CHAPTER 11

Life Span Theory in Developmental Psychology

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Life span developmental psychology, now often abbreviated as life span psychology, deals with the study of individual development (ontogenesis) from conception into old age (P. B. Baltes, 1987, 1997, 2005; P. B. Baltes & Goulet, 1970; P. B. Baltes & Smith, 2004; Brim & Wheeler, 1966; Dixon & Lerner, 1988; Li & Freund, 2005; Neugarten, 1969; J. Smith & Baltes, 1999; Staudinger & Lindenberger, 2003; Thomae, 1979). A core assumption of life span psychology is that development is not completed at adulthood (maturity). Rather, ontogenesis extends across the entire life course and lifelong adaptive processes are involved. A further premise is that the concept of development can be used to organize the evidence about lifelong adaptive processes, although it is necessary to reformulate the traditional concept of development for this purpose (Harris, 1957). The reformulation required highlights that adaptive changes across life can be more open and multidirectional than the traditional concept of development with its strong focus on development as growth in the sense of maturation and advancement may suggest.

Sequencing in the life span gives temporal priority to earlier times and events in life. Aside from this temporal order of any developmental process, however, life span researchers expect each age period of the life span (e.g., infancy, childhood, adolescence, adulthood, old age) to have its own developmental agenda and to make some unique contribution to the organization of the past, present, and future in ontogenetic development. Moreover, life span developmental scholars, if they focus on processes and mechanisms of mind and behavior (such as identity of self or working memory) rather than on age, proceed from the assumption that these processes and mechanisms themselves express manifestations of developmental continuity and change across the entire life span.

Psychology deals with the scientific study of mind and behavior, including practical applications that can be derived from such scientific inquiry. Within this substantive territory of psychology, the objectives of life span psychology are: (a) To offer an organized account of the overall structure and sequence of development across the life span; (b) to identify the interconnections between earlier and later developmental events and processes; (c) to delineate the biological, psychological, social, and environmental factors and mechanisms which are the foundation of life span development; and (d) to specify the biological and environmental opportunities and constraints that shape life span development of individuals including their range of plasticity (modifiability). With such information, life span developmentalists further aspire to determine the range of possible development of individuals, to empower them to live their lives as desirably (and effectively) as possible, and to help them avoid dysfunctional and undesirable behavioral outcomes.

To this end, life span researchers have focused on searching for models and definitions of successful (effective) development. In general, and despite the search for universal considerations, life span researchers have highlighted individual and cultural variations in what is considered success or healthy. One general approach to this topic has been to define successful development as the maximization of gains and the minimization of losses and to consider in the definition of what constitutes gains and losses individual, group, and cultural factors (M. M. Baltes & Carstensen, 1996; P. B. Baltes, 1987; P. B. Baltes & Baltes, 1990a, 1990b; Brandtstädter & Wentura, 1995; Marsiske, Lang, Baltes, & Baltes, 1995). Such an approach is consistent with the postulate that there is no development (ontogenetic change) without a loss, just as there is no loss without a gain (P. B. Baltes, 1987). What is considered a gain in ontogenetic change and what is considered a loss is a topic of theoretical as well as empirical inquiry and defies an absolutist definition. The nature of what is considered a gain and what is considered a loss changes with age, involves objective and subjective criteria, and is conditioned by theoretical predilection and cultural context, as well as historical time.

We offer one more introductory observation on the objectives of life span psychology that it shares with other developmental specialties. Methodologically speaking, the study of ontogenesis is inherently a matter of general *and* differential psychology. Thus, life span research and theory is intended to generate knowledge about three components of individual development: (1) commonalities (regularities) in development, (2) interindividual differences in development, and (3) intraindividual plasticity in development (P. B. Baltes, Reese, & Nesselroade, 1977; R. M. Lerner, 1984; S.-C. Li & Freund, 2005; J. R. Nesselroade, 1991a, 1991b; Staudinger & Lindenberger, 2003). Joint attention to each of these components of individual variability and intra-individual potential, and specification of their age-related interplays, are the conceptual and methodological foundations of the developmental enterprise. Recognizing the methodological significance of the distinction among, and subsequent theoretical integration of, commonalities in development, inter-individual differences in development, and intra-individual plasticity has been a continuing theme in life span research and theory since its inception (Tetens, 1777).

What about the status and location of life span psychology within the territory of developmental psychology? Is life span developmental psychology a special developmental psychology, is it the overall integrative developmental conception of ontogenesis, or is it simply one of the many orientations to the study of development (P. B. Baltes, 1987)? Perhaps most scholars view life span psychology as one of the specializations in the field of developmental psychology, namely, that specialization that seeks to understand the full age spectrum of ontogenesis. In this case, the lens of life span psychologists is focused on the entire life course with less consideration for the details of age-related specificities.

Life span theory, however, can also be seen as the coordinated integration of various age-based developmental specializations into one overarching, cumulative framework of ontogenesis. Using such a life span-coordinating lens, one could argue that, if there is a general theory of ontogenetic development, it needs to be a theory that takes into account that ontogenesis extends from conception into old age. Thus, even if one is primarily interested in the study of infants and infant development, part of one's intellectual agenda requires attention to life span development (Brim, 1976). One example relevant for infancy researchers is the interest in the sequelae of infancy, in the search for its long-term consequences. Another example is the developmental context of infancy, which includes adults as socialization agents who themselves develop. Thus, to understand infant-adult interaction, it is important to recognize that adults are not fixed personages but that they are themselves subject to developmental goals and challenges (Brim & Wheeler, 1966; Hetherington, Lerner, & Perlmutter, 1988; Lachman, 2001; see also Elder & Shanahan, Chapter 12, this *Handbook,* this volume).

What about the organizational frame of life span theory? On a strategic level, there are two ways to construct life span theory: *Person-centered (holistic)* or *function-centered.* The holistic approach proceeds from consideration of the person as a system and attempts to generate a knowledge base about life span development by describing and connecting age periods or states of development into one overall, sequential pattern of lifetime individual development (see also Magnusson, 2001; Magnusson & Strattin, Chapter 8; Thelen & Smith, Chapter 6, this *Handbook,* this volume). An example would be Erikson's (1959) theory of eight life span stages. Often, this holistic approach to the life span is identified with *life course psychology* (Bühler, 1933; see also Elder, 1994; Elder & Shanahan, Chapter 12, this *Handbook,* this volume). Part of a holistic approach includes also efforts where behavioral profiles across a wide range of psychological functioning are in the center of attention and different age groups are contrasted in their profiles and longitudinal interconnections (J. Smith & Baltes, 1997).

The second way to construct life span theory is to focus on a category of behavior or a function (such as perception, information processing, action control, identity, personality traits, etc.) and to characterize the life span changes in the mechanisms and processes associated with the category of behaviors selected. An example would be the life span comparative study of the developmental organization, operation, and transformation of working memory, fluid intelligence, or the cognitive system as a whole (Craik & Bialystok, in press; Salthouse, 1991).

To incorporate both approaches to life span ontogenesis, the holistic person-centered and the function-centered one, the concept of *life span developmental psychology* (P. B. Baltes & Goulet, 1970) was advanced. From our point of view, then, life course psychology is a special case of life span psychology. However, this distinction between life course and life span developmental psychology should not be seen as categorically exclusive. It's more a matter of pragmatics and scientific history. In the history of the field, scholars closer to the social sciences, the biographical study of lives, and personality psychology display a preference for using the term life course development (e.g., Bühler, 1933; Caspi, 1987; Elder, 1994; Settersten, 2005). Scholars closer to psychology, with its traditional interest in mechanisms and processes as well as the decomposition of mind and behavior into its component elements, seem to prefer life span developmental psychology, the term chosen when the West Virginia Conference Series on the field was initiated (Goulet & Baltes, 1970).

HISTORICAL INTRODUCTION

While this section may seem to speak more about the past than the present, it is important to recognize that present theoretical preferences are in part the direct result of historical contexts of science and cultural scenarios rather than of carefully elaborated theoretical arguments. Some of the current issues surrounding life span psychology and its location in the larger field of developmental psychology are difficult to appreciate unless they are seen in their historical and societal contexts (P. B. Baltes, 1983; Brim & Wheeler, 1966; R. M. Lerner, 1983; Lindenberger & Baltes, 1999; Reinert, 1979). For instance, how is it that, especially in North America, life span developmental psychology is a relatively recent advent? This is not true for Germany where life span thinking has a long history.

Many German developmental historians, for instance, consider Johann Nicolaus Tetens as the founder of the field of developmental psychology (P. B. Baltes, 1983; Lindenberger & Baltes, 1999; Müller-Brettel & Dixon, 1990; Reinert, 1979). To Anglo-American developmentalists, however, Tetens is a relatively unknown figure. When Tetens published his two-volume monumental work on human nature and its development *Menschliche Natur and ihre Entwicklung* more than 200 years ago, in 1777, the scope of this first major opus covered the entire life span from birth into old age (see also Carus, 1808, for another early contribution to the field of developmental psychology). In addition, the content and theoretical orientation of this historical classic by Tetens included many of the current-day signatures of what has become known as the life span developmental theoretical orientation. For instance, development was not only elaborated as a lifelong process by Tetens, but also as a process that entails gains and losses, a process embedded in and constituted by sociocultural conditions, and as a process that is continuously refined and optimized *(vervollkommnet)* by societal change and historical transformations (see Table 11.1).

The second major early work on human development, written some 150 years ago by the Belgian Adolphe Quetelet (1835/1842), continued in a similar tradition. His treatment of human qualities and abilities was entirely life span in orientation, and because of his analysis of the dynamics between individual and historical development, Quetelet prefigured major developments in developmental methodology (P. B. Baltes, 1983). For instance, he anticipated the distinction between cross-sectional and longitudinal study designs as well as the need to conduct successions of age studies in order to disentangle effects of age from those of secular change and historical period (P. B. Baltes, 1968; Schaie, 1965; Schaie & Baltes, 1975).

