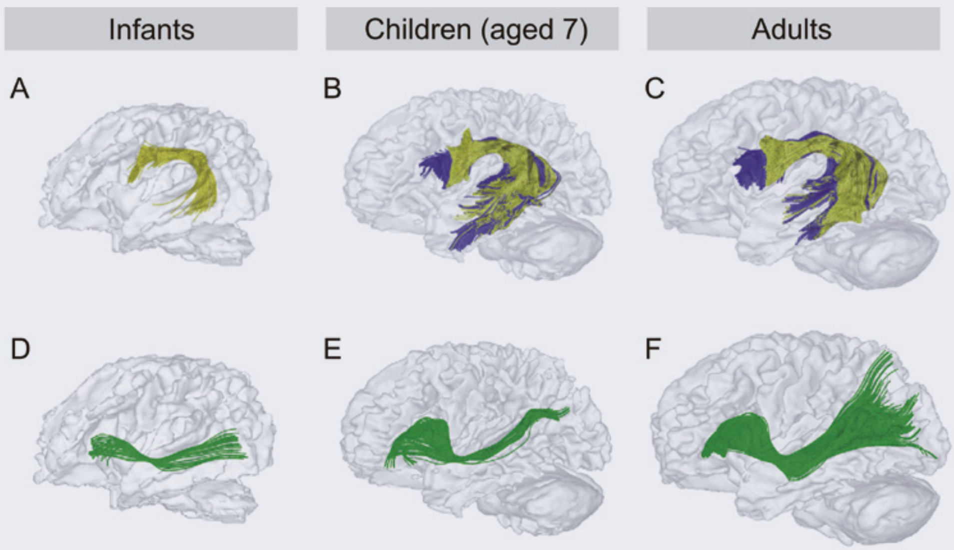


Figure box 3-1 (adapted from Brauer, Anwander, Perani, & Friederici, 2013)

Multilingual children proceed through the same sequence of grammatical development in each of their languages as the respective monolingual children do and achieve native speaker competence in both languages. We thus speak of “two first languages” in such cases (2L1). Only in lexical acquisition do we expect to find that the vocabulary bilingual children acquire for each language is slightly less extensive than that of monolinguals. However, investigations in Canada have shown that a deficit of this kind can be levelled out rapidly in the classroom, with the proviso that children from socially and/or economically disadvantaged groups acquire vocabulary in the second language more slowly than socio-economically more advantaged children (Bialystok, 2001; Bialystok, Craik, Green, & Gollan, 2009).

3.3 The successive acquisition of multilingualism

If the acquisition of a second or further languages does not start at birth but at a later point in time, the possibility of the learner ultimately acquiring native speaker competence becomes increasingly unlikely. Learners of a second language (L2) differ from learners of an L1 language in terms of the acquisition process, the linguistic knowledge acquired and quite possibly the mechanisms of language processing (Clahsen & Felser, 2006). While this does not concern the language as a whole – nor even all domains of grammar– it does apply to core aspects of syntax, morphology and phonology (Clahsen & Felser, 2006). In contrast, the acquisition of lexical knowledge is not subject to any age-related changes in acquisition mechanisms.

The question as to the maximum age at which one can acquire a second language like a native language cannot yet be conclusively answered. Indubitably, however, a later start to acquisition rules out the achievement of native speaker competence, even if the second language is acquired naturally in a communicative context (i.e. not within a classroom environment). In fact, less than five percent of all second language learners effectively attain a near-native competence (Abrahamsson & Hyltenstam, 2009). While opinions differ on whether full native competence is in principle achievable, this seems to be highly unlikely. Furthermore, while invariant acquisition sequences can also be observed in second language acquisition, these differ from those in first language acquisition. There are thus qualitative differences between these two types of acquisition. And this applies in all cases where the individual starts to learn a second language after the age of six. In fact, more recent investigations suggest that even if acquisition begins at the age of just under four years old, some grammatical aspects do not develop as for a native speaker: instead, acquisition proceeds as for older second language learners (Meisel, 2011; box 3-2).

While not the sole origin of changes in language learning capabilities, the maturational changes that the brain and thus the cognitive faculties are subjected to certainly have the most important role to play (see section 2). In the brain, the acquisition and consolidation of native language structures are not only attended by the formation of new synaptic connections but – yet more frequently – by the pruning of unnecessary connections. Fatally, these connections might include the very connectivity that is needed for a second language. If two languages are acquired simultaneously and early on as native languages, however, the neuronal system has a less rigid architecture. Even if the later acquisition of a second language results in a high level of proficiency, this is achieved by co-opting other areas of the brain unrelated to language, and thus by using other cognitive strategies.

From these findings, we conclude that the course of early childhood is marked by sensitive phases in which a range of grammatical competencies can be optimally acquired. To do so, the relevant utterances merely need to occur in the child's linguistic environment in the course of communicative interaction with conversational partners in the native language. This also applies if more than one language is acquired in this period. In other words, the process of neuronal maturation opens up a series of *windows of opportunities*, in which the grammatical knowledge necessary for one or more languages can be effortlessly acquired. This knowledge is then processed in the corresponding regions of the brain. These windows of opportunity close in the course of further development. If the relevant optimal phase is missed during the successive acquisition of language, the acquisition of the corresponding grammatical phenomenon remains possible, but now necessitates the employment of other (and thus generally suboptimal) cognitive processes, which may also require the activation of additional areas of the brain. In comparison to the development of L1, therefore, L2

Box 3-2: Critical development time windows for second–language acquisition

In this study, language proficiency in American English was investigated in a sample of young adults aged between 18 and 33. They had either grown up as monolinguals with English as their native language or as bilinguals with Chinese as their native language and English as the second language. Contact with this second language had occurred during different developmental stages: at ages of one to three years; four to six years; seven to ten years; eleven to thirteen years; or after the age of 16 years. Those individuals who had acquired the second language early on felt more "at home" in English than in Chinese, and were entirely fluent in both comprehension and production. They were tested using sentences that were either semantically or syntactically correct or which were semantically or syntactically deviant. The task was to assess each sentence's correctness. Semantic violations resulted from the fact that words were offered that were not congruent with the preceding sentence context (e.g. "The scientist criticised Max's event of the theorem" –"Max's proof" would be correct). Syntactic violations were more varied and sometimes quite subtle. They concerned phrase structure, e.g. altering the word order so that a preposition occurred in a wrong position ("The scientist criticised Max's of proof the theorem" – "Max's proof of the theorem").

For subjects who had acquired a second language early on and used it for an extended period of time as a dominant language were able to detect semantic violations as fast and as reliably as native speakers. However, error rates increased significantly with the group who started learning English after the age of 16. The assessment of grammatical errors, on the other hand, revealed poorer performance even in those who had started learning English as four-year-olds, and participants' performance continued to decline with increasing age of onset of second language acquisition.

These differences are also seen in the biological correlates of language comprehension (Weber-Fox & Neville, 1996). These findings are not unique. Comparable effects have been confirmed using other samples and when applying different methods of testing (e.g. Clahsen & Felser, 2006; Meisel, 2004).

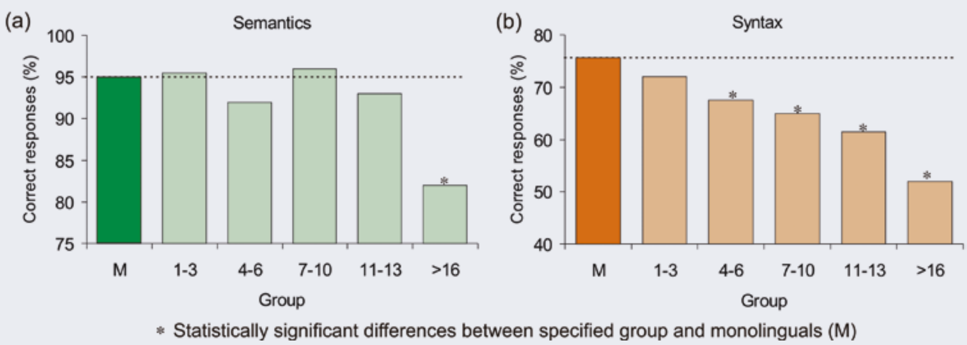


Figure box 3-2 (adapted from Rösler, 2011)

acquisition is generally cognitively more demanding, proceeds more slowly and only in rare cases leads to a kind of success resembling that in L1 acquisition.

Besides support of the general potential for development, formally classified developmental disorders such as specific language impairment, developmental dyslexias or problems with arithmetical tasks require specific interventions. Specific language impairment only affects discrete performance domains and are not associated with lower general intelligence or a less supportive developmental environment. They have their basis in formally classified, probably genetically determined information processing weaknesses in the individual, although they may lead to highly diverse phenotypes. In such cases, targeted interventions are necessary, which comprise therapeutic measures tailored to the individual disorder profile on the basis of individual diagnostic examination. As a rule, the general kind of support programmes run in a classroom context or at day care are not capable of remedying these deficits. Instead, individual interventions by trained specialists (language and learning therapists) are required. Teaching staff in the educational system must also be trained to recognise these distinct developmental disorders, so that children can be referred to relevant specialists at an early age. In this context, we refer the reader to the most welcome German federal-state initiative for language support, language diagnostics and the promotion of reading (Bundesministerium für Bildung und Forschung, 2013), one of whose aims is to foster improvements in this area.

3.4 Conclusions

- As language development in early childhood follows a biologically predetermined sequence, its progression should be aided with educational measures. The course of the developmental sequence itself cannot be altered, however.
- Methods to assess levels of linguistic competence must be applied early on – possibly during routine postnatal visits to the paediatrician or paediatric audiologist. Initially, the focus must be on the phonological aspects of the language. Teaching staff in the educational system must be trained to recognise specific language development disorders, so that children can be referred to specialists at an early age.
- Although a systematic course of treatment cannot begin before the age of three, both parents and educators must be briefed appropriately so that they can respond supportively in the event of a corresponding early diagnosis. They should learn to speak much more slowly and with greater emphasis, and practice stress patterns in interaction with the infant with repetitive rhymes and songs.
- Since an early diagnosis is in itself challenging, both parents and educators should be made thoroughly aware of the principles involved, and could also learn how to help create an environment conducive to language learning. For babies, examples include using varied and overemphasised cadences, clear enunciation, placing stress on key words and plenty of repetition, while question-and-answer formats can be used for slightly older children. Parents and educators should also be informed about indicators of language development disorders, i.e. disorders beyond the capabilities of the above-mentioned measures for language promotion and which require intervention from language therapists. Only in this way can professional help be sought in good time.
- Parents of children whose native language is not the one of the society in which they live should be made aware that achieving full competence in a society's dominant language is possible only if the child has early contact with the language. Parents need not fear this will impede development of the language of origin, however. Acquisition of "two first languages" should be a fundamental goal, if a child is likely to be making its home for the foreseeable future in a society with a language that is not its mother tongue.
- Development of native language competence in two languages is best fostered by the child starting acquisition of the second language as early as possible: if not directly after birth, then in the first three to four (maximum) years of life. In all cases, acquisition should involve interaction with communication partners having native proficiency in the language. Attention should also be drawn to the fact

that the later acquisition of written language skills depends on the level attained in the spoken language. As a rule, weaknesses in spoken language are followed by deficiencies when learning the written language.

- Second language learning by children with German as their first language should also begin as early as possible in order to enable them to acquire a very high degree of competence. Ideally, the acquisition of a second language should begin at preschool age and no later than primary school where possible, since children's language learning capabilities start to deteriorate considerably in the age range between 8–10 years. The successful early acquisition of a second language requires an adequate investment of time, however, as well as highly competent preschool educators or teachers of the language to be learned. If possible, such educators should be native speakers. If the native language is not the one of the society in which a child grows up, then this dominant language should be learned as a second language as early as possible – e.g. in kindergarten or preschool – through interaction with native speakers.

4 Basic cognitive abilities

- People differ in terms of their basic cognitive functioning, also referred to as "general intelligence". Cognitive functioning is revealed in particular when reasoning, independently of the actual content of a problem (be it linguistic, not linguistic, etc.).
- A person's basic cognitive functioning can be measured reliably using standardised intelligence tests and expressed as a relative level of performance compared to the population of age peers. Known as the "intelligence quotient" (IQ), this parameter remains stable over an individual's lifetime, so that an IQ score measured in childhood and adolescence significantly predicts the person's future IQ range in adulthood.
- Cognitive functioning correlates substantially with a wide range of indicators, including the academic degree obtained, career success, income, the likelihood of taking health risks and social mobility. When compared to all other psychological variables that also have predictive value for such indicators, general intelligence explains the greatest proportion of individual differences within a population.
- Basic cognitive abilities develop in a process of continuous interaction between hereditary predispositions and environment-related learning processes. Without adequate environmental influences, genetic predispositions can develop only insufficiently or not at all. Positive environments promote the development of intelligence while negative environments constrain it. The degree to which basic cognitive abilities can develop their potential is limited by the given hereditary predispositions.
- Basic cognitive functioning can be boosted by suitable interventions, such as improved living circumstances, better schooling or specialised support programmes for individuals from poorly-educated backgrounds. Note that increasing the average IQ within a population does not mean that the intervention will even out performance *differences* between individuals, however. Indeed, the opposite is true: improving environmental conditions for all members of a population usually magnifies the differences between them, since more able individuals benefit more from the intervention than their weaker peers.

People differ in terms of their basic cognitive abilities, i.e. in terms of how rapidly and effectively they can understand complex issues or solve problems of varying difficulty, how well they can memorise something, and how effectively they can learn from new experiences and adapt their behaviour to environmental changes. Such differences in cognitive functioning can be observed between different individuals on the one hand (inter-individual differences) and within one and the same individual (intra-individual fluctuations) on the other. Anyone who has spent many years gaining experience in a particular area can solve related problems more rapidly and more adroitly than she/he could at the outset, even if the person's general problem-solving ability has remained unchanged over the years. Special talents also exist, which can enable an individual to perform exceptionally in certain areas. A person who excels as an author or as a composer of symphonies need not be a genius at maths into the bargain. Such conspicuous differences within a person's overall performance profile often lead one to conclude that differences between individuals are perhaps not as significant as they may at first appear. One person can do this, another can do that – and if we only spend enough time practising and learning, we can master any problem, no matter how difficult.

Yet research findings offer no support for this pre-scientific assumption. While certain individuals possess unusual talents and while it is indubitably the case that high-intensity learning correlates with improvements in performance (see below), it is equally true that a person's basic cognitive abilities are substantially *independent* of the domain or situation. Anyone able to solve problems rapidly and effectively in a certain situation, also does so in a quite different situation independently of specialised experience; and anyone able to rapidly acquire knowledge in childhood generally performs similarly as an adolescent and adult. Such empirically validated findings demonstrating that differences in cognitive performance are *independent* of domain and age strongly suggest that people differ in their basic cognitive functioning. In psychological terms, basic cognitive functioning is known as "intelligence". The scientific concept of "intelligence" is derived from numerous empirically verified observations. These include:

- Basic cognitive functioning can be measured reliably by utilising appropriate performance tests (intelligence tests).
- Cognitive abilities measured using different intelligence tests co-vary strongly, i.e. anyone performing well or less well in one test will perform similarly in a different test.
- Scores from these intelligence tests also co-vary substantially with many criteria – e.g. performance at school, career success, health-related behaviour and other attributes. More often than not, therefore, one can use the scores from intelligence tests taken earlier to accurately predict the likelihood that individuals will have more or less success in a certain field, whether at school, in their professional career or in their private life.

In the first part of this section, the scientific concept of intelligence and its utility as a tool to describe inter-individual differences in cognitive functioning will be presented in more detail. The second part then discusses how hereditary and environmental factors affect a person's intelligence. The third and last part then focuses on the question of how an individual's intelligence develops and which interventions during socialisation can be used to ensure a person achieves his/her full potential.

4.1 Intelligence: a proven concept for describing inter-individual differences in cognitive functioning

People given comparable learning opportunities in the classroom and familial support can differ substantially in terms of cognitive performance. These differences are exhibited in the speed and depth of learning of cultural skills such as reading, writing and arithmetic, in storing and utilising knowledge, in the quality of deductive reasoning, and in the rapidity with which information is consumed and processed. These differences in intellectual potential can be successfully mapped out using psychometric intelligence tests. As a rule, these will contain linguistic, mathematical and figural/spatial tasks and thus overlap broadly with a range of academic abilities (Nisbett et al., 2012). While intelligence test content varies widely, common to all of their tasks is a requirement to draw new conclusions on the basis of material with which the subject is familiar (see box 4-1). The examples clearly show that the solving of intelligence test tasks is conditional on knowledge of the respective language and other symbol sys-

Box 4-1: Typical tasks for the measurement of basic cognitive functioning at school-age children

The three examples represent typical numerical, verbal and visuospatial tasks in intelligence tests with which deductive reasoning and thus the g factor (general intelligence, basic cognitive functioning) can be measured.

1) Number sequences:

Which number comes next?

9 – 7 – 10 – 8 – 11 – 9 – 12 – ?

2) Verbal analogies:

Which word fits into the space marked by the question mark?

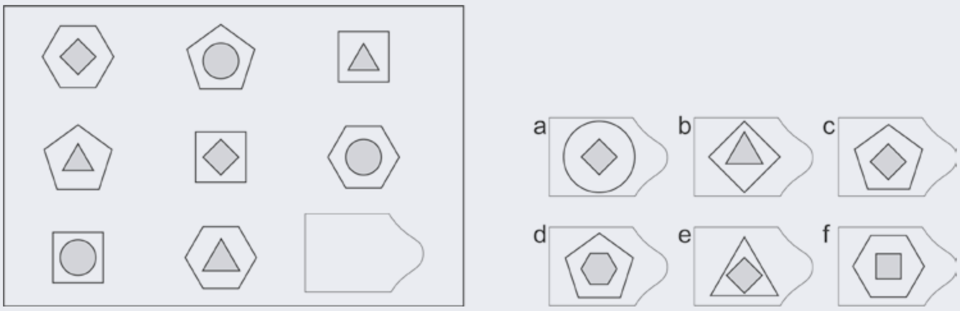
dark : bright = wet : ?
gram : weight = hour : ?

Which word is the odd one out?

a) rain, b) day, c) moist, d) wind, e) dry

3) Matrices

Which of the six elements on the right (a, b, c, d, e, f) fits into the empty space in the matrix on the left?



tems. An individual's intelligence can develop only within a cultural environment. Differences in the speed with which information is processed can already be found in early infancy, however: while these are minor, they correlate systematically with the scores achieved in later intelligence tests (e.g. Bornstein et al., 2006).

While some intelligence tests may appear entirely unrelated (e.g. tasks involving linguistic and non-linguistic skills, memory capacity and rule recognition), scores are strongly correlated, i.e. individuals who do well in one of the tasks will also score highly in a different task. This, in turn, justifies the definition of a general intelligence quotient that is independent of the test material. Since intelligence tests focus on assessing mental flexibility in handling symbol systems, they are especially accurate predictors of academic success in its broadest sense. By summing over all of the tasks solved in the intelligence test, an intelligence quotient (IQ) can be obtained, which tells us the extent to which the person's score deviates from the average value in the population. Accordingly, IQ is not an absolute metric like mass or length. Instead, it describes an individual's deviation from the average test score achieved by a representative comparison sample. An IQ of 100 is equal to the average value in the population, whereas an IQ of 115 means that she/he has a score that is one standard deviation above the average and has thus achieved a test score better than 84 percent of his/her peers in the same age group. If the IQ is equal to 85, then only about 16 percent of the population has a lower value. The term "gifted" is typically used for an IQ score of 130 and above – a score attained by only 2 percent of the population (Rost, 2010).

In terms of precision and reliability, the measurement of intelligence is not comparable to the measurement of parameters such as height or weight. Conversely, intelligence is the most readily measurable psychological attribute. In other words: we can make statements about an individual's intelligence with far greater reliability than we can about other personality characteristics (e.g. sociability, anxiousness). Moreover, the inaccuracy in IQ measurement can be precisely quantified, since empirically derived statements about the accuracy of the test (the reliability coefficient) are part and parcel of every published IQ test. Among other things, the reliability coefficient tells us the degree of consistency between measurement results taken at two different points in time. For intelligence tests, the reliability coefficient is higher than for other psychological metrics (Amelang & Schmidt-Atzert, 2006). For example, the coefficient is .91 for the Raven Test, the most well-known non-linguistic intelligence test (Raven, Raven, & Court, 1998). This means that a test participant who achieved an IQ score of 110 at some point in the past has a 95 percent likelihood of achieving a value between 105 and 115 in a subsequent measurement.

Even if a person's IQ cannot be measured with high precision, the reliability and predictive value of intelligence tests should not be underestimated. The higher the score in the intelligence test, the more successful people tend to be in a wide range of relevant areas. While this applies first and foremost to academic and career success (Lu, Weber, Spinath, & Shi, 2011; Schmidt & Hunter, 2004), it is also relevant for success in social interactions, health, and even life expectancy (Deary, 2012) (see box 4-2).

The average scores achieved in intelligence tests have increased significantly over the last few decades, a fact that has been severally explained by increases in general levels of education and changes in diet (see Nisbett et al., 2012). Yet differences in intelligence test performance also remain in place if the average value of a population is shifted upwards. (This can be compared to the secular trend in human physical growth: over the last 150 years, the average height of Europeans has increased by almost 8 inches, yet we still find small and tall people in the population).

The same applies to practicising intelligence tasks. While training can be used to raise the average score (Nisbett, 2010), differences nonetheless remain. In addition, as soon as new and more difficult tasks are introduced, large inter-individual differences once again appear in the solution rate. In other words: as in other types of performance, the average grade can be increased for intelligence test performance but inter-individual differences will simply reappear, albeit at a higher level. For intelligence tests to fulfil their function of appropriately representing inter-individual differences in cognitive functioning, they need to be recalibrated and standardised from time to time. Yet one fact remains: if the general circumstances within which intelligence can develop improve, the differences between

Box 4-2: Correlations between basic cognitive functioning (general intelligence) and selected criteria

Meta-analyses of longitudinal studies determining the links between intelligence measurements in childhood or adolescence and indicators for success in adult life show a number of close correlations. One meta-analysis has synthesised the quantitative results from a very large number of studies (Strenze, 2007). Its findings are therefore based on several thousand test subjects (see figure below). If one includes only those studies that were conducted to a high methodological standard, correlations are found between intelligence and the highest qualification obtained at school or in higher education (0.56 on average), the career position held (0.45) and the income level achieved (0.23). While the positivity of these correlations is in proportion to the lateness of the intelligence measurement conducted in childhood/adolescence, significant correlations were nonetheless found when intelligence measurements in early childhood were used to predict these markers from adult life.

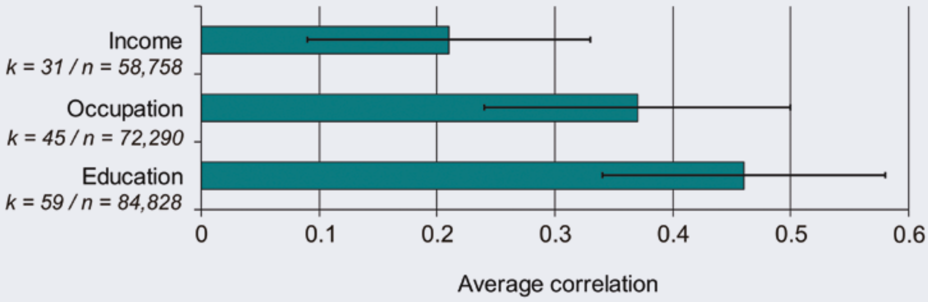


Figure box 4-2 (data from Strenze, 2007). Predictive validity of intelligence measurements in childhood and adolescence for socio-economic success in adulthood. The average correlations (and standard deviations) shown are each based on *k* independent studies with a total of *n* test subjects.

Significant correlations between intelligence measured in childhood and adolescence and subsequent health risks (smoking, alcohol abuse, obesity, psychiatric illness) were also observed (Deary, Weiss, & Batty, 2010). It was also shown that the age-related decline of general intelligence and "fluid", i.e. speed-based intelligence is slowed if the level of intelligence first measured in childhood and adolescence was higher (Hertzog et al., 2009).

Conclusions from these findings are twofold. On the one hand, differences in basic cognitive functioning are clearly able to "foretell" a significant proportion of differences in other markers. On the other, we can also plainly see that basic cognitive functioning does not fully (100 percent) explain these differences in other markers, but only in part. Ultimately, the educational qualifications, career position and income level achieved will also depend on a whole host of other factors. That having been said, these other causes of differentiation are far less easy to record in early childhood. Accordingly, they are less usable for longer-term predictions than general intelligence.

people do not become smaller, although the level of performance achieved rises overall. In other words: the same environment does not make people more similar. Quite the reverse: the differences become more pronounced.

While intelligence can be understood as learning ability, only a moderate correlation exists between intelligence and the learning gains in different domains. While a high score in an intelligence test makes academic and professional success more likely, it is not a guarantee. In an academic sense, learning is described as the construction of knowledge. Accordingly, mastery of a challenge in a particular domain depends on the availability of a well-organised knowledge base that can be accessed flexibly and has good cross-linking between terms, facts and automated routines (Ericsson, 2003, 2006; Schneider & Stern, 2010). While a higher intelligence score might simplify the process of creating such a knowledge base and using it to deal with new challenges, a high level of intelligence cannot generally compensate for a lack of knowledge. Vice versa, less intelligent people can achieve solid performance by establishing a sound knowledge base. Outstanding performance in complex and abstract fields of knowledge is always conditional on above-average intelligence, however. A range of competencies that can be viewed as prerequisites for social participation – such as mastering written language and everyday arithmetic – can also be acquired by people with less advantageous intellectual capacities. Yet this is conditional on the targeted provision of supportive learning opportunities. Apart from the cognitive faculties of intelligence and prior knowledge, other factors such as motivation and interest (see section 5) also influence knowledge acquisition and thus learning success.

Basic cognitive functioning needs to be applied to acquire the knowledge that is considered important by society, and which can be acquired only with a comparatively large investment of effort outside the classroom or later in life. Such knowledge includes written language and – above all – the sciences and mathematics. Since concepts build on one another in almost all scientific disciplines, advanced levels of proficiency can be acquired only if fundamental knowledge and contextual frameworks have been previously acquired. There is reliable evidence, for example, that fostering phonological awareness in preschool children simplifies the acquisition of written language (Schneider, 2009). Findings from longitudinal studies in mathematics also show that promoting mathematical literacy from an early age has a positive effect on the later acquisition of maths skills (Stern, 2009). This applies across the whole spectrum of performance, thus accommodating children with favourable and less favourable intellectual abilities to an equal extent. As regards educational choices, identifying and supporting the acquisition of precursor skills and core knowledge compatible with the disciplines of written language, mathematics and the sciences in the first ten years of life is of especial importance. The same applies to quality assurance for learning and support programmes.

4.2 Reasons for differences in intelligence: not genes or environment, but action of genetic factors mediated by environmental conditions

The fact that people exhibit differences in their basic cognitive functioning itself tells us nothing about the source of these differences. In pre-scientific discussions, the causes are generally seen as either stemming from differences in genetic makeup or differences between environments. Yet, as has already been stated in section 2, this dichotomy is incapable of explaining differences in behaviour. Instead of "genes or environment", the fact of the matter is that behavioural traits always form as a result of continuous interaction between hereditary predispositions and environmental experiences. This also applies unreservedly to cognitive abilities.

The genetic and environmentally-mediated causes of inter-individual differences are the topic of quantitative behavioural genetics (Spinath & Johnson, 2011). For this discipline, standard methodological approaches include twin and adoption studies. Here, behavioural geneticists exploit an opportunity to collect data from individuals whose genetic and environmental similarities are well-known. For example, parents of adopted children are not related to them genetically, but they share environmental factors that could contribute to their similarity. In contrast, since identical twins raised separately do not experience the same environmental influences once separated, any observable similarities can be authoritatively traced back to genetic causes.

Fundamental concepts in behavioural genetics include heritability (abbreviated as h^2), and the effects of a common environment (c^2) or a separate, non-shared environment (e^2). Heritability is understood to mean the degree to which genetic differences can explain the observable inter-individual differences seen within the investigated trait (see box 4-3). The effects of a common environment include the parents' socio-economic status and parenting style, i.e. factors that contribute to the similarity of children who are raised together within the same household. In contrast, the effects of a non-shared environment include different peer groups, different schools or teaching staff, and random events. These are therefore factors that are experienced by one child only and which contribute to dissimilarities between individuals even if raised together.

All of a person's traits – including his/her inner experience and behaviour – are inherent as potential in the genes. For some traits, development proceeds completely unaffected by the environment. Skin colour is one such trait: a child of North European parents will not permanently acquire dark skin even if born and raised near the equator. For traits such as height and weight, genes play a decisive role in explaining individual differences, but environmental influences play a part in the manifestation of the trait concerned. For complex traits such as intelligence, the explanation of individual differences crucially depends on the interplay of genetic and environmental factors over the individual's entire lifetime. Accordingly, the differences in basic cognitive functioning seen between individuals are neither set in stone from birth onwards nor are they arbitrarily modifiable by appropriate environments. Assuming genetic potential is identical, a favourable environment and optimum schooling could significantly increase basic cognitive functioning – including that of children from disadvantaged backgrounds. Conversely, unfavourable environments and substandard schooling may also result in the inadequate development of basic cognitive functioning even for children from more advantaged backgrounds. Evidence for this can be found in international comparisons between societies showing variations in gross national income and formal educational systems (Lynn & Meisenberg, 2010; Lynn & Vanhanen, 2012).

The underlying causes for inter-individual differences in basic cognitive functioning may also vary over an individual's lifetime. That is, the proportion of inter-individual differences that can be ascribed to genetic potential and which results from non-shared environments is not immutable. One of the surprising findings in this context is the rising importance of genetic influences as an individual ages (Deary, Penke, & Johnson, 2010; Plomin & Spinath, 2004). An explanation for this finding is found in the lifestyle choices made by the individual him/herself. These lifestyle choices are made in accordance with the person's genetic makeup and its epigenetic manifestations, and their influence is thus amplified by his/her actions: one chooses environments one feels at home in and works actively to shape them further. In this respect, the gains made by heritability over a lifetime in no way imply a decrease in the power to influence the trait (here: intelligence) for the individual. On the contrary: it underlines the plasticity of the system in the sense that predispositions manifest themselves only within the relevant environment. As such, the gains made by heritability – i.e. the increase in the proportion of inter-individual differences explainable by genetic predispositions – are a further example of the continuous interaction between genetic and environmental factors (see section 2).

Erroneous interpretations of behavioural genetics studies that include reports of heritability estimates (h^2) are not uncommon. Yet behavioural geneticists have long been unanimous in their opinion about what does and does not qualify as heritability (Stern & Neubauer, 2013). *Heritability estimates express the degree to which individual trait differences can be explained by genetic differences between these individuals.* Often, heritability is specified as a percentage value. Yet heritability estimates are not a physical constant, they have no power to explain trait expression for a specific individual and thus provide no precise measurement: they merely indicate the relative proportion of genetically determined variance. Accordingly, it is inadmissible to use heritability estimates to fuel speculations about the limits of changeability in trait expression for an individual (Spinath, 2010). To leave the reader in absolutely no doubt, we reiterate once again, using basic cognitive functioning as an example: even assuming heritability estimates in the region of 80 percent (as can be found in certain circumstances in the literature) this figure neither preordains the personal IQ of an individual nor does it preclude the possibility that an individual's personal intelligence score may undergo substantial changes, which may themselves be in a positive or negative direction (e.g. as a result of illness).

Another example of a background variable across whose spectrum the heritability of intelligence varies is the level of parental education. In this case, we see that the relative significance of genetic factors rises as the level of parental education increases, i.e. if formal schooling is optimal, differences due to genetic predispositions manifest themselves more strongly. A further conclusion is that adverse educational conditions result in environmental influences being ascribed the dominant role in explaining individual differences: in this case, genetically determined differences are less influential than differences in the environment, e.g. social status, well- or poorly-educated parents, their parenting style. The focus on inter-individual differences discussed here does not contradict the established stability of intelligence. This has been impressively documented over the human lifespan and, on the basis of data from the Lothian Birth Cohort study, can be established as being in the order of $r = .73$ at a chronological interval of 68 years (Deary, Whiteman, Starr, Whalley, & Fox, 2004). This study determined the rank-order stability (r), that is, it investigated the precision with which the rank order of individuals in terms of their intelligence at the time of the first measurement matched the rank order at the time of the later measurement, i.e. whether the most intelligent by rank order was still the most intelligent, and whether the second-most intelligent was still the second-most intelligent, etc. This metric thus tracks changes in absolute trait expression affecting both individuals and the group as whole. The comparatively high stability shown by this value allows us to draw the following conclusion for the majority of test participants: those who tended to exhibit above-average performance in childhood also tended to be in the above-average achievement group in old age; further, this consistency also applies to individuals from the lower end of the performance spectrum.

The segments of the genome responsible for the development of intelligence and its variation have yet to be identified. There is much to suggest it is orchestrated by many genes, scattered throughout the chromosomes: these are then recombined during inheritance and thus ensure a large and unpredictable cornucopia of potential configurations (see section 2.5). This also explains why, on average, there is only middling consistency between intelligence quotients measured for close relatives. Parents of

Box 4-3: Heritability

Heritability is a measure that states the degree to which differences between individuals can be ascribed to genetic factors. In the simplest case, this is done by taking the total variance of differences between individuals and estimating the proportion of differences ascribable either to genetic influences or environmental influences. Heritability (h^2) is thus the percentage proportion of genetic variance in relation to total variance.

As an example, a heritability coefficient of .70 for a particular trait means that 70 percent of inter-individual differences can be ascribed to differences in genetic makeup, and 30 percent to differences in personal experience of the environment. The metric h^2 therefore tells us something about the origins of differences within a sample or population. Conversely, it tells us nothing about the size of the genetic proportion of a trait expression in a single individual.

Findings from behavioural genetics studies that provide estimates of heritability are often misunderstood. Indeed, the term "heritability" itself is frequently misinterpreted (Johnson, Penke, & Spinath, 2011). It is important to remember

- that high heritability should not be confused with constraints on changeability for a trait – or even its immutability. The degree of heritability offers a benchmark for the magnitude of genetic influence relative to the influence of the environment on the expression of a trait.
- Heritability is always a relative value. It describes proportions of variance. That is: assuming genetic conditions remain the same, the heritability estimate can increase if the environment becomes more homogeneous, i.e. the influence of non-shared environments decreases. In this case, the influence of the genetic predispositions on the expression of trait differences will become relatively larger. Yet this does not then exclude the environment from being a causative factor in the development of traits.
- Heritability estimates are not absolute values. They vary depending on the general circumstances of empirical studies and on the traits of study participants and their environments. That said, the large number of investigations available shows us that, assuming methodological standards are comparable and of a high quality, estimates of trait heritability can be fairly reliably reproduced.
- Heritability does not tell us anything about the number or identity of genes potentially involved in the expression of a trait.

The proportion of genetic and environmental variance can be estimated by conducting studies with pairs of identical and fraternal twins who were raised separately. Identical twins share an identical genome, so their hereditary potential for the expression of a given trait is likewise equal. In contrast, fraternal twins resemble normal siblings in that they (statistically) share only half of their genetic makeup. This is because the random recombination of genetic information supplied by each parent will (statistically) result in a 50:50 chance that siblings who develop from separate fertilised egg cells are the carriers of the same genetic information supplied by the father or mother. On the other hand, influences from the common environment should nonetheless be the same for both types of twin pairings. In summary: identical twins are similar as a result of both identical genetics and a common environment, while fraternal twin similarity is predominantly due to their common environment and due only to a lesser degree to overlaps in their genetic makeup. By analysing the surplus of trait similarity in identical twins compared to fraternal twins, it is possible to estimate the degree of heritability h^2. Detailed and accessible overviews of this and other estimates of heritability and the concept's associated issues are available in e.g. Plomin, DeFries, McClearn, and Rutter (1999).

The simple model of variance estimates and their additive combination considers only genetic and environmental factors. It makes no assumptions about possible interactions between genetic predispositions and environmentally-caused trait manifestations. Some models attempt to estimate the variance proportions of such interactions, however. Two mechanisms of action are significant here.

- Gene–environment interactions result from the fact that the influence of identical environmental conditions varies depending on the genotype and – conversely – that identical genetic predispositions can develop differently depending on different environmental conditions.

- Gene–environment correlations are present where genotypes are not distributed randomly across environments. A distinction is also made between passive, evocative (reactive) and active gene–environment covariation. Passive gene–environment covariation is due to the fact that parents not only contribute genes to their offspring but also shape the familial environment. Certain genetic predispositions are associated with successful lifestyle skills, for example (better school grades, greater job satisfaction and a higher level of income). The likelihood that people meet and start families with partners from similar environments (Blossfeld & Timm, 2003) then leads to a situation where both the common genetic background and commonalities due to a similar environment are further amplified. Evocative gene–environment covariation describes a case where the environment responds to genetically influenced traits in individuals and then influences their further development. Genetic predispositions can lead to unruly and aggressive behaviour, for example. If the environment then responds equally aggressively, this can act to amplify the manifestation of these genetic predispositions. Active gene–environment covariation describes a situation where persons seek out and shape an environment that "fits" their genetic dispositions – and which then influences their further development. Studies have shown that the importance of evocative and active gene–environment covariation increases over an individual's lifetime.

below-average intelligence can have children with above-average intelligence – and vice versa. While IQ differences are predominantly due to genetic differences, this cannot be equated with increased familial resemblance. In other words: in no circumstances can an individual's IQ be deduced from the IQ of his/her parents and siblings. While it is fairly likely that one will bear a greater resemblance to one's close relatives than those outside the family, this fact cannot be used by the children of professors to lay claims to an academic career, nor does it justify dispensing with talent scouting among children of poorly-educated parents.