The 1777 work of Johann Nicolaus Tetens was never translated into English. It is unfortunate because reading Tetens' deep, although largely conceptual and not empirical insights into the interplay among individual, contextual, and historical factors is a humbling experience. Equally impressive are his many concrete everyday examples and analyses of phenomena of human development (e.g., in the area of memory functioning), which make clear that ontogenetic development is not simply a matter of growth but the outcome of complex and multilinear processes of adaptive transformation. Because of these consistencies between the early work of Tetens and Quetelet and modern research in life span development, life span researchers like to argue that these are examples of why and how a life span orientation spawns a particular theoretical and methodological manner of looking at human development (P. B. Baltes, 1987; P. B. Baltes, Reese, & Lipsitt, 1980; Staudinger & Lindenberger, 2003).

TABLE 11.1 Table of Contents

Chapter	Title
1	On the perfectability of human psyche (Seelennatur) and its development in general
2	On the development of the human body
3	On the analogy between the development of the psyche (mind) and the development of the body
4	On the differences between men (humans) in their development
5	On the limits of development and the decline of psychological abilities
6	On the progressive development of the human species
7	On the relationship between optimization (Vervollkommnung) of man and his life contentment (Glückseligkeit)

Source: From *On the Perfectability and Development of Man,* volume 2, by J. N. Tetens, 1777, Leipzig, Germany: Weidmanns Erben und Reich.

There are several reasons why German developmental psychology treated and treats ontogenesis as lifelong development (P. B. Baltes et al., 1980; Groffmann, 1970; Reinert, 1979). In German-speaking countries, for instance, philosophy, in addition to biology, was a major springboard for the emergence of life span psychology. Because of this close tie to philosophy and the humanities, human development in Germany was widely understood to reflect factors of education, socialization, and culture. In addition, there was also a focus on the topic of human development beyond early adulthood. The widespread knowledge and discussion of essays on old age, such as the ancient texts of Cicero (44 B.C./1744) or the then contemporary text of Grimm (1860), are examples of this nineteenth-century interest among German scholars in issues of development beyond early adulthood. According to these traditions, fueled primarily by philosophy and the humanities, a widely held position among German scholars was that it was within the medium of "culture" that individuals "developed." With very little biological science on maturity or growth at that time, there was no reason to assume that development should be identified with physical growth and, therefore, should stop at adolescence or early adulthood.

In contrast, the Zeitgeist in North America and also in some other European countries, such as England, was different when developmental psychology emerged as a specialty around the turn of the century (1900). At that time, the newly developed fields of genetics and biological evolution (such as Darwinism) were in the forefront of ontogenetic thinking. From biology, with its maturation-based concept of growth, may have sprung the dominant American emphasis in developmental psychology on child psychology and child development. In North America, at least until the advent of social-learning and operant psychology-based theory in the 1960s (Bandura & Walters, 1963; Reese & Lipsitt, 1970), biological conceptions of growth and maturation (Harris, 1957) led the organization and intellectual agenda in ideas about development. Not surprisingly, therefore, in combination with other political and social forces, children became the primary focus of attention in North American developmental psychology.

The focus on childhood was so pervasive that historical accounts of developmental psychology published in the centennial birth year of American psychology (Parke, Ornstein, Rieser, & Zahn-Waxler, 1991) were entirely devoted to child and adolescent development. No mention was made of the major historical life span scholars such as Tetens, Bühler, or Pressey. Even Sheldon White (1992), the author of the centennial article on G. Stanley Hall, one of the major figures in early American developmental psychology who late in his career turned to adulthood and old age to complete his agenda of developmental studies (see Hall, 1922), ignored this opportunity to treat ontogenesis as a lifelong phenomenon.

Before the life span view of ontogenesis entered the field of developmental psychology more forcefully in North American circles in the 1960s and 1970s, several earlier contributions attempted to broaden developmental psychology toward a consideration of the entire life span (e.g., Hollingworth, 1927; Pressey, Janney, & Kuhlen, 1939; Sanford, 1902). These early American publications on themes of life span development resulted not so much in redirecting developmental psychology from child psychology, but in setting the foundation for the emergence of the field of adult development and aging (gerontology). Indeed, many of the active life span psychologists who promoted life span thinking were closely affiliated with efforts to build a psychological science of aging (Goulet & Baltes, 1970; Havighurst, 1948, 1973; Kuhlen, 1963; Neugarten, 1969; Riegel, 1958; Schaie, 1970; Thomae, 1959, 1979).

As a consequence, in American psychology there evolved a strong bifurcation between child developmentalists and researchers on adult development and aging. One indication of this bifurcation was the creation of two relatively independent divisions concerned with lifelong ontogenesis within the American Psychological Association (Division 7: Developmental Psychology; Division 20: Maturity and Old Age, later renamed into Adult Development and Aging). This divide was also reflected in scholarly publications involving age-specific specialties. On the one hand, the creation of a multitude of organizations and journals heralded the arrival of a comprehensive behavioral science of ontogenesis, a trend that continues. The most recent addition of a "new" age specialty is midlife, and not inappropriate for the beginning of a new century, the first handbook on the topic was published (Lachman, 2001). The emergence of this field of midlife development was much enhanced by the work of a MacArthur Network on Midlife Development chaired by one of the early leaders of the life span field, Orville G. Brim (e.g., Brim & Wheeler, 1966; see also Brim, Ryff, & Kessler, 2004). On the other hand, for life span developmental scholars, these age-specific creations were unfortunate events because they did not promote an integrative effort at constructing life span theory.

That a life span approach became more prominent during the recent decades was dependent on several other factors and historical trends. A major factor was a concurrent concern with issues of life span development in neighboring social-science disciplines, especially sociology and economics. In sociology, life course sociology took hold as a powerful intellectual force (Brim & Wheeler, 1966; Elder, 1985, 1994; Mayer, 2003; Riley, 1987; Riley, Johnson, & Foner, 1972; Settersten, 2005).

Within psychology, and aside from the intellectual forces that may have been inherent in the life span field itself (see later sections in this chapter), three external conditions nurtured the burgeoning of interest in life span development (P. B. Baltes, 1987). First, demographically speaking, the population as a whole was aging. Meanwhile, this historical change in the demographic context of human development has been fully reflected in the organization of the American Psychological Association (APA). Perhaps surprising to child developmentalists, the Division (20) devoted to adult development and aging has grown larger than Division 7, called developmental psychology but which, when using the focus of the work of the scholars elected to its presidency, or the scope of its primary journal as indicators, is more or less entirely devoted to the topic of development from infancy through adolescence.

The second related historical event of life span work in the study of ontogenesis was the concurrent emergence of gerontology (aging research) as a field of specialization, with its search for the lifelong precursors of aging (Birren, 1959; Birren & Schaie, 1996; Cowdry, 1939). The Gerontological Society of America, for instance, is as large or larger than its counterpart organization, the Society for Research in Child Development. In fact, linking the study of gerontology to the study of life span development is a critical task of current developmental theory. Are theories of development the same as theories of aging? Do we need different conceptions of ontogenesis to characterize development and aging (P. B. Baltes & Smith, 2004)? For instance, does one approach deal with phenomena of growth, and the other with decline?

A third factor, and a major source of rapprochement between child developmentalists and adult developmentalists, was the "aging" of the participants and of the researchers in the several classical longitudinal studies on child development begun in the 1920s and 1930s (Elder, 1974; Kagan, 1964). What are the effects of child development on later life? Which childhood developmental factors are positive or risk-prone for later healthy development? These were questions that were increasingly pursued beginning in the 1970s as the children of the classical longitudinal studies reached early adulthood and midlife. Some of these studies have even provided a basis for a better understanding of processes in the last phases of life (Block, 1971, 1993; Eichorn, Clausen, Haan, Honzik, & Mussen, 1981; Elder, 1985, 1986, 1994; Holahan, Sears, & Cronbach, 1995; Kagan & Moss, 1962; Sears & Barbee, 1977).

Out of these developments has emerged new territory in developmental scholarship. The need for better collaboration among all age specialities of developmental scholarship, including child development, has become an imperative of current-day research in developmental psychology (Hetherington et al., 1988). But for good life span theory to evolve, it takes more than courtship and mutual recognition. It takes a new effort and serious exploration of theory that—in the tradition of Tetens (1777)—has in its *primary* substantive focus the structure, sequence, and dynamics of the entire life course.

TOWARD PSYCHOLOGICAL THEORIES OF LIFE SPAN DEVELOPMENT: FIVE LEVELS OF ANALYSIS

We approach psychological theories of life span development in five sequential but interrelated steps. Each step will bring us closer to specific psychological theories of life span development. As shown in Table 11.2, we move from the distal and general to the more proximal and specific in our treatment of life span ontogenesis. This movement also implies a movement from the metatheoretical to the more empirical.

TABLE 11.2 Toward Psychological Theories of Life Span Development: Five Levels of Analysis

Level 1:	Biological and Cultural Evolutionary Perspectives: On the Incomplete Architecture of Human Ontogenesis and the Life Span Developmental Dynamics between Biology and Culture
Level 2:	Dynamics of Gains and Losses: Life Span Changes in the Relative Allocation of Resources in Development to Functions of Growth versus Maintenance/Resilience versus Regulation of Loss
Level 3:	A Family of Metatheoretical Propositions about the Nature of Life Span Development
Level 4:	An Example of a Systemic and Overall Theory of Successful Life Span Development: Selective Optimization with Compensation
Level 5:	Life Span Theories in Specific Functions and Domains: Intelligence, Cognition, Personality, Self

Specifically, we consider five levels of analysis. Level 1, the most distal and general one, makes explicit the cornerstones and "norms of reaction" or "potentialities" (P. B. Baltes, 1997; P. B. Baltes & Smith, 2004; Brent, 1978a, 1978b; R. M. Lerner, 2002; S.-C. Li, 2003; Schneirla, 1957; see also Gottlieb, Wahlsten, & Lickliter, Chapter 5, this *Handbook,* this volume) of life span ontogenesis. With this approach, which is also consistent with the levels of integration notion of Schneirla or more recently S.-C. Li (2003), we obtain information on what we can expect about the general scope and shape of life span development based on evolutionary, historical, and interdisciplinary views dealing with the interplay between biology and culture during ontogenesis.

Levels 2 and 3 move toward psychological theories of individual development. On these levels of analysis, while keeping the initial overall framework in mind, we shall describe, using an increasingly more fine-grained level of analysis, specific conceptions of life span developmental psychology. On Level 4, we advance one concrete illustration of an overall life span developmental theory, a theory that is based on the specification and coordinated orchestration of three processes: Selection, optimization, and compensation. Subsequently, and corresponding to a putative Level 5, we move to more molecular phenomena and functions. Specifically, we characterize life span theory and research in areas of psychological functioning such as cognition, intelligence, personality, and the self.

We have chosen this approach—of proceeding from a broad level of analysis to more and more specific and microlevels of psychological analysis—because it illustrates one of the central premises of life span psychology, that development is embedded in a larger evolutionary, historical, and cultural context (P. B. Baltes et al., 1980; Durham, 1991; Elder & Shanahan, Chapter 12, this *Handbook,* this volume; Finch & Zelinski, 2005; Hagen & Hammerstein, 2005; R. M. Lerner, 2002; S.-C. Li, 2003; Magnusson, 1996; Riegel, 1973; Schaie, Willis, & Pennak, 2005). Recognizing the powerful conditioning of human development by biological and cultural evolution and co-evolution emphasizes that the future is not fixed either, but includes features of an open system. In other words, the future is not something we simply enter but also something that we help create and that is dependent on the partially always novel co-construction of genetic, environmental, and cultural conditions (P. B. Baltes, Reuter-Lorenz, & Rösler, 2006). This is especially true for the second half of life and old age. It is there that the relative incompleteness of the biology- and culture-based architecture of human development becomes most conspicuous (P. B. Baltes, 1997; P. B. Baltes & Smith, 2004).

The Overall Architecture of Life Span Development: A First View from the Perspectives of Biological and Cultural Co-Evolution and Biocultural Co-Construction (Level 1)

We now turn in our quest for understanding life span development to the first level of analysis chosen, the overall biological and cultural architecture of life span development (P. B. Baltes, 1997).

Questions about the how and why of the role of biology (heredity) and culture (environment) have formed one of the main intellectual frames in developmental psychology. What is the role of cultural and biological factors in ontogenesis, how do they interact, condition, and modify each other? What is the "zone of development," the "norm of reaction," the "range of plasticity" that we can expect to operate during ontogenesis? Based on genetic and evolution-based factors and on cultural structures, for instance, only certain pathways can be implemented during ontogenesis, and some of these are more likely to be realized than others. Despite the sizeable plasticity of humans, not everything is possible in ontogenetic development. Development follows principles that make universal growth impossible (Hagen & Hammerstein, 2005; S.-C. Li & Freund, 2005).

With a view on the future and future societal changes, we need to recognize first that the overall architecture of human development is incomplete (P. B. Baltes, 1997; P. B. Baltes & Smith, 2003): The overall biological and cultural architecture of human development continues to evolve and in this process co-constructs and modifies each other (P. B. Baltes, et al., 2006). A second insight is that what is most "undeveloped" in the gene-environment interplay is both the genetic base and the culture of old age. While earlier age periods of the life course have a long tradition of biological and cultural co-evolution and co-construction (P. B. Baltes et al., 2006; Durham, 1991; Finch & Zelinski, 2005; Tomasello, 1999) and fine-tuning, the anthropological tradition of biological and cultural co-evolution for later phases of life, historically speaking, is younger. As we move from childhood to old age, the evolutionary (biological and cultural) incompleteness of the overall architecture of the life span increases.

Figure 11.1 illustrates the main lines of argument (P. B. Baltes, 1997; see also Kirkwood, 2003). Note first that the specific form (level, shape) of the functions characterizing the overall life span dynamics is not critical. What is critical is the overall direction and reciprocal relationship between these functions. Figure 11.1 identifies three such directional principles that regulate the nature of ontogenetic development.

Evolutionary Selection Benefits Decrease with Age

The first part of Figure 11.1 represents a conclusion that derives from an evolutionary perspective on the nature of the genome and its age-correlated changes in expressivity (Charlesworth, 1994; Finch, 1990, 1996;

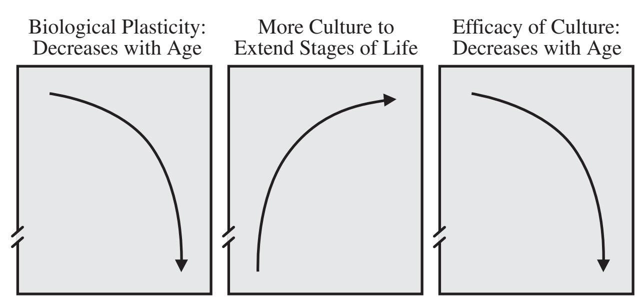

Figure 11.1 Schematic representation of basic facts about the average dynamics between biology and culture across the lifespan. There can be much debate about the specific forms of the functions but less about directionality. From "On the Incomplete Architecture of Human Ontogeny: Selection, Optimization, and Compensation as Foundation of Developmental Theory," by P. B. Baltes, 1997, *American Psychologist, 52,* pp. 366–380.

Kirkwood, 2003; Martin, Austad, & Johnson, 1996; Medawar, 1946). The central argument is that the benefits resulting from evolutionary selection display a negative age correlation, that is, that there is an age-associated declining process of evolution-based natural selection.

During evolution, the older the organism, the less the genome benefited from the genetic advantages associated with evolutionary selection. As a consequence, and certainly after maturity, *the expressions and mechanisms of the genome lose in functional quality as organisms age*. Evolutionary selection was tied to the process of reproductive fitness and its midlife location in the life course. As a consequence, reproductive fitness-based evolutionary selection pressure—which in the long run resulted in a better and better genome—operated *primarily* and more strongly during the first half of life. This general statement holds true even though there are "indirect" positive evolutionary selection benefits carried into and located in old age, for instance, through processes of grandparenting, coupling, or exaptation (Gould, 1984).

During evolution, this age-associated diminution of evolutionary selection benefits was further enhanced by the fact that in earlier historical times only few people reached old age. Thus, evolutionary selection could not operate as frequently to begin with when it came to older individuals. Most individuals died before possible negative genetic attributes were activated or possible negative biological effects of earlier developmental events became manifest. Therefore, and quite aside from other factors of the biological processes of aging (Finch, 1990; Kirkwood, 2003; Martin et al., 1996; Osiewacz, 1995; Yates & Benton, 1995), it has been argued that genes active at later stages of the life course are more often deleterious or dysfunctional genes than those operative at earlier times in the life span.

One concrete illustration of this aging-based weakening of evolutionary selection benefits is the existence of late-life illnesses such as Alzheimer dementia (for other examples see Martin et al., 1996). This disease typically does not become manifest until age 70. After age 70, however, it increases markedly in frequency such that among 90- to 100-year-olds Alzheimer dementia has a prevalence of about 50% (Helmchen et al., 1999). This disease is at least in part a late-life disease because reproductive fitness based evolutionary pressure was unable to select against it. Martin et al. (1996) called such an outcome "selection neutrality."

There are other aspects of a biology of aging that imply an age-associated loss in biological functioning. One is the disposal soma theory of aging that attributes senescence to the accumulation of damage and faults in cells and tissues. Related models of biological aging are wear-and-tear theories, entropy-based conceptions as well as interpretations related to the sources of age-accumulated increases in mutations. Note that some of the factors involved are associated directly with the mechanisms and operative processes of ontogenesis itself. Currently, for instance, age-associated increases in oxidative damage are proffered as a key possibility to account for aging-associated losses in biological efficacy (Kirkwood, 2003; Martin et al., 1996). One variant is the so-called counterpart theory of aging (Birren, 1988; Yates & Benton, 1995). It proffers that aging processes in part are the negative by-products of the early life process of growth. Related to this view is the genetic mechanism of "antagonist pleiotropy" (Martin et al., 1996).

These various considerations about the role of genetic factors result in a converging conclusion regarding the biological architecture of life span development (P. B. Baltes, 1997). Where evolutionary selection and the ontogenetic biology of aging are concerned, the life span of humans displays a loss in plasticity and, in addition, an increasingly unfinished architecture. These insights may be captured with the sentence: "Biology is not a good friend of old age." With age, the genetic material, associated genetic mechanisms, and genetic expressions become less effective and less able to generate or maintain high levels of functioning.

Increase in Need for Culture as Human Development Is Extended in Level and Age Range

What about the role of culture and culture-related factors in preparation of and during ontogenesis? By culture, we mean the entirety of psychological, social, material, and symbolic (knowledge-based) resources which humans developed over millennia; and which, as they are transmitted across generations, make human development as we know it possible (P. B. Baltes et al., 2006; Cole, 1996; Damon, 1996; D'Andrade, 1995; Durham, 1991; S.-C. Li, 2003; Shweder, 1991; Tomasello, 1999; Valsiner & Lawrence, 1997). These cultural resources include cognitive skills, motivational dispositions, socialization strategies, physical structures, the world of economics as well that of medical and physical technology.