4.3 The development of basic cognitive abilities

4.3.1 Social status, the development of intelligence and academic success

Children from socially advantaged groups have a disproportionally greater chance of gaining better qualifications than children from less advantaged groups. In light of the fact that intelligence has a positive effect on a person's academic and general success in life, and also considering the fact that the influence of genes on the development of intelligence is substantial, one may deduce that the provision of better support cannot solely explain the greater academic success enjoyed by children from socially advantaged groups. One may assume that the correlation between educational success and social class is partially due to genetic factors. Indeed, this is possibly determined by gene–environment variation (see box 4-3). One phenomenon responsible is that people are more likely to meet and start families with partners from similar environments than from different ones. This leads to a situation where both the common genetic background and commonalities due to a similar environment are further amplified.

In addition, there is also evidence of intelligence being promoted by effects specific to social class. Twin studies suggest that in well-educated families, adequate support allows genetic predispositions to flourish more fully than is the case in families with a poor educational background. Children from poorly-educated backgrounds are accordingly much more likely to fail to realise their full potential – unless supported by suitable programmes.

4.3.2 Which environment enables the optimum development and use of intelligence?

In the course of a child's development, its cognitive functioning undergoes a series of momentous changes. This universal change, affecting all individuals, has long been the subject of empirical research. Section 2 has explained the development of structures within the brain and sensory functions in the first months of life after birth as a response to a continuous interaction with the environment. The formation of elementary perceptual functions and sensory filters is a precondition for the development of all other cognitive functions. Normally, this course of development is relatively robust when confronted with different environments, i.e. the spectrum of environments as provided by different societies and within a single society is comparatively homogeneous and has no perceptible effect on this development. Only extreme deviations from a "normal" ability to experience the world – such as constraints on vision (cataracts, blindness) or hearing (hearing impairments, deafness) lead to deficiencies detectable throughout a person's lifetime. Such effects seen in extreme groups highlight the importance of adequate environmental experiences in early childhood for development. Such research has also shown how the development of certain brain functions and structures is limited to narrow timeframes. If adequate visual stimulation is absent in the first months of life, for example, complex competencies of the visual system (e.g. the recognition of pattern differences) and multi-sensory functions (e.g. the accurate perception of visual and auditory coincidences in a spatial or chronological frame of reference) cannot develop satisfactorily.

This raises the question of whether the development of basic cognitive functioning is also governed by critical periods, in which specific environmental experiences must be undergone so that intelligence can develop optimally and individuals can reach their maximum intelligence level. Evidence against assuming a *narrow* time window for the development of intelligence as early as the first year of life comes from findings gained by studying severely neglected Romanian orphans. Well-controlled studies led by Michael Rutter in the UK and Nathan Fox in the USA (Beckett, Castle, Rutter, & Sonuga-Barke, 2010; Nelson et al., 2007) are compatible with the view that children who are placed in a supportive environment with foster families before their second year of life need not suffer grave impairments to the development of their intelligence.[2] In contrast, long-lasting disruptions to the development of intelligence were exhibited by children who were aged two and over when placed with a foster family or adopted. The conclusions we can draw from this are twofold: first, the time frames for the positive development of intelligence are probably broader than for the development of fundamental sensory functions; and second, the kind of emotionally positive and supportive environment provided by a family is very important during the first two years of life for the development of basic cognitive functioning. Meta-analyses have demarcated a number of other conditions conducive to the development of intelligence. These include aspects of nutrition (e.g. breastfeeding), training courses aimed at giving mothers from poorly-educated backgrounds tools with which they can offer their children a highly stimulating environment at the earliest possible stage, whether or not parents read aloud and interactively with their children, and preschool attendance (Protzko, Aronson, & Blair, 2013).

For a long time, assumptions about the development of basic cognitive abilities in the period from later childhood to adolescence were influenced by a model first proposed by the Swiss biologist and psychologist Jean Piaget (for a concise and informative introduction, cf. Montada, 2002). Piaget's basic idea was that the capacity for abstract thinking increases in discrete stages. Yet this hypothesis has

2 Notwithstanding the above, long-lasting disruptions to emotional and social behaviour were nonetheless observed in the severely neglected children from Romanian orphanages, even for those who had been adopted at a very young age (Kreppner et al., 2007; see also section 5 of this position paper).

not been confirmed by empirical investigations. Time and again, studies show that children are capable of completing logical thought processes in domains well-known to them, whilst being unable to do so in fields with which they are less familiar.

When acquiring knowledge, children do not start from scratch. Paralleling the acquisition of language, genetic predispositions exist that permit children to establish "core knowledge" at a very early stage. This core knowledge includes an appreciation of the basic laws of physics, e.g. that an object follows a downward rather than an upward path if we let it fall, or that a soft object (e.g. a ball) cannot pass through a harder object (e.g. the surface of a table). Evidence of such core knowledge can even be found in babies, by following the direction of their gaze. If one presents babies just a few months old with simple scenarios, they initially watch these scenarios very attentively. If the same scene is then repeated several times, the babies become bored and direct their gaze elsewhere. After this familiarisation (habituation) phase, one now introduces a scene that is similar but contravenes the basic laws of physics (e.g. one in which it appears that a ball is dropped towards the surface of a table but lands underneath instead of on top of it). In this case, the babies are once again captivated by the scenario. Since findings of this kind have been repeated in multiple studies, we may deduce that some knowledge about the environment is innate. Even at a very early age, children can distinguish between the movements made by living organisms and movements induced in non-living objects. Evidence for basic core knowledge of psychology has also been found (Wynn, 2007).

The availability of core knowledge simplifies further learning in a domain. For example, children learn to count without systematic, professional instruction. Core knowledge reaches its limits, however, once the child must acquire knowledge whose origins lie exclusively in the development of human culture. While natural numbers are understood intuitively, schoolchildren usually find fractions much harder to handle. Equally, while basic knowledge of physics helps small children to identify obstacles and discover their environment, it isn't an immediate help in understanding Newton's laws of motion. Indeed, difficulties encountered in the physics class often result from contradictions between intuitive core knowledge and the scientific laws of physics. Educational institutions such as schools must therefore promote learning processes that are not directly supported by core knowledge (see e.g. Pauen, 2012). Whether genetically determined or triggered by environmental influences, disruptions to brain development at the prenatal stage and in early childhood can impact the formation of core knowledge. For persons with autism spectrum disorder, deficiencies in core knowledge can be detected via social interactions, for example (Frith & Frith, 2012). Severe impairments to arithmetic reasoning can also be traced to undeveloped core knowledge about quantities (Butterworth, 2010). With the exception of such pronounced disorders, core knowledge is a universal resource that is available to all children.

The later stages of intellectual development in childhood can also be better described as "know more" than "think better". Successful cognitive development in childhood is revealed in the acquisition of conceptual knowledge that is not available as core knowledge. Beyond the scope of their core knowledge, children are universal novices, which is why they first structure facts and relationships between knowledge elements according to attributes experienced directly and not by prescriptive classification. Children equate weight with "feeling heavy" for example, which is why they would consider a heap of rice as having weight but would regard a grain of rice as weightless. First and foremost, therefore, cognitive development means restructuring one's knowledge, as part of a communicative process of exchange with others (parents, preschool educators, and teachers). Piaget postulated that the structures relevant for thinking must first develop in the human brain before conceptual knowledge is possible. According to his theory, the cerebral structures available at a certain point in time enable – more or less independently of environmental influences – the acquisition of more abstract concepts and the performance of more complex intellectual tasks. Today, a model of social constructivism is assumed, by which thought processes are developed on the basis of the contextual knowledge acquired in collaboration with other individuals. In other words: while the formation of certain cerebral structures is necessary to enable the performance of perceptual, linguistic and intellectual tasks as well as learning and memory, this development is not invariably pre-programmed but takes place in a process of continuous interaction with the environment and the challenges it poses (see sections 2 and 3).

As with language skills and other cognitive abilities, thinking does not develop simply as a result of a child growing older. These skills and abilities develop not only as a result of the presence of genetically determined predispositions but also because these predispositions unfold through environmental influences. For example, structures in the brain relevant for language are present in all humans but will atrophy if a child receives no linguistic input and is not actively encouraged to speak (see section 3). A comparable rule applies to the structures in the frontal lobe, which provide the biological conditions needed for working memory or problem-solving. Interestingly, modern imaging techniques have led us to discover that the largest structural changes during childhood occur in the frontal lobe, the part of the brain that is involved more than any other in the formation and control of behavioural goals, and in the merging of incoming information and existing knowledge. Learning environments for preschool and primary school children can and should feature challenging content, but must also take account of the respective state of development status in setting goals and integrating information.

This new perspective on cognitive development is particularly relevant for the design of primary school learning opportunities. The long dominant, Piagetian viewpoint sometimes led to didactical approaches whose implementation meant that primary school pupils were less challenged than their capacities would have allowed. The opportunity to build up conceptual knowledge that is compatible with – and can simplify – later learning was missed.

To ensure that basic cognitive abilities develop in accordance with individual genetic predispositions, it is necessary that children are raised from birth in a secure and stimulating environment, and are offered educational programmes that foster active use of the intellect at day care, preschool and primary school. Highly adverse conditions – such as may apply in the case of orphans or children from precarious familial circumstances – can be partially corrected by targeted support programmes that stimulate and strengthen both cognitive and emotional/motivational competencies (see section 5 and 6). Yet scientific evidence has not borne out the assumption that targeted stimulation in early childhood should be able to achieve a substantial and lasting increase in intelligence even for children not raised in disadvantaged environments. While some programmes may claim to train general mental capability at various stages of a person's life, convincing proof of their effective and sustained efficacy has yet to be presented. Nor, despite catching the attention of the media, do the claimed transfer effects from working memory training to general cognitive functioning (e.g. Jaeggi, Buschkuehl, Jonides, & Perrig, 2008; Jaeggi, Buschkuehl, Jonides, & Shah, 2011) stand up to critical scrutiny (z.B. Owen et al., 2010; Redick et al., 2013). In a recent meta-analytic review of a total of 23 studies, Melby-Lervåg and Hulme (2013) come to the sobering conclusion that there is no evidence to be found for convincing transfer effects of high-intensity working memory training to cognitive functioning.

4.4 Conclusions

- Basic cognitive abilities develop by means of interaction between genetic predispositions and environmentally-dependent learning processes.
- Although behavioural genetics studies have repeatedly confirmed a high heritability for basic cognitive functioning, this should not be taken to mean that a person's level of intelligence is unchangeably set in stone from birth onwards. The environment crucially influences the unfolding of genetic predispositions. Positive environments boost – and negative ones hinder – the development of intelligence. Genetic predispositions therefore mark out the boundaries within which basic cognitive functioning can develop.
- For a society's intellectual resources to reach their full potential, steps must be taken to ensure that all children's basic cognitive functioning follows an optimum course of development, i.e. that all children should receive encouragement and support in developing their basic cognitive abilities to the maximum possible extent.
- Yet the proper utilisation of the intelligence inherent in children and adolescents from all groups within the population depends not only on satisfying the basic physical needs of younger children. Steps must be taken to ensure that children are raised in an emotionally supportive, cognitively stimulating environment, and acquire a society's dominant language as a result of their natural interactions with other children and adults.
- In the process of capitalising on intelligence reserves, children should not be confronted with inflated and unrealistic demands and expectations, however. Emotional security, stimulating communication and a readiness to accommodate children's interests are the best means of ensuring positive cognitive development.
- Targeted support programmes are especially likely to succeed if they are able to reach children from disadvantaged social backgrounds. Yet fostering intellectual potential – i.e. improving the average performance of a population – does not imply that all children and adults can achieve an identical level of competence. Even with beneficial training and schooling programmes in place, inter-individual differences in cognitive functioning will still persist. The same environments do not make people more similar. Quite the reverse: differences are generally magnified.
- The quality assurance of learning and support programmes is essential to their success.
- As regards educational choices, identifying and supporting the acquisition of precursor skills and core knowledge preparing for the domains of written language, mathematics and the sciences in the first ten years of life is of special importance.

5 Social, emotional and motivational competencies

- A person's social, emotional and motivational competencies determine the way she/he interacts in social relationships, copes with challenges and stress, and achieves success in the pursuit of his/her goals. A core quality here is the capacity for self-regulation.
- Successful management of life's challenges depends on an adequate degree of self-regulation. Aspects include controlling the experience and expression of emotions, adapting to rules, controlling impulsive behaviour and foregoing short-term goals in favour of long-term goals.
- An initial capacity for self-regulation is established in early childhood and fostered by positive developmental conditions. It is largely – although not entirely – independent of intellectual ability.
- The degree of self-regulation achieved in early childhood is closely associated with many aspects of success in later life. Such aspects include academic and career success, income, financial security, social integration and behaviour properly attentive to personal health.
- Factors influential before birth and in early childhood can exert an effect on neuronal and hormonal processes via epigenetic mechanisms, and thus impinge on social, emotional and motivational development – in both a positive and negative manner.
- Suboptimal conditions of socialisation are often the result of economic problems in the family and, as risk factors, exert a negative influence on the development of self-regulation.
- High-risk developmental conditions can be compensated for by supportive environmental experiences, especially if these are already present in early childhood.
- Since experiences in early childhood are especially important for the further development of social, emotional and motivational competencies, interventions aimed at promoting self-regulation competencies should therefore be scheduled as early as possible – and not solely for disadvantaged children.

Social, emotional and motivational competencies are pivotal indicators for successful development, and are established and fostered in early childhood. The prototype of these skills is self-regulation. Social, emotional and motivational competencies comprise the readiness and capability to regulate one's own lived experience and behaviour appropriately, i.e. by modifying one's own goals and situational circumstances. Such competencies are the foundation on which self-regulation is built. In turn, successful self-regulation serves the formation of positive social relationships, the management of challenges and stress, and the pursuit of short- or long-term goals. An adequate level of socio-emotional and motivational competencies is required for successful life management, whether at school, during one's career, in relationships, when raising one's children or in the management of the general circumstances of one's life – such as eating habits, healthcare or safeguarding one's material prosperity. A person's social, emotional and motivational competencies are largely – although not entirely – independent of his/her intelligence.

The development of social, emotional and motivational competencies is closely associated with the child's early experiences and his/her success in dealing with him/herself and others. Many of these early experiences are shaped by the conditions of socialisation in the respective familial and extrafamilial contexts, and the challenges each child faces as an individual. When a child attends day care for the first time, for example, she/he must accept that it will partially supplant the emotional security and safety of the family home. While this can be perceived as a threat on the one hand, it also offers the opportunity to share new experiences with one's peers. The extent to which the child can tolerate separation from his/her parents, play and cooperate with others, handle group dynamics and negotiate to resolve conflicts, learn to share with others, cope with competition and animosity, communicate his/her feelings and develop empathy for others is important both for the development of social-emotional and motivational competencies, and for their availability in later life, i.e. in adolescence and adulthood.

The success of this process is dependent on the child's differential characteristics, however: these may have been formed by genetic predispositions, by individual experience and by the reciprocal interactions between predispositions and experiences gained within the social environment. Whether – and when –critical periods apply to an individual's developmental process here is not yet known in detail. Yet there are many indications that even negative environmental influences experienced at a very early stage can trigger long-term developmental disorders. These then manifest themselves as deficiencies in socio-emotional and motivational competencies (e.g. Kreppner et al., 2007; see also section 2, box 2-2).

5.1 General developmental phenomena

Temperament. For a long time, it was assumed that, even in very early childhood, genetically predetermined differences in temperament exist that channel the further development of socio-emotional competencies. If "temperament" is understood as a behavioural style with emotional, motor and attentional components, which is genetically preordained, then this does not accommodate the fact that "behavioural styles" in preschoolers are not especially stable in their development, i.e. they respond to the influence of individual socialisation conditions. As aspects of temperament and self-regulation, predispositions such as behavioural control and behavioural inhibition also develop through the interplay of genetic and environmental factors (Rothbart & Sheese, 2007).

Attachment patterns. A central phenomenon for the early establishment of socio-emotional (and presumably behavioural) competencies is the formation of *attachment* (Groh, Roisman, van IJzendoorn, Bakermans-Kranenburg, & Fearon, 2012). Attachment behaviour in the first three months of life is characterised by non-specific signalling of conditions of needs. In a second phase, usually from the age of about three months, children begin to focus more on the socially oriented expression of their needs and emotions. The first actual selective formation of an attachment occurs in the third phase, from the age of six months onwards. By the end of the first year of life, comparatively resilient differences in individual attachment patterns can be discerned. Four such attachment patterns have been identified as representative: (1) secure; (2) anxious-avoidant; (3) anxious-ambivalent; and (4) disorganised. In the long run, the most favourable attachment pattern for future development is *secure attachment*, which lets a child rapidly initiate communicative contact with other people as it matures. An *anxious-avoidant* attachment pattern impedes the establishment of contacts, while *anxious-ambivalent* is often accompanied by emotional outbursts and “immature” communication patterns (e.g., limited play, anxious explorative behaviour, inability to let oneself be comforted). Entirely capricious – and also showing a domineering streak – is the communication pattern shown by the *disorganised* attachment pattern. Since this pattern is observed more frequently in children from socially precarious backgrounds, its prognostic value must be viewed as problematic.

The parents’ own attachment patterns are often passed on to their children. Sensitive caring behaviour on the part of the parents is associated with a secure attachment pattern on the part of a child. Attachment patterns can be regarded as competence structures and are prerequisites for the social development and regulation of emotion. Babies and infants have not yet mastered appropriate self-regulation. In securely attached children, attachment behaviour and self-regulation is usually appropriate to their developmental age. In early development, effective regulation of negative emotions and stress is usually organized by the primary caregiver (external regulation). Children with anxious-avoidant attachment do not have recourse to this strategy. They avoid seeking out support and communicating their negative emotions; instead, they attempt to use distraction to regulate the expression of their own emotions. That said, the distraction from emotionally stressful objects can nonetheless prove to be an effective strategy for regulating one’s individual negative emotions. An anxious-ambivalent attachment describes an ineffective social regulation of emotion: contact with the primary caregiver does not have a regulatory effect. The disorganised attachment pattern leads the child to expect only minimal competence in the regulation of emotion.