Figure 11.1 summarizes our view of the life span dynamics associated with culture and culture-based processes (P. B. Baltes, 1997; P. B. Baltes, Staudinger, & Lindenberger, 1999). The middle section represents the proposition that for ontogenetic development to be extended in level and span of life, an increase in the level and quality of cultural resources is required to continue a productive interplay between culture and age across the life span. There are two parts to the argument for an *age-related increase in the need for more culture.*

The first argument is that for human ontogenesis to have reached higher and higher levels of functioning and to extend itself longer spans of life, whether in physical (e.g., sports) or cultural (e.g., reading and writing) domains, there had to be a conjoint evolutionary increase in the richness and dissemination of culture. Thus, human development the way we know it in the modern world is essentially and necessarily tied to the evolution of culture and its impact on genetic evolution and the kind of life environments individuals transact with as they develop during ontogenesis. And the further we expect human ontogenesis to extend itself into adult life and old age, the more it will be necessary for particular cultural factors and resources to emerge to make this possible.

To appreciate the power of the evolution of such culture-based resources in the process of biocultural co-production consider what happened to average life expectancy during the twentieth century in industrialized countries. It was not the genetic make-up of the individual or the population that evinced marked changes during this time. Economic and technological innovations were the central factors. Similarly, the dramatic increase in literacy rates over the past centuries in industrialized nations was not the result of a change in the genome, but above all a change in environmental contexts, cultural resources, and strategies of teaching.

To prevent a possible misunderstanding: The trajectory depicted in the middle panel of Figure 11.1 does not mean that children require little cultural input and support. Biocultural co-construction always operates though in varying combinations (P. B. Baltes et al., 2006; P. B. Baltes & Singer, 2001; Li, 2003). Early in ontogenetic life, because the human organism is still undeveloped biologically, infants and children need a wide variety of psycho-social-material-cultural support. But in terms of overall resource structure, this support in childhood is focused on basic levels of functioning such as environmental sensory stimulation, nutrition, language, and social contact. Subsequent age stages, however, require increasingly more and more differentiated cultural resources, especially if one considers the high levels of knowledge and technology that adults need to acquire in order to function well in modern societies. Thus, it is primarily through the medium of more advanced levels of culture in the biocultural co-construction process that individuals have the opportunity to continue to develop across the higher ages of the life course.

There is a second argument for the theory that, with age, the need for the supportive role of culture increases. Because of the age-related biological weakening and reduced plasticity described in the left part of Figure 11.1, an age-associated increase in "need" for culture is also necessary because more environmental support is necessary to maintain efficacy. Thus, if and when individuals aspire to maintain their previous levels of functioning as they age, culture-based resources (material, social, economic, psychological) are necessary to maintain high levels of functioning. In the aging literature, the work of Craik (1986; Craik & Bialystok, in press) on the role of environmental support to maintain memory efficacy is exemplary.

Age-Related Decrease in Efficiency of Culture

The right panel of Figure 11.1 illustrates a further overall characteristic of the life span developmental dynamic between biology, culture, and age. Here, the focus is on a third cornerstone of the overall architecture of the life course, that is, the efficacy or *efficiency* of cultural factors and resources (P. B. Baltes, 1997).

During the second half of life, we submit that there is an age-associated reduction in the efficiency of cultural factors. With age, and conditioned primarily by the negative biological trajectory of the life course, the relative power (effectiveness) of psychological, social, material, and cultural interventions becomes smaller and smaller. Take cognitive learning in old age as an example (P. B. Baltes, 1993; Craik & Salthouse, 2000; Lindenberger, 2001; Salthouse, 2003; T. Singer, Lindenberger, & Baltes, 2003). The older the adult, the more time, practice, and more cognitive support it takes to attain the same learning gains. And moreover, at least in some domains of information processing, and when it comes to high levels of performance, older adults may never be able to reach the same levels of functioning as younger adults even after extensive training (P. B. Baltes & Kliegl, 1992; Kliegl, Smith, & Baltes, 1990; T. Singer, Lindenberger, et al., 2003).

We submit that the three conditions and trajectories outlined in Figure 11.1 form a robust fabric, a biocultural, and because of its incompleteness, dynamic architecture of the life span (P. B. Baltes, 1997). This biocultural is not fixed, but subject to further processes of biocultural co-construction. We argue that the general script of this biocultural fabric represents a first tier of life span theory. They represent constraints on the degree of openess of the developmental life span system. Whatever the specific content and form of a given psychological theory of life span continuity and change, we maintain that it needs to be consistent with the frame outlined in Figure 11.1. For instance, we conclude that any theory of life span development positing "general" positive advances across broad domains of functioning in later adulthood is probably false.

The immediate future of old age, therefore, will depend to a large measure on our ability to generate and employ culture and culture-based technology in compensating for the unfinished architecture of biology, for the age-correlated decrease in biological functioning, for the growing gap between mind and body. In the long run, the changing dynamics in the relative impact of genome- and culture-based influences also suggests that interventions into the biogenetic system itself are necessary to generate more desirable states of aging, especially in the oldest-old. Biocultural co-construction is a concept that reflects the need for both biology and culture to cooperate in such aspirations (P. B. Baltes et al., 2006; P. B. Baltes & Singer, 2001; S.-C. Li, 2003).

Life Span Changes in the Relative Allocation of Resources to Distinct Functions of Development (Level 2)

Having characterized the overall biocultural landscape of human development, we move toward a level of organization closer to central concepts of developmental psychology. In Table 11.2, this was designated as Level 2. We take this next step by reflecting about functions (goals) and outcomes of development.

Growth versus Resilience (Maintenance) versus Regulation of Loss

To what degree does the overall biocultural architecture outlined in Figure 11.1 prefigure pathways of development and the kind of adaptive challenges individuals face as they move through life? One possibility is to distinguish between three functions of ontogenetic development. The first two are known from research in child development: *growth* and *resilience* (maintenance and recovery) of functioning (Cicchetti, 1993; Garmezy, 1991; Rutter, 1987). Life span researchers have added to these two functions that of management or *regulation of losses* (P. B. Baltes, 1987, 1997; Brandtstädter & Baltes-Götz, 1990; Brandtstädter & Greve, 1994; Brim, 1988; Dixon & Bäckman, 1995; Heckhausen & Schulz, 1993; Labouvie-Vief, 1982; Staudinger, Marsiske, & Baltes, 1993, 1995). This addition was invoked because, as the growing incompleteness of the biocultural architecture postulates, the foundational frame of lifelong development includes not only conditions of growth and health, but also conditions of permanent loss that, in principle, are not avoidable.

Figure 11.2 displays our general life span developmental script about the allocation of available resources for these three major adaptive tasks of growth, maintenance/recovery (resilience), and regulation of loss (P. B. Baltes, 1987; Staudinger et al., 1993, 1995). With the adaptive tasks of *growth,* we mean behaviors aimed at reaching higher levels of functioning or adaptive capacity. Under the heading of *maintenance* and *resilience,* we group behaviors which are aimed at maintaining levels of functioning in the face of challenge or returning to previous levels after a loss. With the adaptive task of management or *regulation of loss,* we identify those behaviors which organize adequate functioning at lower levels when maintenance or recovery, for instance, because of external-material or biological losses, is no longer possible.

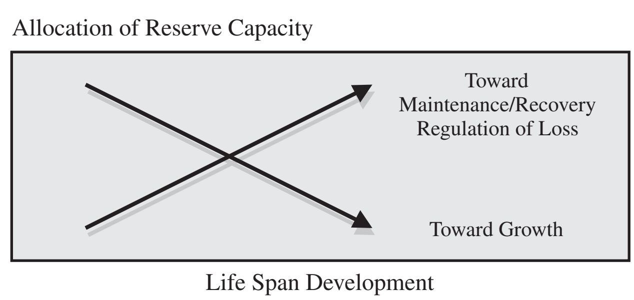

Figure 11.2 Life span changes in the allocation of resources into distinct functions (objectives) of development: growth, maintenance and recovery (resilience), and regulation (management) of loss. *Source:* From "Resilience and Reserve Capacity in Later Adulthood: Potentials and Limits of Development across the Life Span" (pp. 801–847), by U. M. Staudinger, M. Marsiske and P. B. Baltes, in *Developmental Psychopathology: Vol. 2. Risk, Disorder, and Adaptation,* D. Cicchetti & D. Cohen (Eds.), 1995, New York: Wiley.

In childhood and early adulthood, the primary allocation of resources is directed toward growth. During adulthood, allocation toward maintenance and recovery (resilience) is on the increase. Research by Freund and colleagues has shown that individuals of different ages hold mental scripts and preferences that are consistent with this life span change in the focus of allocation (Freund & Ebner, 2005; Riediger & Freund, in press). In advanced adulthood and especially in old age, more and more resources are directed toward regulation (management) of loss, although this need may not be realized as often as desired since the application of compensatory behaviors is effortful (P. B. Baltes & Baltes, 1990a; Freund & Baltes, 2002b). In old age, few resources remain available to be allocated to growth. Consistent with this general view, older adults invest more time into compensation than optimization (M. M. Baltes & Carstensen, 1996; Freund, in press). However, some targets for positive change continue to be realistic, such as advances in emotional and spiritual regulation or wisdom (P. B. Baltes & Staudinger, 2000; Carstensen, 1995; Carstensen, Isaacowitz, & Charles, 1999; Kunzmann, 2004; Staudinger, Freund, Linden, & Maas, 1999). Such a characterization is an oversimplification because individual, domain, and contextual differences need to be taken into account. Thus, the characterization is one about relative probability.