Attachment experiences in early childhood also organise the development of self-regulation competencies, which are viewed as the foundation of volitional competencies (Heikamp, Trommsdorff, & Fäsche, 2013). In psychology, the term “volition” designates the formation, maintenance and activation of intentions and goals. The quality of *caregiving in early childhood* (particularly the sensitivity of caregivers) leads to experiences that also have an effect on self-regulation. Children who personally experience the support and comfort of their primary caregivers in the event of distress, grief, suffering and other negative emotions exhibit more successful socio-emotional development than children who feel left alone with their anxieties. Whatever the cultural background, parental sensitivity and warmth (expressed in the respective culturally-appropriate forms) have been shown to create highly favourable conditions for developing appropriate self-regulation (Trommsdorff, 2012). Ideally, socialisation conditions should be adapted to the pertinent cultural context and the child’s individual traits, and should be oriented towards the development of self-regulation.

Self-concept. The development of a self-concept, primarily consisting of self-perception and evaluation of one’s own motives and abilities (self-efficacy; Bandura, 2001), is a prerequisite for the development of self-regulation. An individual’s self-concept comprises his/her thoughts, feelings and judgments concerning the self in relation to material circumstances (body, possessions) and to cognitive, social and immaterial properties (including capacities in a range of subdomains, relationships with other people, values and attitudes). The self-concept is viewed as a core, largely stable personality trait, which develops in accordance with the respective attachment patterns and which determines behaviour in many life domains (e.g. in challenging situations). An early sign of the formation of a self-concept is offered by an infant’s ability to recognise his/herself confidently in a mirror or photographs. While this can be observed in infants as young as 12 months, most children display confident, fully-developed self-recognition at ages between 18 and 24 months. Initial signs of this are seen in a growing comprehension of the significance of intentions, feelings and thoughts – both of others and of the child him/herself (Harter, Waters, & Whitesell, 1998).

From the age of about 3 onwards, the child gradually develops the ability to describe his/herself. Typical self-descriptions of children of this age feature unrealistically positive portrayals of their own physical skills and abilities, and of their existing social relationships. Regarding estimates of their own abilities, children tend to remain highly optimistic into the first school year. Unsurprisingly, this positively affects the child's motivation to perform. They believe they can achieve almost anything if they simply try hard enough; they do not compare their performance with that of others, and do not draw on even repeated instances of failure when modifying overestimates of their abilities.

Only when children start engaging in social comparisons of their abilities and physical characteristics – usually from the age of 7 onwards – does this unrealistic self-description gradually give way to a self-concept that is more nuanced and closer to reality. The self is increasingly described in relation to other children and by including objective criteria (e.g. grades and feedback on performance provided at school).

5.2 Self-regulation as a prototype of socio-emotional and motivational competencies

Self-regulation in the sense of controlling impulses, the self and behaviour, or self-discipline, is one of the competencies with provable relevance and predictive value for the longer-term developmental and educational success of children and adolescents. Self-regulation comprises emotional regulation and both behavioural and inhibitory control (cf. Karoly, 1993). As a volitional competency, self-regulation enables or simplifies goal-oriented action even despite internal or external resistance or distractions.

Emotional regulation (controlling the experience and expression of emotions) is necessary for the development of social competencies, as they are increasingly visible in peer interaction and in behaviour at school. *Behavioural control* encompasses impulse control, delayed gratification and adaptation to rules. *Inhibitory control* relates to the planning and initiation of actions, and ensures sufficient critical reflection of action options. At preschool age, inhibitory control is considered to be well established if a low degree of impulsiveness and externalisation is observed across representative samples of the child's behaviour.

A core characteristic of self-regulation lies at the heart of following long-term goals, namely the ability to direct and focus one's attention. In preschool (i.e. five-year-old) *children*, the volitional direction of attention is accompanied by an improved ability to delay gratification. In turn, the ability to delay gratification in early childhood can be a powerful predictor of self-regulation in *adolescence*. This manifests as a greater tolerance to stress and frustration, superior socio-cognitive, verbal and academic performance, greater attentiveness and more pronounced planning skills (Mischel, Shoda, & Peake, 1988). As an example, superior abilities in self-regulation allow adolescents to handle challenges to their emotional regulation and attitudes to risk (Steinberg et al., 2009). The ability to delay gratification as measured at preschool age remains relatively stable and can explain individual differences in self-regulation even 40 years later (see box 5-1; Casey et al., 2011). Self-regulation also promotes the development of emotional and social competencies such as empathy, cooperation, and prosocial behaviour.

5.2.1 The relevance of self-regulation for academic success and risk-taking behaviour

Self-regulation is not only relevant for the organization of emotional and social behaviour: it is also an important prerequisite for long-term academic success. Children and adolescents who are able to regulate their emotions and bring them in line with social requirements not only turn out to be more socially competent and popular; their cognitive performance is also often superior. Indirect links may therefore be surmised between self-regulation and both intelligence and academic success (McClelland & Cameron, 2011; Richland & Burchinal, 2013). For example, there is evidence that inferior impulse control heightens the risk of failing to fully deploy existing cognitive capacities. This has a negative impact on academic success (Duckworth & Seligman, 2005). Self-regulation and academic success are closely interrelated, since children who start school with superior self-regulation are able to establish better relationships with teaching staff and have generally more positive attitudes towards school. At primary school, they stand out on account of their superior grades and social competencies (less externalisation of negative emotions in the sense of showing less aggression, disobedience and irascibility). Fostering self-regulation also boosts the levels of performance attained by potential school drop-outs (Ursache, Blair, & Raver, 2012).

If early self-regulation problems – such as aggressiveness, impulsiveness, etc. – occur before starting school, this need not yet imply an unfavourable prognosis over the long term, since such behavioural patterns are at that time still fairly unstable. For example, neither a stability of level nor differential stability has been demonstrated for aggressiveness as a behavioural style at preschool age. Accordingly, the degree of aggressive behaviour observed in a child at a particular point in time is largely not valid to predict the degree of aggressiveness observable at a later point in time. For such behavioural patterns, it seems likely that situational circumstances (and their subjective perception) are of greater importance than personal behavioural dispositions. Studies have also shown how genetic dispositions towards aggressiveness tend to manifest stability in the phenotype if environmental conditions are unfavourable, but not if they are favourable. That is, a favourable environment can permanently reduce a child's tendency towards aggressiveness. However, an elevated risk for externalising negative emotions and for an accretion of behavioural problems is especially increased by a child's failure to adequately develop self-regulation skills even after entering school.

The significance of self-regulation is also made very clear by the widespread phenomenon of attention deficit hyperactivity disorder (ADHS). Children with ADHS typically have difficulties with the management of anger and frustrating experiences. Although these children know full well that impulsive, angry responses are neither desirable nor appropriate and their ultimate goal is to suppress such outbursts, they are not always successful in doing so. In situations that trigger anger (e.g. being frustrated by a school exercise or teased by a fellow pupil), such children tend to respond with uncalled-for, impulsive outbursts of rage (Hinshaw & Melnick, 1992).

Longitudinal studies have repeatedly shown that successful self-regulation in childhood is highly significant for subsequent educational success, and for health and risk-taking behaviours over the life-span (Moffitt et al., 2011; see box 5-1). In adolescence, momentous biological and social changes occur, whose – generally positive – effects are felt most

Box 5-1: Impact of self-regulation in childhood on criteria for success in life

An extensive longitudinal study in New Zealand recruited over 1,000 children, who were examined several times for over 30 years (see also section 2, box 2-2). A variety of risk factors for socialisation were identified. One key predictor for academic achievement, mental and physical health, and success in adult life in general was the degree of self-regulation achieved in childhood (Moffitt et al., 2011).

Self-regulation in childhood was accessed in the first ten years of life at various points in time and by using several methods (such as behavioural observation and appraisals from parents and teachers) with the aim of measuring aggressive, hyperactive behaviour, attention spans and impulsivity. These data were summed up to form an aggregate measure of self-regulation (from 1 = low to 5 = high self-regulation) that was used to assign study subjects to one of five groups. When subjects reached the age of 32, interviews were conducted and objective measurements were taken to investigate numerous variables concerning health (mental, physical), income, financial problems or financial security and general living circumstances. Objective data on participants' criminal tendencies were also collected from New Zealand's court records. The figure below illustrates a number of the correlations observed.

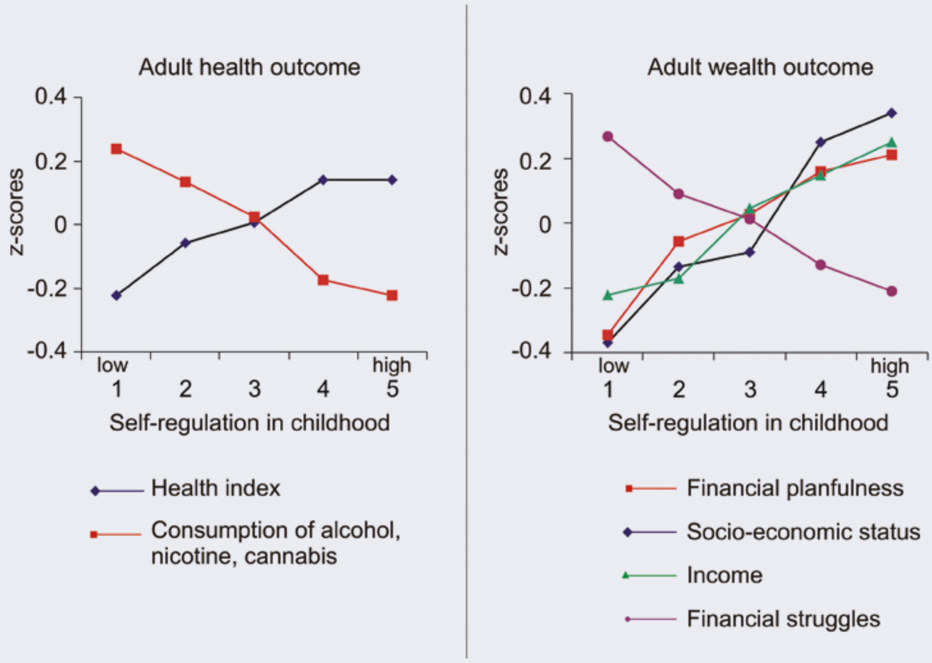


Figure box 5-1-1 (data from Moffitt et al., 2011). Associations between self-regulation in childhood and a range of variables for success in adult life. Left: indicators for physical and mental health. Right: indicators for financial circumstances.

Especially striking are the strong gradients between self-regulation and later success in life, observable for almost all indices. The greater the self-regulation in childhood, the greater the increase of positive indicators for success in life during the individual's later development, i.e. better health, higher income and fewer financial problems. The same applies to several other indicators not shown here, such as delinquency and the degree of social integration.

Many studies have shown that precarious familial circumstances in childhood are linked in particular to disadvantageous attachment patterns and inadequate self-regulation in children. This link has also been studied in more detail. The figure below offers a number of typical variables for physical and mental health (body-mass index, tooth decay, frequency of alcohol abuse diagnosis) at 26 years of age. These indicators were evaluated in relation to social status achieved as well as status mobility. The individual's own status in adulthood was either the same as the parents' status (remaining high or low over the long term) or had changed due to mobility (rising = mobile ↑ or falling = mobile ↓). The data show that unfavourable socio-economic circumstances in childhood ("low" or "rising" groups) are associated with considerably higher risks to health in adulthood than is the case for favourable conditions ("high" or "falling" group). This pattern of findings also applies to other variables such as blood pressure, physical fitness, dental hygiene and smoking. One may presume that these effects are conditional on differences in the socio-emotional and motivational competencies grounded in self-regulation. Importantly, risks remain elevated even for rising mobility, i.e. the effects of experiences undergone in early childhood persist into adult life and are only partially compensated for by later experiences and the adopted lifestyle.

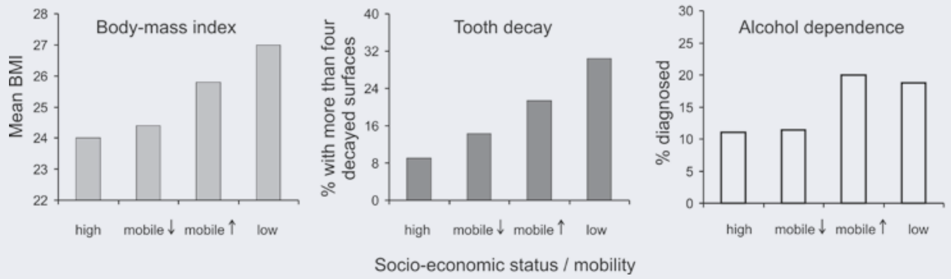


Figure box 5-1-2 (data from Poulton et al., 2002). Correlations between socio-economic status in childhood as well as later socio-economic mobility and indicators for physical and mental health.

strongly on planning ability and frustration tolerance as components of self-regulation (Steinberg et al., 2009).

5.2.2 Conditions of emergence for self-regulation as a competence and motivation

The development of self-regulation involves the interaction of socialisation factors at several levels (Bronfenbrenner, 1979). Furthermore, the individual manifestation of self-regulation competencies also depends on the respective socio-economic and cultural environment (Weiland & Yoshikawa, 2011). The interactions between cultural, socio-economic, familial, academic and biologically anchored conditions are multifarious and do not permit a straightforward prediction of successful self-regulation. Even prenatal risk factors – such as the mother's personal experience of violence in pregnancy – can mould the child's socio-emotional experience and behaviour (Radtke et al., 2011) and influence its development into adulthood. The same applies for familial experiences in early childhood (Groh et al., 2012) and later at school. Depending on the interplay of context and the child's biological predisposition in terms of temperament, the effects of the circumstances of socialisation can vary throughout the child's development. For example, the significance of authoritarian or supportive parental behaviour varies in terms of its impact on self-regulation in accordance with culture, age and gender (Trommsdorff & Heikamp, 2013; Trommsdorff & Rothbaum, 2008).

Developmental conditions for inadequate self-regulation

Factors influential before birth and in early childhood can exert an effect on neuronal and hormonal processes via epigenetic mechanisms (see section 2.5), and thus exert a positive or negative effect on socio-emotional and cognitive development (van IJzendoorn et al., 2011; Belsky et al., 2007). Suboptimal socialisation conditions are often the result of economic problems in the family and, as risk factors, exert a negative influence on the familial context (mediated via conflicts, depression, stressful experiences for parents and children). As such, they also affect self-regulation competencies and thus can influence aspects such as academic and career success, social adjustment and health. Evidence from longitudinal investigations has shown that precarious familial circumstances in childhood, plus their common corollary of inadequate development of competence in self-regulation or behavioural control, are associated with elevated health risks, limited career success and a higher incidence of psychiatric illness (e.g. Moffitt, Caspi, & Rutter, 2006; box 5-1, figure 5-1-1). The fact that even upward mobility in later life cannot compensate for shortcomings in self-regulation acquired in childhood is a convincing example for the significance of competencies acquired in early childhood for (e.g.) a person's later medical history (cf. figure box 5-1-2; Poulton et al., 2002).

As an origin of insufficient self-regulation, high-risk socialisation circumstances can also result from problematic attachment experiences in early childhood. Anxiously attached children are not able to use primary caregivers for the regulation of their negative emotions: they respond more strongly to stress and have an increased risk of externalising behaviour (dysregulation) (Groh et al., 2012). Yet if high-risk developmental circumstances are accompanied by supportive and compensatory environmental experiences – especially occurring in early childhood – they can prove to be reversible, not least as a result of interactions between environmental experiences and biological processes (Ellis et al., 2011; van IJzendoorn et al., 2011) (cf. also section 2).

5.2.3 Support and intervention possibilities

Adequate protective factors can foster resilience (Masten, 2014) in children when coping with stressful situations and negative environmental factors. This is especially important for children growing up in high-risk environmental circumstances. Groups at high risk include children without a reliable primary caregiver, children of overburdened parents, children of impoverished and poorly-educated parents, and children who experience domestic violence or a lack of parental care and warmth, or those who grow up in disadvantaged neighbourhoods. Empirical studies confirm that such factors, coupled with early negative experiences in a familial context, present risks that – mediated by parent–child relationships – exact a toll on later executive functions (Rhoades, Greenberg, Lanza, & Blair, 2011). The cause and effect relationships between parental behaviour, the extent of the child's self-regulation and the positive socio-emotional competencies contingent on the latter are multifarious and still remain to be elucidated in detail. That said, the long-term consequences of parental social status and education – and of domestic violence, stress and abuse in childhood – have been verified for the degree of self-regulation, e.g. behavioural control, later achieved (Caspi et al., 2005).

Longitudinal studies substantiate the long-term developmental ramifications of a range of childhood self-regulation competencies for the individual's further development in adulthood (health, prosperity, criminality) (Moffitt et al., 2011; see box 5-1). Such studies supply evidence of a close association between the degree of self-regulation achieved in childhood and indicators for health, drug use, financial prosperity and social integration as surveyed in adulthood. The greater the degree of self-regulation between the ages of three and five the greater will be the success in later life, as measured in adulthood using the afore-mentioned indicators.

Familial processes (e.g. social and cultural capital, parent–child relationship) and *extrafamilial conditions* (e.g. type of caregiving offered at day care and preschool) play a key role as both risk and protective factors for the development of self-regulation and, in turn, for associated social and emotional competencies. However, one must also take into account that the behaviour of caregivers may also depend on their attitudes and experiences, and on the child's behaviour, as well as on other contextual – e.g. economic – conditions.

As a result, intervention programmes should take into account both intra- and extrafamilial circumstances as well as the child's biological predispositions (e.g. sensitive phases) (Shonkoff & Philips, 2003). Special requirements pertain to intervention programmes targeting the integration of migrants, since the socialisation circumstances of migrant children may be characterised by conflicting cultural values and norms. Interventions should take place as early as possible and according to sensitive periods in the child's development. Orphans temporarily being raised in children's homes benefit from early adoption and integration into supportive surroundings. Proceedings of The Leiden Conference on the Development and Care of Children without Permanent Parents (2012) include recommendations for successful interventions using alternative family structures. The *Tools of the Mind* programme has proven to be a comparatively successful intervention programme for children from economically disadvantaged families (Diamond, Barnett, Thomas, & Munro, 2007; see box 5-2).

Interventions do more than help a child follow a positive path of development. Some early support programmes also set their sights on long-term socio-economic effects, in cases where investments in cognitive, emotional and social competencies for children – especially those from disadvantaged families – aim to recoup benefits for society as a whole (Berlin, 2011). Here, economists' interests focus on "non-cognitive competencies" and, in particular, the role of self-regulation for social adjustment, academic or professional achievement and health-related behaviour (Heckman, 2006) (cf. section 6). In each case, these competencies are intended to help maximise the "benefit" for society as a whole, which has until recently primarily been interpreted as economic growth. Yet the concept of economic growth as the sole arbiter of benefit is now being challenged. As a result, a whole series of other indicators for societal development is being discussed, including quality of life and education (see also: Human Development Index, "Gross National Happiness"). Other indicators significant for successful coexistence within a free and democratic society should also be taken into account. These include a culture of debate, information literacy (and access), understanding of the law and tolerance. Such variables are presumably interconnected with the attributes of socio-emotional and motivational competencies as mentioned in this section, as well as with cognitive functioning. Yet one should also note that these kinds of relationships have received minimal attention in sound empirical studies to date.

The plasticity of self-regulation competencies – i.e., the capacity to be shaped by targeted interventions – has also not been adequately researched. A number of intervention programmes have furnished evidence of long-term positive effects from early support on socio-emotional and academic development. Further clarification of these interventions' mechanisms must still be provided, however. While taking into account the individual circumstances of children as well as parental characteristics, and while catering to requirements of society at large, interventions should aim to minimise developmental risks (particularly in the case of socio-economically deprived families) while also fostering developmental potential. In each case, care should be taken to accommodate the *context of prior development and of the interventions themselves.*

5.3 Conclusions

- The development of social/emotional and motivational/volitional skills is crucially dependent on the formation of a secure attachment with a primary caregiver in early childhood. In a stable family, these persons are usually the parents: their sensitivity and warmth creates positive, culturally appropriate conditions for socialisation. A secure attachment aids the child in forming a positive and realistic concept of the self, and in developing greater proficiency in self-regulation.

- Such self-regulation competencies express themselves in emotional regulation and both behavioural and inhibitory control. That is to say: negative emotions are not externalised directly, and the individual can make

Box 5-2: Promotion of executive functions and self-regulation competencies in childhood – the *Tools of the Mind* programme

An influential programme of intervention, the *Tools of the Mind* programme (Tools of the Mind Staff, 2012) is based on reflections of the Russian psychologist Vygotsky on the development of executive functions in childhood. It utilises a series of exercise modules that are intended to promote the development of functions relating to inhibitory control, working memory and cognitive flexibility. Developed in Denver (CO, USA), the programme has been in use for over 17 years in the USA and Canada as a support resource for children of day care and preschool age, and its use has also been accompanied by systematic research programmes. One crucial finding is that the long-term promotion of executive functions and the transfer of generalised effects to contexts in which training has not yet taken place are observed only if the respective functions are intensively and continuously supported and strengthened very early on in development. Training module content includes tasks in which children must resist immediate desires and temptations or in which they must focus their attention and ignore distractions. Further tasks stimulate intellectual flexibility, requiring children to change their point of view or habitual behaviour, while other tasks train the capacity of the children's working memory. In all, the course includes over 40 different modules for training executive functions.

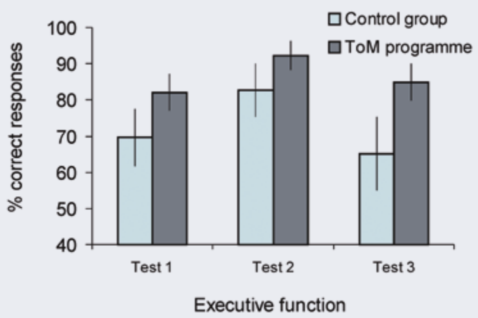


Figure box 5-2 (data from Diamond et al., 2007). Performance differences between children participating in the *Tools of the Mind* (ToM) programme and children in the control group, who experienced typical day care only. Differences were seen in a range of experimental tests that were utilised to record the children's executive functions. One example of a positive executive function is a child deciding to ignore an appealing object in order to complete a task.

As an example, we cite one experimental study aimed at assessing the programme's success (Diamond et al., 2007). Preschool children (mean age 5.1 years) from a town in Canada with a majority of households in the low-income bracket were randomly assigned to two groups: the first group of 85 children was to receive regular training from preschool educators qualified in the *Tools of the Mind* programme, while a second control group of 62 children received day care typical for the area. The groups were parallelised with regard to a wide range of markers (sex, ethnicity, household income, mother's level of education).

At the end of the first and second year of the study, children completed a series of tests designed to measure the degree of executive control. Children had not encountered the tasks before, during their previous training. One aspect assessed was whether children could complete an agreed task without letting themselves be distracted. By comparing conditions with and without the distractions, it was possible to establish a degree of "distractibility" for the two study groups. The figure above gives examples of the superior performance achieved by the *Tools of the Mind* group in three tests during which distractions irrelevant to the tasks appeared, requiring the inhibition of spontaneous behavioural tendencies. A second analysis showed that the performance in these tests correlated significantly with a number of academic performance measures, i.e. the better the self-regulatory behaviour shown in the test, the better the performance in the academic tests. These tests included vocabulary tests as well as tests of mathematical ability, literacy and reading comprehension. Follow-up studies must now show whether this training can also affect general life management in adolescence and adulthood, i.e. whether it can also have a positive impact on variables such as physical and mental health, career success and social integration.

goal-oriented decisions between conflicting behavioural choices and can inhibit impulsive behavioural tendencies – such as when choosing to delay gratification. Empirical studies show that the degree of proficiency in self-regulation observed in childhood reliably predicts the course of later development in adolescence and adulthood in terms of academic and career success, social adjustment, physical and mental health, socioeconomic status and prosperity. The level of self-regulation competencies decisively shapes an individual's overall success in life.

- Groups at particularly high risk of developing inadequate self-regulation competencies include children without a reliable primary caregiver, children of overburdened parents, children of impoverished and poorly-educated parents, and children who experience domestic violence or a lack of parental care and warmth, or who grow up in disadvantaged neighbourhoods. For children in these risk groups, particular commitment must be shown in the form of support programmes, so as to encourage the development of self-regulation competencies. Programmes based on the *Tools of the Mind* model (see box 5-2; Tools of the mind staff, 2012) appear promising in this context.
- Longitudinal studies have shown that the experiences of early childhood have far-reaching implications for the further development of socio-emotional and motivational competencies. Appropriate interventions aimed at fostering executive functions and self-regulation competencies should therefore be planned as early as possible, and not solely for disadvantaged children. Institutional programmes should be used to actively promote support for individual socialisation – yet without levelling out individual differences. Awareness should be raised among both parents and teachers of the need to recognise the importance of self-regulation and its corollary social, emotional and motivational competencies, and to foster these abilities.

6 Perspectives from the economics of education and educational sociology

- The economics of education views educational interventions as a production process, and assesses both the impact of this process on the individual development of cognitive and non-cognitive skills and its return on investment (ROI).
- Several intervention studies, largely conducted in the US, show that the ROIs for educational investments are typically maximised if they are of exceptional pedagogic quality and applied at early stages during development.
- While investments in later phases can also be effective, the cost-benefit ratio declines in relation to the age of the beneficiary. The most relevant time for educational investments is therefore early childhood – especially for children from disadvantaged backgrounds.
- Coupled with their particular efficiency, early educational investments also have considerable potential to increase educational equality within a society.
- Educational sociology investigates the sociostructural factors influencing decisions taken for or against certain educational measures and the consequences thereof.
- Educational choices are determined not only by differences in ability and performance due to a child's social background (primary effects of social origin), but also by class-specific decision-making behaviour resulting from different values being placed on the costs and benefits of educational options (secondary effects of social origin).
- The significance of primary and secondary effects of social origin varies depending on the socio-cultural groups involved (e.g. level of education, social status, migration status). If primary effects are pronounced, early childhood education and care services and all-day schools, etc. should act to balance out a lack of potential for parental encouragement and support. Where secondary effects are strong, interventions to cut educational costs for low-income families or raise awareness of the prospects for success offered by educational options should be considered.

6.1 The spectrum of research in educational sociology and the economics of education

One approach taken by the economics of education is to systematically assess the effects achieved by various educational, developmental and socialisation interventions. In terms of methodology, these kind of impact analyses face the particular challenge of systematically controlling for other non-measured or non-observable differences. One particular aspect that must be considered is (self-)selection as regards certain programmes and interventions specific to education (see section 6.4).

The economics of education also analyses the efficiency of specific educational interventions. Such analyses of efficiency are of fundamental importance in light of the paucity of resources at a number of levels. In considering resource scarcity, the economics of education adopts a different perspective to other approaches in empirical educational research (e.g. teaching and learning research in pedagogics and psychology). Efficiency analyses evaluate the processes and interventions of educational policy in terms of whether the result achieved could have been obtained by deploying fewer resources or whether a superior result could have been achieved by using the same set of resources. Such analyses use a broad interpretation of "resource scarcity", i.e. not only in the sense of monetary policy, but also in the sense of individual restrictions in the investment of time (i.e. also considering the opportunity cost of choices).

In the economics of education, the significance and impact of education is investigated from both a macro- and microeconomic perspective. In macroeconomic models, education is considered from the perspective of a national economy's human capital as a core driver of economic growth. By taking into account the qualitative dimensions of human capital (as documented by the competencies found in schoolchildren, for example), models from the field of growth theory can show that investment in human capital results in the enjoyment of substantial macroeconomic returns (cf. Hanushek & Kimko, 2000). In contrast, studies focusing solely on the quantitative dimension of education (such as the number of years of schooling, for example) have produced mixed findings, however (for a summary of such results, see e.g. Wolter, 2001). The qualitative dimension of human capital is often assessed using the cognitive abilities of schoolchildren, as documented in international studies comparing pupils' performance. Other macroeconomic approaches have also been taken, which map out the significance of basic cognitive abilities in terms of technological progress or use macroeconomic intelligence markers to chart the health of the overall national economy.[3]

Macroeconomic models assume a macro factor of "human capital" in order to compare separate national economies in terms of their human capital resources. They do not focus on individual educational processes, however. This is the realm of microeconomic studies, which consider educational processes at the level of the individual. Such studies view a child's development as a (production) process that requires specific inputs (such as stimulation or caregiving) at specific times. The end result of this process is the development of individual skills. Here, economists distinguish between cognitive and non-cognitive skills (e.g. motivation or self-regulation, cf. section 5). This latter set of skills has been addressed more fully in recent research on the economics of education and labour economics (e.g. Carneiro, Crawford, & Goodman, 2007; Bowles, Gintis, & Osborne, 2001), following a long period focusing solely on cognitive aspects.

Today, sociological educational research concentrates primarily on the availability of and reasons for educational choices. These include decisions for or against education and care services, the choice of secondary school, professional training options, a decision to take a school-leaving certificate or college degree, the continued pursuit of educational goals in later life or participation in continuing professional development. Decisions vary widely by sociostructurally differing group. Furthermore, variations specific to social origin occur even in cases where children exhibit comparable levels of ability. More work is therefore needed on social groups' educational aspirations, expectations of success and opinions on the costs or benefits of qualifications, so as to clarify their relevance for educational inequality. Moreover, while such decisions tend to gain in importance only in later childhood and adolescence, it is abundantly obvious that the foundations underlying such decision-making are co-established by socialisation processes in early childhood (e.g. by the level of language proficiency achieved, see section 3).

3 These include analyses from the field of psychology, such as Rindermann & Thompson (2011).

6.2 The fundamental importance of educational investment in early childhood

One issue studied by education microeconomists is to analyse the degree to which an individual experiences sensitive periods in which specific environmental aspects must be present to ensure the development of personal skills (cf. chapter 2). Skills are self-productive: that is, an acquired skill amplifies the potency of later inputs (cf. Cunha & Heckman, 2007). On the whole, recent research in education economics highlights the superior efficiency of experiences gained earlier in life while stressing that the return on educational investments is then at a maximum compared to later phases and decreases with advancing age (see figure 6-1). This association has been studied in particular for Afro-American children from disadvantaged families (cf. Heckman, 2006; Heckman, 2007). On the basis of these longitudinal findings, and from a lifespan perspective, it appears particularly efficient to implement educational investments in early childhood, especially for children from disadvantaged or poorly stimulated family backgrounds. As regards disadvantaged children, these investments are not only especially efficient, but are also advisable in the light of considerations about social justice, since they work to increase the overall educational equality in a society (cf. Heckman, 2006). Educational investments made at a later point in an individual's life frequently involve a conflict of interests between intervention efficiency and equity considerations. In young adulthood, for example, it would be efficient to prioritise investments in further education for pupils with excellent grades. On the other hand, reasons of educational equality would recommend investing in the education of young adults without a school-leaving certificate.

Following a long period in which such studies were primarily conducted in the US and UK – and often for highly specific programmes – more work is now being done in the evaluation of universal programmes, such as the expansion of early childhood education and care services in Scandinavian countries. One example is the study conducted by Havnes and Mogstad (2011). They evaluated a reform of Norway's early childcare system implemented during the 1970s. This reform led to a significant expansion of participation in publicly-funded preschool educational facilities. Overall, this expansion of the system providing childcare and early education is associated with improved school-leaving qualifications in early adulthood, greater success on the job market and a reduction in social service dependency (cf. Havnes & Mogstad, 2011). The data also showed that disadvantaged children (especially children of mothers with a low level of education) benefited most from the early childhood education and care services.

Although economists highlight the superior efficiency of educational investments made in early childhood, this does not mean that they consider investments made at a later point in life as ineffective or economically inefficient (cf. section 2.4). Even considered from the lifespan perspective, investments made in education at a later point in time may also "pay their way". Empirical studies in education-

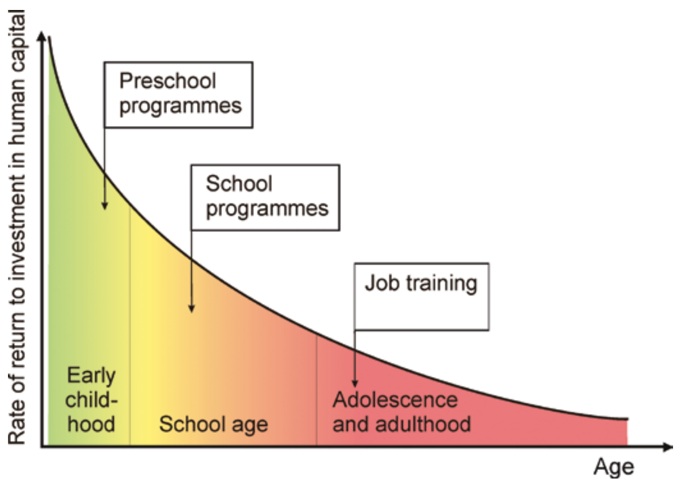


Figure 6-1 (modified from Heckman, 2006). Lifespan perspective on educational returns of investment (human capital).

al research from a range of disciplines in the social sciences have indeed furnished proof of the positive effects of educational programmes – even those implemented later in life. Yet the effect sizes reported are highly variable. In general, we see that the return on investments is higher the earlier they are implemented in early childhood, so as to ensure that children can follow a successful developmental trajectory and socialisation. Investments should therefore be made in early childhood, so as to increase the profitability of later educational investments. This finding is crucially dependent on the self-productivity of abilities and humans' high capacity for learning, as well as the plasticity of the nervous system in early stages of development. Moreover, from a cross-sectional perspective, the modern national economy will find it both efficient and effective to invest in the education of adolescents and adults. This is a particularly significant requirement, since individuals who were excluded from educational investment in early childhood can still benefit from educational programmes that target adolescents and adults. While the following sections will tend to focus on analyses from the field of education in early childhood, this should not be taken to mean that later investments in education are neither profitable nor economically efficient per se.

6.2.1 Studies on the efficiency of early childhood education and care programmes: cost–benefit analyses

The higher profitability of educational investments in early childhood is supported by findings from neurobiological and psychological research. In empirical education economics, these findings stem from numerous studies of effectiveness (cf. Camilli, Vargas, Ryan, & Barnett, 2010; Nores & Barnett, 2010 and Barnett, 2011) and on analyses of efficiency in particular. Studies of efficiency, which examine data on individuals to assess the impact of educational investments, have to date been conducted primarily in the US and the UK (cf. overview provided by Barnett, 2011; Karoly, 2012; Mervis, 2011). Such studies largely evaluate the costs and benefits of highly-specific early education programmes. The methods used contrast the costs of specific interventions with utility components assigned a monetary value. This evaluation of discrete utility components constitutes a major challenge, which is associated with a plethora of difficulties and assumptions. Ideally, all measurable utility streams should be both recorded and evaluated – i.e. also including effects resulting from improvements in an individual's state of health or reductions in his/her delinquency.

A further challenge facing such analyses is the problem of evaluating not merely short-term utility but also the long-term benefit – and, ideally, the benefit enjoyed over a person's entire lifetime. Today, such studies also consider the later success of individuals on the job market as well as other elements of measureable benefits – such as a lack of welfare dependency, good health and a low rate of delinquency. Considered from the point in time of the investment, it can generally be said that the value of a future benefit decreases the later it occurs. In the context of socialisation in early childhood, cost–benefit analyses must therefore discount all utility components occurring after the intervention over the period during which the cost is incurred (for a detailed review of the opportunities and challenges of cost–benefit analyses in early childhood studies, cf. Karoly, 2012).

For the most part, the available cost–benefit analyses of educational interventions in early childhood have assessed specific programmes for certain target groups with a limited regional scope (e.g. Barnett, 2011). At the same time, these programmes are of excellent pedagogical quality, not only providing extrafamilial education and care but ensuring parental involvement as well. In terms of study design, several programmes are modelled as convention-

Box 6-1: The *Perry Preschool Project:* a study to identify the short-, medium-, and long-term impact of early childhood support programmes

Worldwide, the *Perry Preschool Project* is probably the most famous research project examining the impact of a pedagogic intervention in early childhood. Launched in 1962 in the city of Ypsilanti in Michigan, USA, the study continues to run to the present day. Lasting between one and two years, the intervention was designed to provide support to socially disadvantaged children aged 3–4 and their families. The children participating in the study all had a low IQ (of less than 90) when the study began and came from families experiencing precarious economic circumstances. At the age of 3–4 years, the children were randomly assigned to a treatment and a control group. The treatment group received a very high-quality support programme (2.5 hours of support daily in a dedicated facility, given by trained and qualified staff, plus additional house visits to the family).

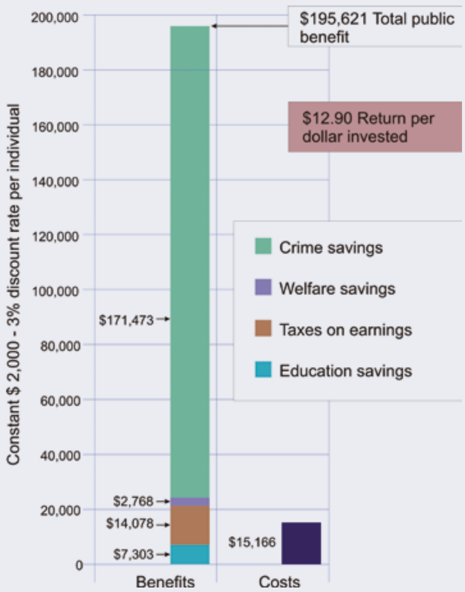


Figure box 6-1 Overall economic benefits and costs of the *Perry Preschool Project* (after Schweinhart et al., 2008).

A total of 123 children participated in the study, and were tested and interviewed annually up to the age of 11. Since then, further tests and interviews have been conducted – involving almost all of the original study participants. In later years, data from school statistics, plus welfare data, police records and court files were also systematically evaluated.