In our view (e.g., P. B. Baltes, 1987; Freund & Baltes, 2002b; Staudinger et al., 1995; for related arguments, see also Brandtstädter & Greve, 1994; Brim, 1992; Edelstein & Noam, 1982; Heckhausen, 1997; Labouvie-Vief, 1982), the life span shift in the relative allocation of biology- and culture-based resources to the functions of growth, resilience, and the management of loss is a major issue for any theory of life span development. This is true even for those theories that, on the surface, deal only with growth or positive aging (e.g., Erikson, 1959; Perlmutter, 1988; Ryff, 1984, 1989a). In Erikson's theory, for instance, the acquisition of generativity and wisdom are the positive developmental goals of adulthood. Despite the growth orientation of these constructs, even in Erikson's theory their attainment is inherently tied to recognizing and managing issues of generational turnover as well as of one's finitude and impending death. Another example is research on another facet of positive aging, wisdom (P. B. Baltes & Staudinger, 2000; Kunzmann & Baltes, 2003a, 2003b; Sternberg & Jordan, 2005). The expression of wisdom becomes more and more difficult as the oldest ages are reached, and its very content includes the recognition and mastery of the losses of life.

To illustrate this dynamic of coordinating in an adaptive manner facets of growth, maintenance, and regulation of loss, see Margret Baltes and her colleagues' research (M. M. Baltes, 1995, 1996; M. M. Baltes & Silverberg, 1994; M. M. Baltes & Wahl, 1992). This work focuses on the interplay between autonomy and dependency in different age groups including children and the old. While the primary focus of the first half of life is the maximization of autonomy, the developmental agenda changes in old age. In old age, to deal effectively with age-based losses and to retain some independence, the productive and creative use of dependency becomes critical. By invoking dependency and support, resources are freed for use in other domains involving personal efficacy and growth.

According to Margret Baltes, for older adults to maintain autonomy in select domains of functioning, the effective exercise and use of dependent behavior is a compensatory must. By invoking dependency and support, resources are freed up for use in other domains involving personal efficacy and growth. Furthermore, this program of research also showed that the three-fold developmental-function script is present in how others approach behavioral interactions with members of different age groups. In children, the primary script in the social world is one of supporting independence. The reverse (a dependency-support script) is true when interacting with older persons (M. M. Baltes, 1996).

In sum, a further step in developing life span theory is to recognize and specify the nature of the dynamics of individual as well as social resource allocation for growth, maintenance (resilience), and regulation of loss. Of particular importance is the nature of the shift in this systemic interplay and orchestration over the life course. Research presented later in this chapter on the theory of selective optimization with compensation (P. B. Baltes & Baltes, 1990a; Freund & Baltes, 2002a) will show how this general conceptual emphasis is translated into the study of specific domains such as cognition or motor behavior.

Deficits as Catalysts for Progress (Growth)

The attention given to the age-related weakening of the biological foundation in Figures 11.1 and 11.2 may have suggested that the consequences of such a loss in biological quality implies also a pervasive age-related loss in behavioral functioning, in other words, that there may be no opportunity for growth at all in the second half of life in those domains where biological factors are important.

To prevent this possible misunderstanding, we next describe why this is not necessarily so, why deficits in biological status also can be the foundation for progress, that is, antecedents for positive changes in adaptive capacity. At least since the publication of "Limits of Growth" by the Club of Rome, there has been increasing public awareness that more is not always better and that progress is possible even in the context of limitations and constraints. Biocultural co-construction was already introduced as a metascript. Similar perspectives derive from considerations of the adaptive processes in evolution as well as from consideration of the function of compensation during ontogenesis (see also P. B. Baltes, 1991, 1997; Brandtstädter, Chapter 10, this *Handbook,* this volume; Dixon & Bäckman, 1995; Durham, 1991).

The most radical view of the notion that deficits can spell progress is contained in the notion of *culture as compensation.* That is, the condition of a limitation or a loss generates new forms of mastery and cultural innovation. As researchers study what is not yet known, cultural attention shifts to those areas where there is an objective or subjectively perceived lack or a deficit. In this line of thinking, the human organism is by nature a "being of deficits" (*Mängelwesen;* Gehlen, 1956) and social culture has developed or emerged in part to deal specifically with biological deficits.

Memorization strategies, for instance, were developed in part because human memory is not optimal. To give another example: The fact that humans are biologically vulnerable regarding outside temperatures (lack of perfect thermo-regulation) is among the reasons for a highly developed body of knowledge, values, and technology about textiles and clothing. This applies both to cultural evolution on the societal level and to individual ontogenesis. Research on psychological compensation is a powerful illustration of the idea that deficits can be catalysts for positive changes in adaptive capacity (Bäckman & Dixon, 1992; M. M. Baltes & Carstensen, 1996; P. B. Baltes & Baltes, 1990b; Dixon & Bäckman, 1995; Marsiske et al., 1995; Rowe & Kahn, 1987).

A Family of Metatheoretical Propositions about Life Span Developmental Theory (Level 3)

Because of the complexities associated with life span ontogenetic processes and the challenge involved in the articulation of adequate theoretical concepts, there has been much discussion in life span work about metatheory of development (e.g., P. B. Baltes, 1987; P. B. Baltes et al., 1980; Labouvie-Vief, 1980, 1982; R. M. Lerner, 1991, 2002; J. R. Nesselroade & Reese, 1973; Overton & Reese, 1973; Reese, 1994; Riegel, 1976). Included in this discussion was a continuing dialogue about the shortcomings of extant conceptions of development as advanced primarily by child developmentalists (e.g., Collins, 1982; Harris, 1957). A *family of metatheoretical propositions* intended to characterize the nature of life span development was one outcome of this extensive discussion (P. B. Baltes, 1979a, 1987; R. M. Lerner, 1983).

In the following discussion, we attempt to update this effort at a metatheory of life span development (Table 11.3). In doing so, we also point out that similar metatheoretical work exists in other quarters of developmental theory, particularly in conceptual work associated with cultural psychology, evolutionary psychology, and systems theory (see also Fischer & Bidell, Chapter 7; Gottlieb et al., Chapter 5; Thelen & Smith, Chapter 6, this *Handbook,* this volume). In the present context, however, we emphasize the uniqueness of the positions advanced by life span scholars.

Reformulating the Concept of Development from a Functionalist Perspective: Development as Change in Adaptive Capacity

From a life span theory point of view, it was important to articulate concepts of development that go beyond unidimensional and unidirectional models that had flourished in conjunction with the traditional biological conceptions of growth or physical maturation. In these traditional conceptions (Harris, 1957; Sowarka & Baltes, 1986), attributes such as qualitative change, ordered sequentiality, irreversibility, and the definition of an end state played a critical role. Primarily by considering ontogenetic development from a functionalist perspective (Dixon & Baltes, 1986), the traditional conception of development was challenged.

Development as Selection and Selective Adaptation (Optimization). The traditional concept of development emphasizes a *general* and *universal* development of an entity geared toward a higher level of functioning which, in addition, continuously incorporates most if not all previously developed capacities (Harris, 1957; R. M. Lerner, 1983, 2002; H. Werner, 1948). Historically, this view of ontogenetic development has been pictured as the unfolding and emergence of an entity,

TABLE 11.3 Family of Theoretical Propositions Characteristic of Life Span Developmental Psychology

Life span development: Ontogenetic development is a lifelong process that is co-constructed by biology and culture. No age period holds supremacy in regulating the nature of development.

Life span changes in the dynamic between biology and culture: With age and certainly after adulthood, there is a growing gap between biological potential and individual-cultural goals. This gap is fundamental to ontogenesis as the biological architecture of life is incomplete and inevitably results in loss of adaptive functioning and eventually death.

Life span changes in allocation of resources to distinct functions of development:growth versus maintenance versus regulation of loss: Ontogenetic development on a systemic level involves the coordinated and competitive allocation of resources in three distinct functions: (1) growth, (2) maintenance including recovery (resilience), and (3) regulation of loss. Life span developmental changes in the profile of functional allocation involve a shift from the allocation of resources for growth (more typical of childhood) toward an increasingly larger and larger share allocated to maintenance and management of loss.

Development as selection (specialization) and selective optimization in adaptive capacity: Development is inherently a process of selection and selective adaptation. Selection is due to biological, psychological, cultural, and environmental factors. Developmental advances are due to processes of optimization. Because development is selective and age-associated changes in potential, compensation is also part of the developmental agenda.

Development as gain/loss dynamic: In ontogenetic development, there is no gain without loss, and no loss without gain. Selection and selective adaptation are space-, context-, and time-bound. Thus, selection and selective adaptation imply not only advances in adaptive capacity but also losses in adaptivity for alternative pathways and adaptive challenges. A multidimensional, multidirectional, and multifunctional conception of development results from such a perspective.

Plasticity: Much intraindividual plasticity (within-person variability) is found in psychological development. The key developmental agenda is the search for the range of plasticity and its age-associated changes and constraints.

Ontogenetic and historical contextualism as paradigm: In principle, the biological and cultural architecture of human development is incomplete and subject to continuous change with biological and cultural factors, conditions, and co-constructing and modifying each other. Thus, ontogenetic development varies markedly by historical-cultural conditions. The mechanisms involved can be characterized as principles associated with biocultural contextualism. As an illustration, development can be understood as the outcome of the interactions (dialectics) between three systems of biological and environmental influences: (1) normative age-graded, (2) normative history-graded, and (3) nonnormative (idiosyncratic). Each of these sources evinces individual differences and, in addition, is subject to continuous change.