The *Perry* study found evidence of numerous positive effects for the experimental group. For instance, a rapid increase in IQ was recorded. Over time, IQ scores did eventually balance out between the treatment and control group. For standardised tests in language, reading and mathematics, children in the treatment group achieved better results than children in the control group (a lag in these results was sometimes observed). This competitive edge in academic test results was maintained over the long term. This very costly programme of intervention was evaluated by a variety of cost–benefit analyses. These analyses investigated the costs and the benefits for the participants and their families (personal benefit), as well as the benefits for the taxpayer and society as a whole (societal benefit). The various utility components, such as improved academic achievement, higher lifetime income, increased tax receipts, less dependency on welfare and a lower rate of delinquency in the experimental group, were evaluated in monetary terms. Depending on the specific methodological approach taken, the *Perry Preschool Project* has a cost–benefit ratio of either 1:10 or 1:17. Common to all cost–benefit analyses is the finding that the long-term benefits of the *Perry Preschool Project* are far in excess of its costs (see figure above).

Sources: Belfield et al. (2006), Heckman et al. (2010)

al intervention studies, featuring random assignment to experimental and control groups, whereas others use a quasi-experimental design without randomisation but controlled for potentially disruptive influence factors. The most well-known of these studies is the *Perry Preschool Project*, which even today continues to measure the effects of an intervention made over fifty years ago, in the 1960s in Ypsilanti (Michigan, USA) (for up-to-date analyses, cf. Belfield, Nores, Barnett, & Schweinhart, 2006; Heckman, Moon, Pinto, Savelyev, & Yavitz, 2010). The cost–benefit analysis of the *Perry Preschool Project* shows that the benefits considerably exceed the costs. Findings such as improved academic achievement, higher lifetime income, increased tax receipts, less dependency on welfare and a lower rate of delinquency in the treatment group were evaluated in monetary terms (see box 6-1). Similar cost–benefit analyses are available for the *Abecedarian Study*, a study with a similarly limited regional scope, which assessed the efficiency of an all-day intervention programme for disadvantaged children (cf. Barnett & Masse, 2007). The *Chicago Child-Parent Program* was evaluated using a quasi-experimental design. The cost–benefit analysis associated with this program is based on a much larger sample of over 1,000 children. A special feature of this programme is that three time-limited interventions were made – one only in early childhood, one only at primary school age, and one in both early childhood and at primary school age – and compared in terms of their efficiency. The findings show that interventions in early childhood generate the highest rates of return (Reynolds, Temple, Robertson, & Mann, 2002; Reynolds, Temple, White, Ou, & Robertson, 2011). Other analyses of effectiveness and efficiency investigating the impact of nationwide programmes with a lower pedagogic quality – such as the evaluation of the US *Head Start Program* – either find the effect sizes to be much smaller or identify no impact over the long term (e.g. U.S. Department of Health and Human Services: Administration for Children and Families, 2010). For lower-quality programmes, the state of the evidence thus presents a mixed picture (cf. also Barnett, 2011). Studies looking at the impact of interventions applied later also contrast the lower efficiency of such interventions compared to achieving a good level of education earlier in life (for a classic example of the evaluation of improvements to school quality, cf. Krueger & Whitmore, 2001).

It must be emphasised that the results of these predominantly North American studies cannot simply be applied directly to other regions – including Germany and other target groups. In assessing these studies, one must bear in mind that they are, for the most part, big-budget, high-quality interventions targeting educationally disadvantaged children in highly specific regional contexts. Indeed, this focus on specific target groups with purpose-built programmes and facilities stands in sharp contrast to the core tenet of universal early childhood education and care services for all children in Germany's elementary-level system, which – as empirical studies have shown – fails to serve all children equally (e.g. Schober & Spieß, 2013). Until comparable efficiency analyses have been completed for Germany, international studies provide valuable insights into the significance of targeted and high-quality educational investments in early childhood.

6.3 The significance of pedagogic quality

In Germany, no sound analyses of efficiency comparable to the US investigations are available for the field of early childhood education. Only very recently have more comprehensive effectiveness analyses of the pedagogic quality of German mainstream educational institutions offering early childhood education been published, in which the quality of day care facilities has been scientifically evaluated. Such studies have shown that the pedagogic quality of German facilities tends to be mediocre (cf. Kuger & Kluczniok, 2009; Tietze et al., 2012; Tietze, Roßbach, & Grenner, 2005). These findings are surprising to the extent that a series of studies has shown that longer-term positive impact is primarily (if not exclusively) resultant from a high quality of preschool educational facilities. One example of such an investigation is the *Effective Preschool and Primary Education 3-11 Project* (EPPE 3-11). This large-scale longitudinal study from the United Kingdom shows that long-term positive impact on later academic performance results solely from the high quality of preschool educational facilities for children aged 10 and under (cf. Sammons et al., 2009). In other words: the long-term positive impact in the domain of cognitive functioning achieved by mere attendance at a preschool educational facility or attendance at a facility of only low to medium quality is either vanishingly small or, in the worst case, non-existent. This is confirmed by findings from German studies such as the German pilot study *KiDZ – Kindergarten der Zukunft in Bayern* ("Kindergarten of the Future in Bavaria"; cf. Roßbach, Sechtig, & Freund, 2010) or the *BiKS* study run by the University of Bamberg ("Bildungsprozesse, Kompetenzentwicklung und Selektionsentscheidungen im Vor- und Grundschulalter" – educational processes, competence development and selection decisions in preschool- and school age). These highlight the core role played by facilities' pedagogic quality, and the family.

Quality effects depend in particular on the quality of stimulation within a facility as well as the prevailing conditions – tractable at least in principle by policy decisions – such as group size, educator–child ratio and the level of training for facility staff (e.g. Blossfeld & Roßbach, 2012). In this context, a number of investigations point to the positive impact obtained by smaller group sizes, a lower staff-to-child ratio and a higher level of training for early childhood education and care teachers.

In order to prioritise the function of learning in the triad of education, learning and caregiving in early childhood education and care services, and improve accountability in pedagogic work, all of Germany's federal states have developed curricula for early childhood education and care services, in particular day care centres in recent years. Even compared to a decade ago, a far greater emphasis is now placed on both broad-based support for personal development, and on specific support for children in disciplines such as maths, language, and precursor skills for reading and writing or the natural sciences (e.g. Blossfeld & Roßbach, 2012). The curricula stress that this should not be the sole remit of purpose-built (i.e. pre-planned and pre-structured) courses but should also be embedded in the general everyday activities of a preschool educational facility. The impact of these curricula is contested, however, since their implementation by the individual federal states has been handled very differently and is in many instances a non-binding recommendation.

New requirements have also been set for (very) early linguistic assessment and assistance, so as to enable children with deficiencies (compared to their peer group) in mastering the German language to make a positive start to schooling (see section 3). This type of support is designed in particular for the benefit of children whose language of origin is not German. A further challenge is presented by the need to cope with an increasingly heterogeneous composition of groupings in early childhood education and care services. This applies in particular to the increasingly flexible age limits applied to children when enrolling in early education and care services and, in particular, for children of migrant parents. This heterogeneity is further amplified by calls to ensure the greater inclusion of children with special needs. There is also an expectation that early childhood education and care services should offer more assistance for the parents and that day care facilities should develop in the direction of family centres or parent-child centres; a contributory element here is the fact that high returns on investments in early education and caregiving are more likely if the programmes also include modules oriented towards the parents. The idea is to link children's education, learning and care with familial education and other kinds of support for families and children. Finally, attendance at preschool educational facilities should also make a specific contribution to preparing children for school. That said, it must be emphasised that support programmes with a stronger "early education" focus are neither intended to pre-empt school learning nor provide teaching in the sense of formal schooling. Support programmes of this kind could also include promotion of self-regulation competence in children, for example (see e.g. programmes such as *Tools of the Mind*, see box 5-2).

6.4 Differences in competence and educational choices at later stages of the educational pathway

In educational research studies in sociology, a key distinction is made between the primary and secondary effects of social origin (Boudon, 1974; Relikowski, Schneider, & Blossfeld, 2010). This distinction highlights the fact that social origin is able to impact educational opportunities via two separate mechanisms. *Differences in competencies and performance due to social origin* arise as a result of class-specific socialisation processes, cultural differences between families and differential potential for academic support offered by parents, as well as individual genetic predispositions. As a consequence, children from weaker social groups often possess lower levels of competencies and achieve poorer grades than children from families whose social status and educational background is comparably higher. Children from weaker social classes thus have fewer chances in the educational system from the outset. Boudon terms these associations the *primary* effect of social origin.

Beyond the effect of social class on personal performance and competence, the influence of a second mechanism is also felt, termed the *secondary* effect. This is described as *class-specific decision-making behaviour*. Depending on social background, families assess the costs and benefits of higher school tracks differently and vary in their opinion of the intrinsic value of quality education. One key aspect of this decision-making process is the motive to maintain status: in schooling their children, families have a strong interest in securing a status at least equal to the status of the family itself. Accordingly, families from more prestigious social backgrounds make efforts to offer their children a high level of education that prevents intergenerational status loss. Depending on social standing, parents thus seek out different types of schools for their children, even if the latter exhibit a comparable level of performance and competence.

Since the intensity and the relative importance of primary and secondary effects of social origin suggest the implementation of very different courses of policy, a theoretical distinction between these two disparities is advisable (Relikowski et al., 2010). Taking the presence of strong primary effects as an example, day care and all-day schools could compensate at least partially for poor encouragement and support potential on the part of the parents (see also the discussion of compensatory effects of preschool institutions). In contrast, strong secondary effects could necessitate interventions to reduce the costs of schooling for low-income families or those with poor access to education, so as to improve children's prospects for attending higher education.

While impressive advances have been made in developing a theory capable of explaining the secondary effects of social origin (Breen & Goldthorpe, 1997; Erikson & Jonsson, 1998), the question of an adequate method for estimating the magnitude of primary and secondary effects remained intractable for a long time. Indeed, a method enabling the direct comparison of the relative effect sizes of primary and secondary effects between social groups of heterogeneous origin was developed only recently by Erikson, Goldthorpe, Jackson, Yaish, and Cox (2005). This analysis shows that the influence on educational choices specific to social origin (e.g. whether a child is sent to higher-level secondary school or not) is greatest for the group with average competencies and school grades (cf. also German studies such as Maaz & Nagy, 2009).

Recent longitudinal data, such as those from the Bamberg *BiKS* study, show that parents in non-selective school systems (such as in the German federal state Hesse) believe their children to be capable of achieving much higher academic qualifications than parents in other systems (such as in Bavaria). This picture can be further strengthened on the basis of teacher recommendations. As with other studies – e.g. the "Transition Study" (Maaz & Nagy, 2009), representative for Germany – findings from the *BiKS* study suggest that the institutional conditions applicable within specific federal states exert an influence on the children's educational opportunities and thus on the reproduction of social inequality (Gersch, Baumert, & Maaz, 2009; Zielonka et al., 2013).

Social background effects are superimposed on many state-specific differences, however, thereby partially amplifying them (Relikowski, Ylmaz, & Blossfeld, 2012): parents' educational experiences appear to shape their notions of education and the appraisal of their children's potential success. Children from educationally underprivileged groups remain seriously disadvantaged, however, regardless of their home federal state and thus regardless of the prevailing institutional frameworks. They tend to receive poorer grades even if their abilities are identical. In most states, even if their abilities are the same and their grades likewise – but lying near the cut-off point – they are less likely to be advised to attend a higher-level secondary school (cf. Dumont, Neumann, Becker, Maaz, & Baumert, 2013). In looking for reasons to explain the above, we see that teaching staff also consider the potential for familial support when making their recommendation.

For some parents from higher social groups, a wider range of options are available for maintaining their aspirations in cases where these are initially foiled by the child's grades or the recommended transition to secondary schooling (Kleine, Paulus, & Blossfeld, 2009). By comparing federal states in which the legally-binding status of the secondary school recommendation varied, Gersch et al. (2009) showed that binding secondary school recommendations acted to lessen social disparities affecting transition. Dollmann (2011) was able to confirm these findings for the state of North Rhine-Westphalia by showing how the introduction of binding secondary school recommendations lessened the impact of social origin on post-primary school transition. Specifically: within the framework of binding secondary school recommendations, not only do academic achievements carry more weight, but "unrealistic" educational aspirations of middle-class parents also appeared to exert less of an influence.

If we consider specific groups that the German educational system ought to be addressing, it should be noted that absolute educational inequality among migrants is significantly lower than that among German nationals – which is attributable to the generally lower significance of secondary effects (Relikowski et al., 2012). In addition, one also finds that migrants have a greater rate of higher secondary school transitions when school grades and social origin are taken into account. These results point to a particularly pronounced migration-specific motivation for academic advancement, whose realisation is obstructed primarily by poorer performance at school (difficulties with the local language) (Gersch, 2012). In terms of providing support to children of migrants, this means policy interventions must concentrate explicitly on the mechanisms of primary effects of social origin. Here, too, an expansion and intensification of early-stage day care could constitute a starting point that is particularly effective in levelling the playing field where problems with language are found – especially in the case of children affected because German is rarely spoken in the family home.

In summary, one can say that the organisation of the educational system determines at what point in a child's lifetime educational choices must be made by the families (and teaching staff) – and with which consequences – and to which extent these can then be subsequently corrected (Blossfeld, 2013). Overall, we recommend designing the educational system to be porous for as long as possible and ensuring qualifications' compatibility (avoiding educational "dead ends"). Here, the second-chance, and recently instituted third-chance educational pathway (non-selective higher education) in Germany each constitute a major step in the right direction.

Notwithstanding the above, a longitudinal study by Fend, Berger, and Grob (2009) offers empirical evidence that while organisational reforms of the educational system (such as introducing an orientation stage or comprehensive school system) may temporarily reduce effects specific to social origin, parents are nonetheless ultimately successful in asserting their personal preferences over the long term. For later educational choices in particular, whose success is not assured from the outset – such as the decision to take a university degree, for example – the influence of the school appears to decline while the familial resources tend to take centre stage once again. For middle-class children, this means that their families of origin – each of whom strive to make best use of their strategies and resources on behalf of their children – ultimately achieve their goals, regardless of the type of school.

There is therefore much to be said for not merely providing early support for children, but for taking a more comprehensive approach that more actively involves families of disadvantaged groups in educational support measures (familial education).

6.5 Conclusions

The following conclusions can be drawn from the economics of education:

- Returns are especially high for investments in programmes in *early childhood* and their funding should thus be secured and increased over the long term. Such programmes generate a benefit for society as a whole. This means assigning more public resources to this area – not merely from municipalities and federal states but also at a federal level. A sustained contribution to the costs of high quality education and care services in early childhood by the federal government is especially worthy of further consideration.
- Investment in the *pedagogic quality* of early education and care programmes is a particular necessity, as the high profitability of educational investments made in early childhood depends on high-quality teaching. Recent studies on the pedagogic quality offered by German day care facilities give this recommendation particular weight, as their findings reveal that such facilities' quality is no better than mediocre (cf. the results of the *National Investigation of Learning, Caregiving and Education in Early Childhood (NUBBEK)* study; Tietze et al., 2012).
- The efficiency of educational investments can be increased by targeting their deployment, as long as segregatory effects can be avoided. This recommendation is underpinned by the empirical finding that high-quality education and care can be especially beneficial to children from disadvantaged families. Accordingly, the German system of providing support to early childhood education and care must also tackle the issue of providing enhanced support that is focused on specific target groups and/or children from specific neighbourhoods.

- Stronger involvement of families in early childhood education and care services can boost the efficiency of these interventions. This recommendation is underpinned by the finding that a high level of efficiency has been achieved above all by educational programmes where parents are systematically involved. One option for Germany might be the targeted expansion of early childhood education and care services into “Family Centres” or “Parent & Child Centres”.
- An increased level of educational investment targeting early childhood ought not to lead to the neglect of educational investments made for adolescents and young adults. This recommendation derives from the fact that the efficiency of educational investments in early childhood is boosted by later investments along the individual’s educational pathway.
- Attendance of high-quality early childhood education and care supports a child’s development in terms of both socio-emotional and cognitive/performance-related aspects. Longer-term positive effects will depend on services of a high quality. It is therefore worthwhile to further increase the quality achieved by German early childhood education and care facilities and to invest in higher quality: only then can the theoretically sizeable benefit from educational investments in early childhood be realised.
- The educational quality of early childhood education and care services is defined above all by the process quality, i.e. the direct interaction of the teachers with the children within the facilities themselves. Structural quality characteristics influence these processes, and these latter processes can be changed and improved by policy frameworks. In this context, key points to address will include making group sizes smaller, reducing the staff-to-child ratios, and improving basic as well as further training for the facility’s staff. Note that the criteria in each case will vary in accordance with the age group. Consideration should also be given to altering the content of curricula and making them compulsory nationwide, without compromising the diversity of pedagogic processes.

The following conclusions can be drawn from educational sociology:

- The primary and secondary effects of social origin require different political measures. If primary effects are pronounced, day care facilities and all-day schools, etc. should act to at least partially balance out a lack of parental encouragement and support potential. For immigrant populations in particular, such interventions could make a major contribution to reducing linguistic deficiencies and establishing a level playing field for entry into the educational system.
- Where secondary effects are strong, interventions to cut educational costs for low-income families or raise awareness of the prospects for success offered by educational options should be considered. German families from lower-status groups are particularly unfamiliar with the higher education system and tend to view the cost–benefit ratios of higher education degrees as unfavourable.
- Prevailing institutional conditions materially influence the educational options available to children and thus the reproduction of social inequality by the education system. More open – i.e. more porous – systems offer better chances of acquiring a higher level of education. More rigid systems using early selection act to curtail weaker social groups’ chances in particular.

7 Consequences and recommendations

Findings from neurobiology, psychology, linguistics, sociology and economics are consistent in showing how early childhood experiences have a long-term influence on a person's later course of development. The effects of these early experiences – both positive and negative – can be traced into adult life. There are two reasons for this:

(1) Hereditary predispositions and environmental influences always work in tandem to determine the structure and workings of the nervous system – and thus both behaviour and inner experience. Accordingly: hereditary predispositions do not automatically result in the development of specific structures within the nervous system or certain behavioural traits: without exception, "compatible" environmental influences are also required for predispositions to manifest themselves. Yet the reverse is also true: favourable environments can positively influence development only in cases where susceptible hereditary predispositions are available. This close interaction between nature (genes) and nurture (environment) applies throughout life, yet especially in early childhood.

(2) In early childhood, critical and sensitive phases exist, in which the individual must undergo certain environmental experiences. Only then can key structures within the nervous system and the associated behavioural patterns develop to the fullest extent possible. If these critical periods are not "satisfied" by the necessary environmental influences, neuronal development remains incomplete and certain types of behaviour can then be acquired only to a limited extent – or not at all. Such deficits are irreversible and accompany a person throughout life. Even when specifically targeted by training in later life can such deficits rarely be compensated for and are sometimes entirely intractable.

Critical and sensitive phases are highly likely to play a significant role for most domains of development. Evidence of this is particularly strong for

- basic perceptual abilities of the visual and auditory system;
- language;
- cognitive abilities; and
- personality characteristics such as stress resistance and self-regulation competencies.

Seen from the lifespan perspective, funding early childhood education is thus a particularly advisable strategy. While this applies to the development of all children, it is particularly relevant for children born with sensory impairments or raised in less favourable environments (precarious familial circumstances, poorly educated parents, etc.). Such fundamentally unfavourable environmental conditions must be recognised early on, since compensatory programmes must act at an early stage and thus before the conclusion of sensitive phases.

Investment in high-quality educational and day care programmes *in early childhood* is especially profitable both for the individual and for society at large, since it establishes positive conditions ensuring favourable to further developmental steps. Such funding should thus be secured and expanded over the long term.

While recent research findings attach particular importance to early childhood educational programmes, one should not overlook the need for later educational programmes catering to adolescents and young adults. Since subsequent experiences always build on earlier ones, however, the effectiveness of later investments will depend on the degree of success to which earlier educational programmes have established favourable conditions.

Since genetic predispositions and environment factors are inextricably intertwined, natural potential must be actively addressed and fostered in all children. Nor does this apply solely to children from less favourable environments: children from favourable backgrounds also need encouragement and active support appropriate to their predispositions. Only in this way can the intellectual and social resources available within a society develop to their fullest potential.

For the domains covered within the main text – i.e. linguistic, cognitive, social, emotional and motivational competencies – the following recommendations are made:

7.1 Linguistic competence

The development of language in early childhood follows a biologically predetermined sequence of sensitive phases, during which children must be exposed to the target language(s) in meaningful interaction. Only on the basis of this kind of experience can the language-relevant areas and association connectivity fully develop within the brain, and only then can a native grammatical competence be attained. Educational programmes can and should be used to support the developmental process – which can be guided but not altered.

Where children grow up in families in which the society's dominant language, German, is not spoken as a native language, access to German should be provided as early as possible, i.e. no later than at the age of three or four. One may otherwise assume that full linguistic competence in German will not be achieved.

Parents of children whose native language is not German should be made aware that early contact with German is essential for children to attain native-speaker competence in this language. They should also be informed that this will not hinder development of the child's language of origin: early bilingual competence does not impair linguistic or cognitive capacities. If a child is likely to be making its home for the foreseeable future in Germany, acquisition of "two first languages" should start as early as possible, i.e. before the child's fourth birthday.

Children from monolingual households should also begin learning second languages as early as possible, so as to enable the acquisition of a high level of competence. Ideally, the acquisition of a second language should begin before the child starts school and no later than primary school where possible: children's language learning capacities start to deteriorate considerably during the age range from 8–10 years. Successful early acquisition of a second language requires an adequate investment of time, however, and it requires the availability of preschool educators who are highly competent in the language to be learned.

Assessments of levels of linguistic competence must be administered early on – possibly during routine postnatal visits to the paediatrician or paediatric audiologist. Initially, the focus must be on the phonological aspects of the language. Only in this way can deficiencies affecting normal language development be identified early on and compensated for by taking appropriate action.

7.2 Basic cognitive abilities

The basic cognitive abilities – i.e. language proficiency, problem-solving abilities and memory skills – develop from the interplay of genetic predispositions and environmentally-dependent learning processes. The level of intelligence a person can achieve is not written in stone at birth but is also dependent on the environment, which crucially influences the unfolding of genetic predispositions. Positive environments boost – and negative ones hinder – the development of intelligence. Genetic predispositions therefore mark out the boundaries within which basic cognitive abilities can then develop. This does not contradict the high heritability of basic cognitive abilities repeatedly confirmed by studies in behavioural genetics. The degree of heritability itself says nothing about a *single* individual's genetic predisposition or learning ability, but specifies the degree to which genetics or the environment are capable of shaping inter-individual differences, i.e. the variance within a population.

To enable a society's intellectual resources to reach their full potential, steps must be taken to ensure that all children's basic cognitive functioning follow an optimum course of development. Ideally, this means each child should be supported and encouraged to attain its personal maximum level of proficiency in basic cognitive abilities. This process should involve offering programmes that demand neither too little nor too much from the respective child's predispositions.

Properly utilising the intelligence inherent in children and adolescents drawn from across the entire population depends not only on satisfying basic physical needs in early childhood, however. Steps must be taken to ensure that children are raised in an emotionally supportive, cognitively stimulating environment, and that they acquire a society's dominant language and cultural proficiencies as a result of natural interactions with other children and adults.

Cognitive development should not be taken for granted. It requires targeted stimulation and continual gains in knowledge that permit the solving of increasingly complex cognitive problems. Skills and knowledge content gained later always build on what has been learned before. The stronger the foundation, the more rapid and effective the learning processes it can support. The knowledge and cognitive bases to the domains of written language, mathematics and the natural sciences learned before a child's tenth birthday are therefore of particular importance for later educational choices and development at school.

Targeted support programmes are especially likely to succeed if they are able to reach children from disadvantaged social backgrounds. Yet fostering the intellectual potential in certain groups – i.e. improving their average performance – does not imply that all children and adults can achieve an identical level of competence. Even with positive training and schooling programmes in place, inter-individual differences in cognitive functioning will still persist.

As a consequence, a society should not act solely to promote the development of intelligence, but should also provide career choices that can be taken by individuals with varying levels of cognitive functioning. Increasingly, technologically advanced societies offer career prospects only for people with superior basic cognitive abilities. The economic, sociological and psychological consequences of this situation are manifold. It may give rise to difficulties for individual groups on the labour market, causing affected persons to suffer from a lack of life satisfaction and a higher susceptibility to mental and physical illness. Equally, such problems may also indirectly cause increased rates of criminality and suboptimal care – and thus fewer opportunities – for the next generation. Here, the societal actors involved in policy-making decisions (government, employers, union representatives, etc.) must work to find solutions.

7.3 Social, emotional and motivational competencies

The development of social/emotional and motivational/volitional skills is crucially dependent on the formation of a secure attachment with a primary caregiver in early childhood. These are usually the parents themselves: their sensitivity and warmth creates positive, culturally appropriate conditions for socialisation. A secure attachment is essential for the child to form a positive and realistic concept of the self, and to develop greater proficiency in self-regulation and the ability to cope with stress effectively.

Such self-regulation competencies express themselves in emotional regulation and inhibitory control, i.e. they enable the individual to make goal-oriented decisions between conflicting behavioural choices and inhibit impulsive behavioural tendencies – as when choosing to delay gratification. Empirical studies show that the level of self-regulation competencies observed in childhood reliably predicts the course of later development in adolescence and adulthood in terms of academic and career success, social adjustment, physical and mental health, socioeconomic status and prosperity. The level of self-regulation achieved determines many aspects of an individual's overall success in life.

Groups at high risk of developing inadequate self-regulation competencies include children without a reliable primary caregiver, children of overburdened parents, children of impoverished and poorly-educated parents, and children who experience domestic violence or a lack of parental care and warmth, or who grow up in socially-disadvantaged neighbourhoods. For these risk groups, particular commitment must be shown – in the shape of active support programmes – to encourage the development of self-regulation competencies. Programmes based on the *Tools of the Mind* model (Tools of the Mind Staff, 2012) appear promising in this context.

Longitudinal studies have shown that the experiences of early childhood have far-reaching implications for the later development of social, emotional and motivational competencies. Appropriate interventions aimed at fostering executive functions and self-regulation should therefore be planned as early as possible – i.e. for those attending preschool – and not solely for disadvantaged children. Institutional programmes should be used to actively promote support for individual socialisation. Awareness should be raised among both parents and teachers of the need to recognise and promote self-regulation as well as its corollary social, emotional and motivational competencies.

7.4 Consequences for educational policy

Attendance at a preschool educational facility supports a child's development in terms of both socio-emotional and cognitive/performance-related aspects. Longer-term positive effects will depend primarily on teaching being of a high quality. It is therefore worthwhile to further increase the quality achieved by German preschool educational facilities and to invest in higher quality: only then can the theoretically prodigious returns on educational investments in early childhood be secured.

The educational quality of day care facilities is defined above all by the process quality, i.e. the direct support processes available within the facilities themselves.

Structural quality characteristics influence these processes, and these latter processes can be changed and improved by policy frameworks. In this context, key items to address will include making group sizes smaller, reducing the number of children cared for by each preschool educator, and improving basic/further training and continuing professional development for the facility's teaching staff. Note that the criteria in each case will vary in accordance with the age group. More thought should be given to altering the content of curricula and making them compulsory nationwide: this can be achieved while retaining the diversity of pedagogic processes.

Yet it is important to recognise that even programme-driven support at the preschool stage – e.g. at day care – need not mandate formal schooling. Actively supporting children's cognitive and emotional socialisation creates ideal educational opportunities for them at an early stage. This does not imply that these children are being moulded to serve economical goals but, on the contrary, that individual chances can be seized. A common prejudice against preschool teaching often stems from misconceptions about playful and situated learning in a classroom. Education in early childhood has little in common with conventional learning. For example, encouraging multilingualism in day care does not mean that preschool children should start being given language classes. The presence of native speakers – from English-, Russian-, Turkish- or French-speaking regions, for example – is quite sufficient to ensure children acquire a different language by (playful) interaction with one another.

The efficiency of educational investments can be increased by targeting their deployment, assuming dissociative effects can be avoided. Children from disadvantaged families in particular can benefit from education and care that is of a high quality. Accordingly, the German system of day care must also tackle the issue of providing enhanced support that is focused on specific target groups and/or urban districts.

Stronger involvement of families in educational/support programmes outside the home can boost the efficiency of these interventions. Evidence for high efficiency is demonstrable above all for educational programmes where parents are firmly "on board". One option for Germany might be the targeted expansion of day care facilities into "Family Centres" or "Parent & Child Centres".

An increased level of educational investment targeting early childhood ought not to lead to the neglect of educational investments made for adolescents and young adults. The efficiency of educational investments in early childhood is boosted in particular by later investments over the person's lifetime.

Educational choices are determined not only by differences in ability and performance due to a child's social background (primary effects of social origin), but also by class-specific decision-making behaviour resulting from different values being placed on the costs and benefits of educational options (secondary effects of social origin).

The primary and secondary effects of social origin imply a flexible approach to policy-making. If primary effects are pronounced, day care facilities and all-day schools, etc. should act to at least partially balance out a lack of potential for parental encouragement and support. For immigrant populations in particular, such interventions could make a major contribution to reducing linguistic deficiencies and establishing a level playing field for entry into the educational system.

Where secondary effects are strong, interventions to cut educational costs for low-income families or raise awareness of the prospects for success offered by educational options should be considered.

Prevailing institutional conditions materially influence the educational options available to children and thus the reproduction of social inequality by the education system. More open – i.e. more porous – systems offer better chances of acquiring a higher level of education. More rigid systems using early selection act to curtail the chances available to weaker social groups in particular.

7.5 Research desiderata

The findings reported in this position statement articulate how a person's development is decisively moulded by the experiences she/he undergoes in early life and how this acts to determine his/her life trajectory over the long term. Such associations between experiences made in early childhood – and even before birth – and the formation of traits in later phases (adolescence and adulthood) have been revealed by investigations made within molecular biology, neurophysiology and neuroanatomy, as well as studies in linguistics, psychology, educational science, sociology and economics. Yet many of these findings are still relatively unconnected with one another, since in most cases only a restricted set of variables has been investigated by the various studies. Frequently, the long-term impact has also been investigated only at a single subsequent point in time. Likewise, many studies have used a retrospective model, i.e. one establishes specific traits observed later as the study outcome and then attempts to localise special characteristics – if any – present in early stages of development. While these limitations do not fundamentally compromise the reliability of previous findings, they highlight research deficiencies that must be rectified to achieve a deeper understanding of the principles of conditional dependency in child development. Not least because interventions designed to prevent and compensate for unfavourable development or to foster and strengthen favourable development are crucially dependent on knowledge of the causal relationships between specific experiences on the one hand and individual development trajectories on the other.

To date, research shows that longitudinal studies organised over as long a period as possible offer an indispensable starting-point for understanding the complex, temporal interdependence of early experiences and trait expression in later life. This requires major efforts to be made on the part of both research institutions and funding bodies. Researchers must design their studies so that they can be continued for decades, or as long a period as possible, and independently of their own careers. This requires binding funding commitments over long periods of time. Only then can comprehensive and representative datasets be collected and collated. Another crucial aspect is the establishment of interdisciplinary research teams, so as to document and analyse changes at the various levels of observation and their interdependencies.

In contrast to work conducted by researchers in the UK and US, Germany has provided few representative longitudinal studies to date capable of mapping out the developmental trajectories by children into adolescence and adulthood, and which are available to the wider national and international scientific community. Recent years have seen the addition of new panel studies capable of filling this gap over the medium to long term. Several existing studies have also greatly expanded their childhood research focus (see box 7-1).

While these projects are a welcome addition to empirical educational research, one must nonetheless emphasise that the specific methodological approach-

Box 7-1: Prominent, publicly-funded projects on socialisation and educational research in Germany using a long-term study design

The German publicly-funded research infrastructure addressing socialisation and educational research includes the German *Socio-Economic Panel* Study (SOEP), the *National Education Panel Study* (NEPS) and the *pairfam* study (*Panel Analysis of Intimate Relationships and Family Dynamics*), funded as a long-term undertaking by the German Research Foundation (DFG).

The German *Socio-Economic Panel* study (SOEP) is a representative panel survey that has been collecting data since 1984 and is based at the German Institute for Economic Research in Berlin (DIW Berlin). The SOEP is a multi-topic survey: its data provide information on issues of income, employment, education and health. In 2003, the SOEP considerably expanded its childhood-related questions. From 2010, SOEP analyses focusing on childhood-related issues can be augmented by an additional family-specific sample set, *Families in Germany* (FiD). The FiD survey respondents are sourced from subgroups of particular significance for family policy: low income families, single-parent families, families with three children and more and families with very young children.

The *National Education Panel Study* (NEPS) is based within the Institute for Longitudinal Educational Research (INBIL) at the University of Bamberg. The stated objectives of NEPS are to collect representative longitudinal data on competence development, educational processes, educational choices and educational returns on investment within formal, non-formal and informal contexts over an entire lifetime. NEPS manages a total of six panel studies that start at different stages in life. The first study was launched in 2010. The "new-borns cohort" starts with children who are 7 months old.

Launched in 2008, the relationships and family panel *pairfam* is a multidisciplinary longitudinal study with the aim of researching family and relationship lifestyles within Germany. Respondents include persons from specific birth cohorts as well as their partners, parents and children. In terms of content, the study aims to address the multi-layered processes of partnership development and management, the process of starting and developing a family, parenting styles, childhood development and intergenerational relationships.

Other longitudinal studies that primarily serve the needs of social reporting complement these panel studies. For the research community, longitudinal studies available include the *Growing Up in Germany: Everyday Contexts* (AID:A) survey run by the German Youth Institute (DJI) and the *German Health Interview and Examination Survey for Children and Adolescents* (KiGGS) based at the Robert Koch Institute (RKI).

es to the planned data collections can only yield findings of limited conclusiveness. Nor can they therefore replace research specific to other individual topics.

While many questions about the relationship of early childhood experiences to individual development can be researched using epidemiological studies and the long-term collection of data, it should nonetheless be emphasised that convincing causal links and their underlying processes can ultimately be unearthed only by adopting an experimental approach. Since experimental interventions involving humans operate within very narrow bounds and must observe the most rigorous ethical standards, research must also consider the use of animal models. This is true in particular for research conducted on bases for development within molecular biology, genetics, neurophysiology and neuroanatomy – and these bases' role in the expression of behavioural traits.

Fundamental principles identified by molecular biology and physiology have interspecies validity. Equally, as many research studies have shown, the elementary principles of behavioural trait development are entirely amenable to research in well-controlled animal experiments, even on non-primates. Such studies are also of particular relevance since the life cycles of non-primates are considerably shorter. As a result, causal relationships between early environmental influences and later consequences across the individual's life-course can be observed over much shorter periods of time than would be possible in humans.

Desirable areas for research include the following:

- Basic research drawing together psychology and the neurosciences with the aim of discovering the link between brain development and cognitive ability, social skills and the development of personality.
- The demarcation of sensitive periods for the development of emotional and motivational competencies.
- Investigation of age-/context-based dependencies affecting learning ability in humans and the impact of moderating variables.
- Longitudinal intervention studies to test theories of development that assume a strong interrelationship and conditional dependency of individual stages within development.
- Longitudinal studies aimed at achieving a scientifically sound estimate of the efficacy of interventions and programmes that are intended to actively support the development of linguistic, cognitive, emotional/motivational and self-regulation competencies in early childhood. Evidence-based decision-making is conditional on such studies being available. They must be initiated early on and accompany corresponding interventions and programmes continuously.
- Investigations into the significance of prenatal experiences on the development of cognitive, socio-emotional and motivational competencies.
- Investigations into the influence of specific boundary conditions on the efficacy of interventions, such as genetic typing, traumatisation, parenting style.
- Investigations into methods of correcting atypical development processes with negative repercussions, as well as demarcating the relevant learning and training conditions.
- Investigations into the impact of intrauterine and postnatal environmental factors (physical, physiological, psychological) on the expression of individual genes or gene complexes in the sense of epigenetic effects.
- Investigation of development-dependent neuroplasticity and the basis of sensitive and critical developmental stages from the perspective of molecular biology.
- Investigations of experimentally induced atypical development trajectories and their potential correction.

Myths[4], facts, conclusions

The following tables summarise a number of the myths and claims that surface in public discussions addressing socialisation. The relevant empirical facts are presented in the middle column, with the conclusions we can draw from these facts on the right. In each case, the facts are accompanied by references to the sections in the text that discuss the circumstances in more detail.

4 The term "myth" as used here should be understood in a figurative sense, to mean an incorrect or vague impression of actual facts circulating within public opinion.