Toward a general and functionalist theory of development: The effective coordination of selection, optimization, and compensation: On a general and functionalist level of analysis, successful development, defined as the (subjective and objective) maximization of gains and minimization of losses, can be conceived of as resulting from collaborative interplay among three components: (1) selection, (2) optimization, and (3) compensation. The ontogenetic pressure for this dynamic increases with age, as the relative incompleteness of the biology- and culture-based architecture of human development becomes more pronounced.

Updated from "Erfolgreiches Altern als Ausdruck von Verhaltenskompetenz und Umweltqualität" (pp. 353–377), by M. M. Baltes, in *Der Mensch im Zusammenspiel von Anlage und Umwelt,* C. Niemitz (Ed.), 1987, Frankfurt-am-Main, Germany: Suhrkamp; see also P. B. Baltes, 1987, 1997, and P. B. Baltes et al., 2006.

primarily formed from sources within that entity and by mechanisms of transformation or stage-like progression.

Such a unidirectional, growth-like view of human development appeared contradictory to many findings in life span psychology, which included negative transfer from earlier development to later developmental outcomes, differences in rates, age-onsets, and age-offsets of developmental trajectories, multidirectional patterns of age-related change, as well as discontinuities in prediction. Figure 11.3 represents an early representation of this differentiated view of development elicited by life span thinking and findings, which posed a challenge to traditional conceptions of development as unilinear and holistic growth (see also Labouvie-Vief, 1980, 1982).

Historically, one approach to this gap between theory and findings was to explore the usefulness of the distinction between development and aging (Birren, 1964). Life span theorists, at least within psychology, opted for a different strategy (P. B. Baltes, 1987). They attempted to either modulate the traditional definitional approach to development or to offer conceptions that highlighted the view that ontogenetic development was not identical with the notion of holistic and unidirectional growth. In these efforts, life span scholars shared the goal of reformulating the concept of development, although they differed in the degree of radicality and in specifics. Labouvie-Vief (1980, 1982; see also Pascual-Leone, 1983; Riegel, 1976), for instance, introduced new forms (stages) of systemic functioning for the period of adulthood, based on conceptions of development as adaptive transformation and structural reorganization, thereby opening a new vista on Neo-Piagetian constructivism. In our work (e.g., P. B. Baltes, 1983, 1987; P. B. Baltes et al., 1980), but also that of others such as Brandtstädter, Featherman, and Lerner (Brandtstädter, 1984; Featherman & Lerner, 1985; Featherman, Smith, &

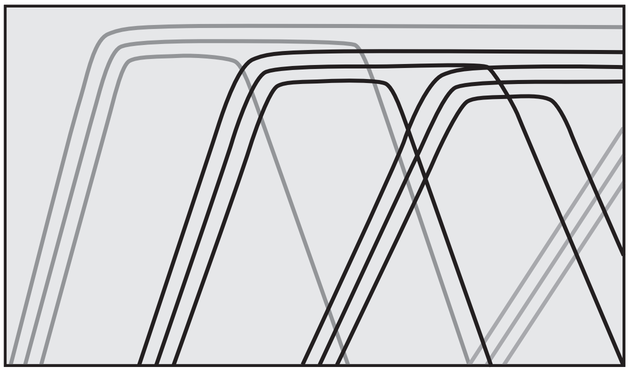

Figure 11.3 Hypothetical examples of life span developmental processes. Developmental functions (behavior-change processes) differ in onset, duration, termination, and directionality when charted in the framework of the life course. Moreover, developmental change is both quantitative and qualitative: Not all developmental change is related to chronological age, and the initial direction is not always incremental. *Source:* From "Plasticity and Variability in Psychological Aging: Methodological and Theoretical Issues" (pp. 41–66), by P. B. Baltes and M. M. Baltes, in *Determining the Effects of Aging on the Central Nervous System,* G. E. Gurski (Ed.), 1980, Berlin, Germany: Schering.

Peterson, 1990; R. M. Lerner, 1983), we were perhaps more radical in our departure from extant theoretical models of development. We attempted to approach the conceptualization of development by a theoretical framework of neofunctionalism (Dixon & Baltes, 1986) and contextualism (R. M. Lerner, 1991; Magnusson, 1996). Within that approach, the nature of adaptive change with life span development was driven by consideration of a larger set of influences and the kind of challenges that people face as their lives unfold. In our view, such a neofunctionalist approach was the most open to a full consideration of the new facets of ontogenetic change (such as multidirectionality, multifunctionality, adaptive specificities, and predictive discontinuity) that life span researchers were confronted with. At the same time, this broadened conception of development permitted maintaining traditional growth-like conceptions of development as a special class of developmental phenomena.

The result was to go beyond the traditional conception of development as growth and open the concept of development to a larger framework of changes. In our own work, we opted for defining development as *selective age-related change in adaptive capacity*. Development as selection and selective adaptation displays many attributes. For instance, it can be active or passive, conscious or subconscious, internal or external, and continuous or discontinuous. Moreover, in the long run or in different circumstances, it can be functional or dysfunctional.

This intellectual movement toward a broadly based functionalist conception of ontogenesis entailed a number of features. For instance, to reflect more accurately their understanding of the empirical evidence about life span changes, and also drawing from alternative conceptions of ontogenesis such as canalization and selective neuronal growth (Edelman, 1987; Waddington, 1975), self-organization (Barton, 1994; Maturana & Varela, 1980; Prigogine & Stengers, 1984), as well as expert systems (Chi, Glaser, & Rees, 1982; Ericsson & Smith, 1991; Weinert & Perner, 1996), life span researchers began to emphasize that any process of development is not foremost the unfolding of an entity. Rather, they focused on development as ontogenetic selection from a pool of more or less constrained potentialities and the subsequent selective optimization of the entered pathways including the construction of novel pathways that were not part of the original system (P. B. Baltes, 1987; Labouvie-Vief, 1982; Marsiske et al., 1995; Siegler, 1989). As a given pathway of ontogenetic development is chosen and optimized, others are ignored or suppressed. In short, some life span theorists ventured a new start and suggested treating ontogenetic development as a process of dynamic and selective adaptation reflecting the interaction of biological, cultural, and contextual factors as well as the proactive role of individuals in shaping their course of development (P. B. Baltes, Reuter-Lorenz, et al., 2006; Brandtstädter & Lerner, 1999). Thus, with the focus on selection and selective adaptation, life span researchers were able to be more open about the pathways of lifelong ontogenesis.

Development as a Gain-Loss Dynamic. Not surprisingly, a related change in emphasis advanced in life span theory and research was on viewing development as *always* being constituted by gains and losses (P. B. Baltes, 1979a, 1987; P. B. Baltes et al., 1980; Brandtstädter, 1984; Brim, 1992; Labouvie-Vief, 1980, 1982; J. Smith, 2003). Aside from functionalist arguments, there were several empirical findings that gave rise to this focus.

One example important to life span researchers was the differing life span trajectories proposed and obtained for the fluid mechanics and crystallized pragmatics of intelligence (P. B. Baltes, 1993; Cattell, 1971; Horn, 1970; Horn & Hofer, 1992; S.-C. Li, Lindenberger, et al., 2004; McArdle, Ferrer-Caja, Hamagami, & Woodcock, 2002; Schaie, 1996, 2005). Very much in line with the life span dynamic between biology and culture expressed in Figure 11.1 (pp. 575), intellectual abilities that are thought to reflect the neurobiologically based mechanics of intelligence—like working memory and fluid intelligence—typically showed normative (universal) declines in functioning beginning in middle adulthood. Conversely, intellectual abilities that primarily reflect the culture-based pragmatics of intelligence—such as professional knowledge, language competence, and wisdom—may show stability or even increase into late adulthood. As to the ontogenesis of intelligence, then, gains and losses do co-exist.

Thus, as some life span theorists considered substituting the concept of an age-related selection-based change in adaptive capacity for the concept of development, one of the topics that motivated their agenda was the importance of viewing as fundamental to any ontogenetic change the notion of simultaneous gains and losses associated with these changes. From a functionalist point of view (Dixon & Baltes, 1986), it is more or less understood that changes in adaptive capacity can be positive or negative, that a given change in developmental capacity may imply different consequences depending on the outcome criteria and the adaptive contexts involved. Thus, the radical view was advanced that, contrary to traditional conceptions of development, there was *no gain in development without loss, and no loss without gain* (P. B. Baltes, 1987). Life span researchers, then, conceive of ontogenetic development not as a monolithic process of progression and growth, but as an ongoing, changing, and interacting system of gains and losses in adaptive capacity. Throughout life, development always consists of the joint occurrence of gains and losses, both within and across domains of functioning. Such an approach does not preclude that on some level of systemic analysis (i.e., considering the entirety of adaptive capacity in a fixed cultural context), ontogenetic development evinces an overall increase or decrease in adaptive capacity.

To strengthen the general case for reformulating the concept of development, life span researchers also suggested applying this multifunctional, multidimensional, and multidirectional view of development to the field of child development (P. B. Baltes, 1976, 1987; Labouvie-Vief, 1982). Consider as an example the ontogenesis of language recognition and language acquisition in childhood. When one language is acquired as mother tongue, sound recognition and sound production capacity for other languages decreases, especially if such second and third languages are acquired after early childhood (Levelt, 1989).