8.1 General principles of development and socialisation (→ section 2)

Myths	Facts	Conclusions
"It's never too late to learn." People can learn anything at any point in their lives. If something was not learned in early childhood, this omission can easily be rectified in later life.	In early childhood, sensitive phases and critical periods exist, during which certain things can be learnt especially well, effectively and easily (→ section 2.1). During these phases, the unfolding of genetic predispositions is stimulated by specific environmental factors so as to ensure that the organism can adapt optimally to its environment. If adequate environmental impressions are absent during these periods, certain structures in the brain and their attendant functions develop incompletely or not at all. This applies to fundamental visual and auditory abilities, for example, the motor system, language, and – in all likelihood – to the expression of personality traits such as anxiousness and self-control (→ section 2.2).	Adequate environmental stimuli must be available in early childhood. Particularly in the case of unfavourable environmental conditions (sensory impairments, precarious familial circumstances, poor access to education, etc.), compensatory programmes should be introduced early on, ideally before the closure of sensitive phases. Early support, i.e. no later than preschool and the first years of schooling, offers the best foundations for successful later development. This is because interventions are most effective – and their potency is further increased by later experiences – when they are offered at optimum stages in development.
Early negative experiences can be balanced out by positive experiences later in life.	Early negative experiences (e.g. sensory impairments, neglect, failure to promote language learning) leave their mark on the brain of a developing child for the rest of its life. Such experiences undergone during sensitive phases cannot be fully erased later on. Permanent, elevated risks affecting health and adaptation are the result (→ section 2.3).	The importance of targeted support measures, especially at an early age, therefore rises the worse environmental conditions are. Negative environmental factors (e.g. domestic violence) must be prevented or stopped at an early stage.
"You can't teach an old dog new tricks." As a person ages, it becomes increasingly harder to learn – and some things become impossible.	Learning ability in fact lasts a lifetime, although it is not available to the same degree for all domains: in later life, learning is a qualitatively different process to the one seen in critical periods in early childhood. For many domains, later learning takes place within the boundaries already established in childhood (→ section 2.4).	Training programmes must accommodate the altered learning capabilities relevant to each age group. Beyond early childhood, some types of proficiency can be acquired only by investing prodigious effort and commitment.

Myths	Facts	Conclusions
Once a person is 20, age starts to take its toll and performance starts to degrade.	Age-related decline has been shown to occur at different rates for different domains. Losses related to speed-based tasks (known as “fluid intelligence”) occur earlier and are more pronounced over a lifespan than losses in memory-related performance (known as “crystallised intelligence”) (→ section 2.4).	While age-related decline cannot be halted by training, appropriate activities can at least slow it down. Positive effects are achieved by cognitive challenges and physical training. The time at which deficits first appear also depends on the resources acquired during development.
Age-related decline is roughly the same for all people.	Age-related decline is characterised by major inter-individual differences (→ section 2.4).	Even in a post-career context (e.g. after retirement), an environment should be available that presents challenges appropriate to the individual’s respective level of performance, so as to maintain cognitive and physical capabilities.
Characteristics are either inherited (and hence innate) or are acquired by learning.	Each and every behavioural trait develops from the continuous *interaction* of genetic predispositions and environmental experiences. Even traits that are strongly genetically predetermined often develop only after receiving adequate environmental stimulation. Natural potential can be influenced positively or negatively by environmental factors (→ section 2.5).	If we look at the evidence, neither the case for genetic determinism nor the case for environmental determinism is in fact justified.
Innate characteristics are determined at birth and cannot be modified later.	Hereditary potential develops only in the presence of environmental factors and offers opportunities for experience-driven change (→ section 2.5).	Innate potential must be exercised and awakened. At the same time, overly excessive demands and expectations must be avoided.
Learned characteristics and competencies can be arbitrarily modified in their expression and quality.	Hereditary potential works to limit the extent to which environmental factors can influence behaviour (→ section 2.5).	

Myths	Facts	Conclusions
Training activities improve performance for every individual; everyone benefits to the same extent from training activities.	An individual’s benefit from interventions often depends on his/her level of competence; those who are more proficient often derive a greater benefit than their less proficient peers (→ section 1.2).	Proven changes within a group do not always permit conclusions to be drawn for all of its members.
Interventions level out differences between individu-als.	Interventions can work to raise the mean score achieved within a group. Inter-individual differences persist, however, and differences between individuals may even become more pronounced (→ section 1.2).	People differ from one another in terms of their abilities, temperament, learning ability and behaviour. Accordingly, a group of individuals will derive varying benefits from training activities offered. Training may also exacerbate inter-individual differences.

8.2 Language (→ section 3)

Myths	Facts	Conclusions
Competence in a language can always be acquired if one simply lives long enough in the language's native environment and interacts with native speakers.	Native-like competence is generally achieved only in cases where the individual starts learning the language before the age of four. Native grammatical competence in particular (i.e. syntax, morphology and phonology) can no longer be acquired in full in later years – specifically, past the child's sixth birthday. Achieving grammatical competence in a foreign language becomes increasingly more difficult when age of onset of acquisition is delayed (→ section 3.1).	Parents of children whose native language is not German should be made aware that achieving native-like competence is possible only if the child has early contact with the language. Parents need not fear this will impede development of the language of origin, however. Acquisition of "two first languages" should be a fundamental goal, if a child is likely to be making its home for the foreseeable future in Germany.
One can acquire full, native competence only in a *single* language.	Provided children are exposed to the languages in interaction with native speakers in early childhood, i.e. before the fourth birthday, they can acquire native competences in two or even three languages without risking developmental impairments (→ section 3.2).	The acquisition of second languages should also begin as early as possible in order to enable the learners to attain a high level of competence. Ideally, second language acquisition should begin before starting school – certainly no later than primary school, since the language acquisition capacity deteriorates considerably at around age 8–10. Ensuring preschool educators and teaching staff are well qualified is also extremely important.
The same developmental mechanisms apply in the case of syntax and semantics.	Acquisition of syntax in a language at a level equivalent to that of a native speaker is limited to a developmental time window that closes between ages four and six. In contrast, a language's vocabulary can be acquired and augmented throughout life; lexical learning is not subject to maturational changes resulting in specific, limited critical periods (→ section 3.1, box 3-2).	The basic grammatical patterns (in phonology, morphology, syntax) of the language(s) that will be dominant in later life should be acquired as early as possible. This establishes the best possible foundation and starting point for extending linguistic competence at later stages in life, both in terms of other languages and in terms of the vocabulary of languages already acquired.

Myths	Facts	Conclusions
A critical development time window exists only for the first language.	Critical development time windows for language acquisition end for all languages – not merely the first language – no later than between a child's eighth and tenth birthday (→ section 3.1).	If children are being raised in families where German is not spoken as a native language, their access to this language should be provided as early as possible; one may otherwise assume that full linguistic competence in German will not be achieved. It is also important to facilitate contact with native speakers at an early stage.
Language is a purely psychological phenomenon. Language acquisition takes place independently of the brain's biological development.	Language acquisition follows a developmental sequence that is coupled tightly to the development of specific cerebral structures. During its first years of life, a child is particularly receptive to linguistic input and the formation of language-specific areas and neural connectivity (→ section 3.1, box 3-1).	As language development in early childhood follows a biologically predetermined sequence, its progression should be aided with educational measures. The developmental sequence itself cannot be altered, however.
Early deficits in a language – as a result of hearing impairment or other problems, for example – can be compensated for even as late as adolescence or early adulthood by completing high-intensity language training.	The existence of critical periods for language acquisition means that training activities following the closure of this critical phase may well achieve positive effects but are less effective and the degree of language competence attainable is generally inferior (→ section 3.1, section 2.2).	Assessments determining levels of linguistic competence must be applied early on – possibly during routine postnatal visits to the paediatrician or paediatric audiologist. Initially, the focus must be on the phonological aspects of the language. If the individual requires the fitting of a hearing aid or a cochlear implant, this should be performed at the earliest possible point in time. Even before a systematic course of language therapy is introduced – generally from the age of 3 onwards – both parents and preschool educators must be briefed so that they know how to react to an early diagnosis of hearing problems. They should learn to speak much more slowly and with greater emphasis, for example, and practice interactive stress patterns with the child in formats such as repetitive rhymes and songs.

8.3 Basic cognitive functioning (→ section 4)

Myths	Facts	Conclusions
The concept of basic cognitive functioning (intelligence) is simply incorrect. There are a great many separate, self-contained cognitive competencies.	Cognitive performance scores across a wide range of unrelated tasks (linguistic, computational, figural-spatial) are strongly related. Roughly 50 percent of inter-individual differences in intellectual performance can be traced back to basic cognitive functioning or "general intelligence". This fundamental competence is expressed in the ability to perform deductive reasoning, perceptual discrimination and in working memory capacity (→ section 4.1).	To a certain degree, hereditary limitations on basic cognitive abilities can be compensated for by targeted training activities and the acquisition of knowledge. Ultimately, however, these predefined boundaries cannot be eliminated and there is a limit on how performance deficits in one cognitive domain can be balanced out by performance advantages in another.
A person's basic cognitive functioning (intelligence) cannot be reliably measured using tests.	A person's basic cognitive abilities can be accurately determined with the use of "IQ tests". The accuracy achieved by these tests is so high that there is a 95 percent likelihood that scores resulting from two independent measurements will deviate by only ±5 IQ points. No other psychological trait can be measured with comparable success (→ section 4.1).	
The intelligence score measured by an IQ test has no predictive value for day-to-day life: at best, it merely forecasts academic potential.	The ability scores achieved in IQ tests can be used as significant predictors for a large number of aspects of life success. The correlations between the IQ scores measured in childhood and in adolescence and the characteristics of success as identified in adulthood are ~.50 for the final qualification obtained on leaving school or higher education, ~.40 for career success and ~.25 for the level of income achieved. No other behavioural traits offer superior predictive value for these characteristics (→ box 4-2). IQ scores achieved in childhood and adolescence are also significant predictors for the individual's later state of health and his/her social mobility.	If one is interested in obtaining a methodologically sound and highly reliable prognosis of a child's or adolescent's potential performance, one should assess this individual's basic cognitive functioning by means of standardised IQ tests.

Myths	Facts	Conclusions
High-IQ individuals are certain to succeed at school.	While high intelligence makes academic and professional success likely, it is not a cast-iron guarantee. Targeted acquisition of knowledge is also necessary (→ section 4.1). Furthermore, life success is also importantly dependent on emotional, motivational and social competencies (→ section 5.2.1).	Cognitive development should not be “taken for granted”. It requires targeted stimulation and continual gains in knowledge that permit the solving of increasingly sophisticated cognitive problems.
Genes are the primary origin of differences in intelligence. Positive or adverse environments are the primary origin of differences in intelligence.	Differences in intelligence have their origin in genetically determined predispositions *and* environmental factors (→ section 4.2). A high level of potential in basic cognitive abilities can develop only if a child grows up in a highly stimulating environment and also possesses sufficiently favourable hereditary predispositions (→ section 4.3).	The development of cognitive abilities cannot be “taken for granted”: it requires targeted stimulation to fully develop innate (hereditary) potential.
A supportive environment and high quality formal schooling can work to cancel out the differences in intelligence seen between individuals.	Supportive environments play a decisive role in facilitating the development of genetic potential. While this enables gains to be made in the average performance of a group of individuals, differences between individuals of greater and lesser cognitive capacity will persist. Indeed, it is even the case that efforts to ensure equal schooling conditions for all will actually amplify performance differences between individuals (→ section 4.3).	Even if conditions of schooling are optimum, one should refrain from exaggerated expectations of the performance level achievable. Instead, expectations should match the individual’s hereditary potential.
High heritability for a trait means that its expression is predetermined, once and for all.	High heritability for a trait means that the *differences* between individuals can for the most part be traced to differences in hereditary predispositions. This does not exclude environmental or learning-driven changes, however (→ section 4.2, → box 4-3).	Despite the high heritability of intelligence, cognitive functioning can be influenced by training.

Myths	Facts	Conclusions
The degree of heritability determined for a group of people gives an indication of the strength of genetic influence for each of the group's members.	The degree of heritability determined for a group of people gives *no* indication of the strength of genetic influence for each of the group's members (→ section 4.2, → box 4-3).	Heritability merely estimates the relative contribution made by genetic influences to the total variance.
The development of basic cognitive abilities is independent of critical periods. Genetic predispositions can also be stimulated at later stages of childhood by the introduction of suitable support measures.	The prerequisites for the full development of a child's genetically predisposed basic cognitive functioning are that it should suffer no impairments to sensory functions in the first year of life, nor should it live in a highly adverse environment (e.g. without a primary caregiver) for a lengthy period of time (→ section 2.2, section 4.3, box 2-1).	Sensory impairments must be diagnosed as early as possible and, where possible, either resolved or compensated for. Children born into especially negative living conditions must be offered the opportunity to leave these surroundings as early as possible and to be relocated into a stimulating and emotionally stable environment.
If children are raised in favourable environments, their intelligence level can be permanently increased by the use of commercial training programmes.	In the case of children raised in more favourable environments, no convincing evidence has yet been offered that shows commercial training programmes are capable of permanently raising general intelligence beyond the bounds of the given predisposition (→ section 4.3).	Support programmes are especially effective for children whose environmental conditions are less favourable (precarious familial circumstances, poor access to education and low parental social status).

8.4 Social, emotional and motivational competencies (→ section 5)

Myths	Facts	Conclusions
Temperament traits in early childhood are genetically predetermined and therefore resistant to influence.	Behavioural styles in preschool children are not yet developmentally stable; only behavioural dispositions are genetically predetermined. The extent to which these develop depends on specific environmental factors (e.g. parents' attachment style, stress in the family, etc.) (→ section 5.1).	A stable family group and secure attachment to primary caregivers are prerequisites for the development of emotional, social and motivational competencies. These should be supported where appropriate. High-risk groups include orphans and children living in poverty or whose parents are unable to cope. Purpose-built support measures are advisable here.
Social, emotional and motivational competencies develop largely independently of one another.	Attachment patterns between children and their primary caregivers lay the groundwork for the development of social, emotional and motivational competencies, and, in particular, for the development of the capacity for self-control (→ section 5.1).	
A capacity for self-regulation in childhood has no predictive value for self-regulation and overall success in adult life.	A capacity for self-regulation in childhood (at the age of 3–5) is a significant predictor of self-regulation and overall success in adult life. A high capacity for self-regulation has a positive effect on almost all areas of life: academic achievement, career, income, partnerships, health (→ section 5.2, box 5-1).	Early promotion of self-regulation is especially effective, since a high degree of developmental plasticity is present in early childhood. An improved capacity for self-regulation is then able to exert an influence on a large number of cognitive, socio-emotional and motivational competencies.
Success (in school, at work, etc.) is essentially dependent on basic cognitive functioning (intelligence).	Social, emotional and motivational competencies are largely independent of basic cognitive abilities but constitute key prerequisites for success in the academic, professional and social spheres (→ section 5.2).	The capacity for self-regulation can be trained independently of intellectual competencies, assuming a minimum quota of basic cognitive abilities is present.

Myths	Facts	Conclusions
Genetic predispositions for personality traits always manifest themselves in behaviour as dictated by their particular and specific nature.	The manifestation of genetic predispositions (e.g. for aggressive behaviour) is not dictated by their nature but favoured by certain environments (e.g. precarious familial circumstances, domestic violence; → section 5.2).	Supportive and compensatory environmental experiences can limit the expression of negative behavioural tendencies, especially if these are present in early childhood.
Objectionable social behaviour in childhood is irreversible.		
Training measures aimed at increasing the capacity for self-regulation have the same effect at any age.		
The effect of training courses aimed at increasing the capacity for self-regulation is not general, but relates solely to the tasks specifically trained.	Evidence for the effectivity of programmes such as *Tools of the Mind* shows that their effects are generalised (→ section 5.2.3, box 5-2).	The longer-term effects of corresponding programmes must be investigated in further controlled studies.
Supportive activities are required only for children from precarious familial circumstances.	Hereditary predispositions must always be stimulated by suitable environments (→ section 5.2.3).	Socialisation should not be "taken for granted". Positive – i.e. supportive – environments must always be present in order to aid in the development of hereditary predispositions.

8.5 Economics of education economics, Education sociology (→ section 6)

Myths	Facts	Conclusions
Resources invested in education achieve the same cost–benefit ratio whatever the individuals' ages if the benefit is measured using success markers (e.g. low rate of unemployment, lower rate of welfare dependency).	Educational investments made at earlier stages in life can achieve a better cost–benefit ratio than investments made at later stages. This cost–benefit ratio is particularly large if the educational interventions make use of critical development time windows (→ section 6.2).	From a lifespan perspective, educational investments in early childhood are particularly advisable. The return is especially high for investments in a very high-quality of early childhood education and care families. Their funding should thus be secured and increased over the long term. Such high quality programmes generate a benefit for society as a whole.
Educational investments made later in life are ineffective: there is nothing to be done once people are stuck in their ways.	Later educational interventions are generally more complex and more expensive. The changes that they can achieve are smaller than those possible via interventions made during early development. Later investments are not ineffective, however, since people exhibit a lifelong learning ability (→ section 6.2).	Later educational interventions are all the more efficient the better the foundations established by earlier educational programmes are (self-productivity of abilities). Yet an increased level of educational investment targeting early childhood ought not to lead to the neglect of educational investments made for adolescents and young adults, especially in cases where these individuals were inadequately supported in their childhood.
Cost–benefit analyses made within the economics of education take into account only the direct monetary benefit or direct costs involved.	Analyses made by education economics take into account a broad spectrum of benefits and cost, which can be converted into long-term monetary utility components using various elaborated methods (→ section 6.2, box 6-1).	An evaluation of early childhood education and care investments must value a wide variety of utility components and match these to a common scale of values. Discounts must also be taken into account, i.e. the value of a later benefit must initially be given a discounted value at the point in time of an investment.
Educational interventions are always a good idea, even if their quality is not that high. It is better to do something than nothing.	A benefit can be obtained only in the case of high-quality interventions whose efficacy has actually been verified (→ section 6.2, box 6-1).	Investment in the *pedagogic quality* of early education and care programmes is a particular necessity, as the high profitability of educational investments made in early childhood depends on high-quality teaching.

Myths	Facts	Conclusions
Children from social groups with poor access to education are less likely to make transitions to higher secondary school: this is mostly the result of differences in abilities and performance due to social origin.	As well as performance differences specific to social origin (primary effects), class- and group-specific differences in educational decisions are also seen (secondary effects). While a need to maintain status drives the better-educated classes, the expectation that advanced education involves increased costs is the typical view of more poorly educated classes and groups (→ section 6.4).	Interventions should not only compensate for performance and skill differences conditional on social origin, but should also consider the motives for educational choices within various social groups. Families should be more fully informed about the opportunities and expectations of educational pathways.
Educational interventions make sense only if they originate from professional institutions external to the family.	Alongside improvements to the quality of educational institutions (crèches, day care centres, schools, etc.) the greater involvement of families in early education and care services is also important, as this can increase the efficiency of interventions (→ section 6.3).	Alongside the support oriented primarily towards the child outside the family, these programmes should also involve the family itself.

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The group of research scientists named below was involved in the preparation of the present position statement, which was then submitted to a total of six referees. Their remarks were incorporated into the final German version, as were comments from the Leopoldina Presidium and the Standing Committee – the joint representative body of Leopoldina, the Union of German Academies of Sciences and Humanities and the National Academy of Science and Engineering (acatech). The position statement was approved by the Standing Committee on March 19, 2014.

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