The study of tasks requiring probability-based imperfect rather than logic-based perfect solutions is another example (P. B. Baltes, 1987). The more advanced the cognitive status of children (in the sense of capacity for formal-logical reasoning), the less children are able to respond to cognitive problems that are essentially not perfectly solvable and therefore require the use of maximization rather than optimization strategies. Weir (1964) conducted an early critical experiment on this question in the domain of probability-based learning. In probability learning tasks without perfect solutions, there is the seemingly paradoxical finding that very young children outperformed older children and college students. Considering adaptive trade-offs between levels (stages) of cognitive functioning, this finding becomes meaningful. It is likely that the older children and young adults achieved lower performance outcomes because they understood the experimental task as a logical problem-solving task and, therefore, continued to employ task-inappropriate but developmentally more "advanced" cognitive strategies aimed at "perfect" optimization.

In retrospect, it is perhaps not surprising that the gain-loss dynamic was identified primarily by life span researchers as a central topic of ontogenetic analysis. On the one hand, life span researchers, because of their concern for long-term processes, were pushed toward recognizing the varied forms of developmental change associated with cultural evolution. On the other hand, on a subjective-phenomenological level, the issue of gains and losses becomes more conspicuous as one considers adult development and aging. In this phase of life, declines and losses, especially those due to biological aging, are difficult to ignore.

Recently, one additional concept has been advanced to characterize the nature of life span changes in adaptive capacity. This concept is *equifinality*. Equifinality highlights the fact that the same developmental outcome can be reached by different means and combination of means (Kruglanski, 1996). The role of equifinality (a related notion is the concept of overdetermination) is perhaps most evident when considering the many ways by which individuals reach identical level of subjective well-being (P. B. Baltes & Baltes, 1990b; Brandtstädter & Greve, 1994; Staudinger et al., 1995). Other examples come from research on goal attainment conducted in the framework of action psychology (Brandtstädter, Chapter 10, this *Handbook,* this volume; Gollwitzer & Bargh, 1996). In this approach, researchers have distinguished between two general categories of equifinality: equifinality associated with contextual (contingency) match and equifinality based on substitutability (Kruglanski, 1996). In life span research, notions of equifinality are important, for instance, when attempting to speak of general-purpose mechanisms and ways to compensate, both in the domains of intelligence and personality. The potential for developmental impact is larger if the resources acquired during ontogenesis in the sense of equifinality carry a broad scope of generalization and use in rather different contexts.

A Focus on Plasticity and Age-Associated Changes in Plasticity

Arguably, plasticity is the concept most emphasized by life span researchers (P. B. Baltes & Schaie, 1976; P. B. Baltes & Willis, 1982). Note that plasticity does not refer to complete or arbitrary malleability of behavior. Rather, it denotes that behavior is always open and constrained at the same time. Hence, the focus on plasticity highlights the search for the potentialities of development including its boundary conditions. This notion of plasticity also implies that any given developmental outcome is but one of numerous possible outcomes, and that the search for the conditions and ranges of ontogenetic plasticity, including its age-associated changes, is fundamental to the study of development. Taken to the extreme, the notion of plasticity can be taken to challenge the conceptual foundation of any genetically based fixity in ontogenesis including the notion of an immutable norm of reaction (see also Gottlieb, 1998). While such vistas are intellectually stimulating, they are likely overextending the scope of the empirical evidence as well as the constraints of evolutionary theory (Hagen & Hammerstein, 2005). The very concept of plasticity of biological plasticity depends on genetically based prerequisites and related constraints for life and its developmental course.

For several reasons, life span researchers increasingly moved in the direction of making the study of plasticity a cornerstone of their metatheoretical posture and empirical work. In retrospect, we emphasize three such reasons. First, as many life span researchers did work in the field of aging, plasticity-related ideas were invoked to counteract the prevailing negative stereotype of aging as a period of universal decline with no opportunity for positive change (P. B. Baltes, 1987; P. B. Baltes & Labouvie, 1973; P. B. Baltes & Willis, 1977; Labouvie-Vief, 1977; S.-C. Li, 2003; Perlmutter, 1988). Thus, when aging researchers demonstrated in intervention-oriented research the enhancement possibility of the aging mind, even in domains such as fluid intelligence and memory in which decline was the norm, this was counterintuitive evidence. Such evidence made clear that aging, as we observe it today, is but one expression of what is possible in principle. It makes conspicuous why the intellectual and societal project of constructing aging is still in the making (P. B. Baltes, 1987, 1997; Rowe, 1997).

Second, the concept of plasticity accentuated that life span development does not follow a highly constrained (fixed) course, especially when culture- and knowledge-based phenotypic expressions are concerned. Thus, the focus on plasticity brought into the foreground that "humans have a capacity for change across the life span from birth to death . . . [and that] the consequences of the events of early childhood are continually transformed by later experiences, making the course of human development more open than many have believed" (Brim & Kagan, 1980, p. 1). Such views of lifelong plasticity have become prominent in biological quarters as well (e.g., Cotman, 1985; Finch & Zelinski, 2005; Kempermann, in press).

Third, the concept of plasticity opens new vistas on interdisciplinary perspectives. A view, more recently developed (P. B. Baltes et al., 2006) is that the basic questions of plasticity can be linked to similar concepts in the social sciences. Thus, the insistence on lifelong plasticity in human development is also consistent with the argument advanced most prominently by social scientists that much of what happens in the life course is a direct reflection of the goals, resources, and norms of a given society and that societal contexts differ in the structure, emphases, and sequential ordering of such factors (Brim & Wheeler, 1966; Mayer, 1990; Riley, 1987; Settersten, 2005). For this purpose, Figure 11.4 specifies three types of plasticity: neuronal/bodily, behavioral, and societal (see also P. B. Baltes & Singer, 2001; Baltes, Reuter-Lorenz, & Rösler, 2006; S.-C. Li, 2003; S.-C. Li & Linderberger, 2002).

Neuronal/bodily, behavioral, and societal plasticity, as defined in Figure 11.4, form a frame within which the contributions to questions of potential and its realiza-

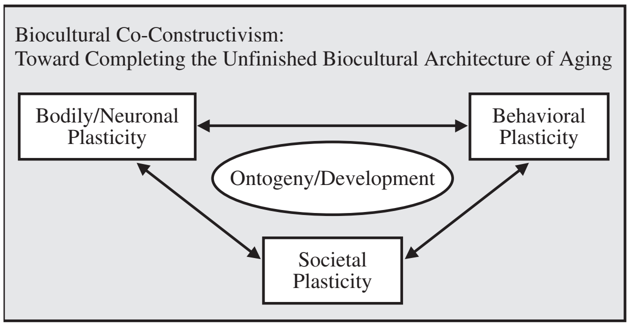

Figure 11.4 Each of the major scientific disciplines concerned with human development have developed a focus on plasticity to understand mechanisms and variations in outcomes: Genetic/neuronal/bodily, behavioral, and societal plasticity are important examples. *Research Report of the Max Planck Institute for Human Development,* 2003–2004. See P. B. Baltes, P. Reuter-Lorenz, & F. Rösler, 2006, for further elaboration.

tion offered by the various life, behavioral, and social sciences engaged in the study of human development can be understood and interrelated. Each of the components depicted does not operate in isolation. Rather, in the sense of biocultural constructivism they interact and modify each other.

Research on neuronal/bodily plasticity uses outcomes such as neurogenesis, synaptic powering, and other indicators of brain differentiation to represent individual brain development and interindividual differences therein. Work on behavioral plasticity highlights outcomes on the level of mind and behavior associated with differing conditions of life experiences, including cognitive practice. Societal plasticity illustrates variations at the macrolevel (e.g., resources and norms associated with gender, social class, ethnicity, etc.) and the role of social constraints and opportunities. Relevant evidence is typically collected by comparative social-science work on groups or nations rather than individuals and on theories of societal influences (e.g., norms, socialization) that shape developmental trajectories and their social differentiation. A societal plasticity perspective presumes that individuals belonging to different groups have similar potentialities which, however, are realized to different degrees and qualities (see also Settersten, 2005).

Returning to developmental psychology: As work on individual behavioral plasticity progressed and showed large variation in developmental manifestations, the concept of plasticity became a mental script that supported the general idea of development as being more open and pluralistic than traditional views of behavioral development during childhood and beyond seemed to suggest. Thus, the concept of plasticity highlighted the metatheoretical posture *that any course of development is but one of a pool of potentialities;* that the "nature" of human development is not fixed; and that (aside from the fact of finitude) there is no single end state to human development.

The perhaps most important line of inquiry was the quest for understanding interindividual differences and *age-related developmental changes in plasticity.* While plasticity as a phenomenon was extended beyond childhood, there were theoretical and empirical reasons why plasticity should not be age-less but changing with age. Thus, the search for the range of plasticity resulted not only in evidence for malleability and plasticity; it also produced new evidence on individual and age-based constraints in the range (norm of reaction) of possible development (P. B. Baltes & Lindenberger, 1988; Kliegl et al., 1990; Plomin & Thompson, 1988). In work on cognitive aging, for instance, the goal was to learn about maximum potential in different age groups.

This line of inquiry suggested different facets of behavioral/developmental plasticity. One was the differentiation between *baseline reserve capacity* and *developmental reserve capacity.* Baseline reserve capacity identifies the current level of plasticity available to individuals. Developmental reserve capacity is aimed at specifying what is possible in principle if optimizing interventions are employed to test future ontogenetic potential. Furthermore, major efforts were made to specify the kind of methodologies, such as developmental simulation, testing-the-limits, and cognitive engineering, that lend themselves to a full exploration of ontogenetic plasticity and its limits (P. B. Baltes, 1987; P. B. Baltes & Willis, 1982; Kliegl & Baltes, 1987; Kliegl, Mayr, & Krampe, 1994; Lindenberger & Baltes, 1995b).

Within the frame of sizeable plasticity, then, the expression of human development is a matter of collaboration and co-construction between different factors and mechanisms. Indeed, an increasingly more full-blown constructivist perspective on human potentialities has become a modern theme of developmental research (Aspinwall & Staudinger, 2003; P. B. Baltes et al., 2006; P. B. Baltes & Smith, 2004; Brandtstädter & Lerner, 1999; S.-C. Li, 2003; S.-C. Li & Lindenberger, 2002). With a constructivist perspective one highlights the notion that human development is constructed by the interplay of biological, psychological, and social forces. Part of this construction relies on agentic behavior of individuals. Individuals are contributors to their own development. The resulting concept is that of *developmental biocultural co-constructivism* (P. B. Baltes, Freund, & Li, 2005; P. B. Baltes & Smith, 2004; S.-C. Li, 2003). With the advent of biocultural co-constructivism, the quest for interdisciplinary collaboration has attained a new state of urgency. In our view, the life span approach with its emphasis on viewing the conditions of human development as historically incomplete and more open than traditionally assumed has been a major partner in advancing this intellectual position.

Ontogenetic and Historical Contextualism as Paradigm

Highlighting the notion of plasticity as a cornerstone of life span research on human development alludes to another key feature of life span metatheory, the paradigm of contextualism. In evolutionary selection theory and the evolutionary basis of adaptive fitness, the role of context is paramount. Recently, P. B. Baltes and Smith (2004) have shown how modern versions of contextualism include the perspective of biocultural co-constructivism to avoid the idea that context is strictly environmental in origin.

Therefore, as developmental psychologists attempted to move beyond microgenetic representations of the learning process as a marker of experience to capture context as a system of influence, they engaged themselves into metatheoretical perspectives on contextualism. Such a contextualist view, rather than a focus on "mechanist" or "organismic" models of development (Overton & Reese, 1973; Reese & Overton, 1970), evolved with force in the 1970s (Datan & Reese, 1977; Riegel, 1976), and as already described in the preceding section, it continues into the present. This approach was similar to the evolution of ecological-contextualist perspectives offered by cultural psychology (Bronfenbrenner, 1977; Bronfenbrenner & Ceci, 1994; Cole, 1996).

According to contextualism and also action theory (see Brandtstädter, Chapter 10, this *Handbook,* this volume), individuals exist in contexts that create both special opportunities for, and limitations to, individual developmental pathways. Delineation of these contexts in terms of macrostructural features, like social class, ethnicity, roles, age-based passages and historical periods, is a major goal for the sociological analysis of the life course (e.g., Elder, 1994; Elder & Shanahan, Chapter 12, this *Handbook,* this volume; Heckhausen, 2000; Kohli & Meyer, 1986; Mayer, 2003; Riley, 1987; Settersten, 2005). In fact, this was a time when sociologists and developmental psychologists attempted to interrelate their various endeavors (e.g., Sorensen, Weinert, & Sherrod, 1986). For life span psychologists, and perhaps also for child developmentalists (P. B. Baltes, 1979b), this dialogue opened their vista on the scope, temporal patterning, and differentiation of biological and social forces (incidentally much instigated by various committees on human development arranged by the U.S. Social Science Research Council).

A Macro-Model of Developmental Influences

During this time of intensive collaboration between life course sociologists (e.g., Riley et al., 1972) and life span psychologists, the first author and his colleagues (P. B. Baltes, Cornelius, & Nesselroade, 1979; P. B. Baltes et al., 1980) proposed a heuristic model that attempted to integrate biological, sociological, and psychological considerations in one framework in order to understand the entire fabric of development-producing contexts: Three biocultural components were considered at the foundation of human ontogeny: *Normative age-graded influences, normative history-graded influences,* and *nonnormative (idiosyncratic)* influences. Normative in this context refers to a high degree of generality. Nonnormative factors highlight the more individualized conditions such as winning in a lottery.

To understand a given life course, and interindividual differences in life course trajectories, this model suggests that it is necessary to consider the operation and interaction among these three classes of influences (Figure 11.5). Note that these sources contribute to similarities in development, but also, because they exist in systematic group variations, for instance by social class, genetic dispositions, and ethnicity, they also contribute to systematic interindividual variations and subgroup-specific patterns of life span development (P. B. Baltes & Nesselroade, 1984; Dannefer, 1989; Riley et al., 1972).

Age-graded influences are those biological and environmental aspects that, because of their dominant age correlation, shape individuals in relatively normative ways for all individuals. Consider the temporal and domain structure of life span developmental tasks (Havighurst, 1948), the age-based process of physi-

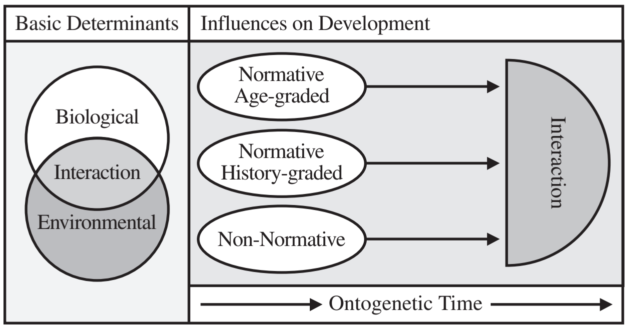

Figure 11.5 Representation of the operation of three major biocultural influence systems on life span development: (1) normative age-graded, (2) normative history-graded, and (3) nonnormative life events. These influence systems vary in their level and interactions for different individuals and for different behaviors. As a whole, the operation of these systems produces commonalities and individual differences in ontogenesis. *Source:* From "Plasticity and Variability in Psychological Aging: Methodological and Theoretical Issues" (pp. 41–66), by P. B. Baltes and M. M. Baltes, in *Determining the Effects of Aging on the Central Nervous System,* G. E. Gurski (Ed.), 1980, Berlin, Germany: Schering.

cal maturation, or the sequential arrangement of developmental contexts (family, school, work, etc.) as examples.

History-graded influences are those biological and environmental aspects that may make ontogenetic development different across historical cohort and periods. Consider the historical evolution of the educational and professional system as an example, or, for a more punctuated period-specific example, the advent of a war. Thus, a given ontogeny proceeds at the same time in the contexts of age-based ontogenetic time as well as historical cohort time. This position has been argued most fervently by Matilda Riley (1987). In the early phases of life span psychology, research on birth-cohort effects has made the strongest case for consideration of historical contextualism (Elder, 1974, 1990; J. R. Nesselroade & Baltes, 1974; Schaie, 1965, 1996). The topic of historical embeddedness, and the extricating of age-based versus cohort-based differences in ontogenetic development, was also the foundation for the formulation of new developmental methodologies such as cross-sectional and longitudinal sequences (see the following discussion).

Nonnormative influences on development, finally, reflect the individual-idiosyncratic biological and environmental events that, while not frequent, can have powerful influences on ontogenetic development (Bandura, 1982; Brim & Ryff, 1980). The influence of these nonnormative events (such as winning a lottery, losing a leg in an accident) is especially powerful because they generate conditions that are less predictable, less amenable to social control and support, and therefore may represent extreme situations of challenge (approaching testing-of-limits), not unlike the concept of *Grenzsituation* introduced by the philosopher Karl Jaspers (Kruse, 1992; Maercker, 1995).

In life span theory, these three sources of influence create the contexts within which individuals act, react, organize their own development, and contribute to the development of others. None of these patterns of biologically and environmentally based influences is likely to operate independently from the other. They are part of biocultural co-construction with reciprocal and modifying influences. Such a focus on the dynamics of biocultural co-construction also makes explicit the lack of full predictability of human development as well as the boundedness that individuals experience as they engage in the effort to compose and manage their lives (Brandtstädter, 1984; Brandtstädter & Lerner, 1999; R. M. Lerner, 1984, 1991). And finally, such a focus on contextualism places individual development in the context of the development of others. It is not surprising, therefore, that life span researchers have easily embraced concepts such as collaborative development, collaborative cognition, or interactive minds (P. B. Baltes & Staudinger, 1996a; Resnick, Levine, & Teasley, 1991). However, what remains underdeveloped in life span psychology is the empirical counterpart to this theoretical position. Only more recently have we witnessed research efforts to include these contextual- and social-interactive approaches in the study of interactive networks such as communities of learning (Mandl, Gruber, & Renkl, 1996), life course convoys (Kahn & Antonucci, 1980), mentors (Bloom, 1985), cohort formations (Riley, 1987), kinship relationships (Hammerstein, 1996), cohort-related changes in education and health (Schaie, 1996, 2005), the role of neighborhoods, or changing policies in retirement and elderly care.

Methodological Developments

Life span research opened new territories and because of the temporal, contextual, and historical complexities involved required much attention to developmental methodology (P. B. Baltes, Reese, & Nesselroade, 1988; Cohen & Reese, 1994; Hertzog, 1985; Magnusson, Bergman, Rudinger, & Törestad, 1991; J. R. Nesselroade

& Reese, 1973). In our view, this concern about adequate methodology was so important to life span researchers because their orientation toward long-term ontogenetic processes and linkages and the decomposition of the biocultural dynamic represented an extreme challenge to the goals and methods of developmental analysis.

From Cross-Sectional to Longitudinal to Sequential Methodology. A first example is the development of methods appropriate to the study of age-related change, interindividual differences in age-related change, and the role of historical changes in the contexts of development. Traditionally, the main designs used in developmental psychology were the cross-sectional and the longitudinal method (P. B. Baltes & Nesselroade, 1978, for historical review). The focus on the interplay between age-graded, history-graded, and nonnormative factors suggested, however, that such methods were insufficient (P. B. Baltes, 1968; N. B. Ryder, 1965; Schaie, 1965). This challenge to track both historical and individual-ontogenetic change resulted in the formulation of so-called sequential methods (P. B. Baltes, 1968; Schaie, 1965, 1996, 2005).

Figure 11.6 depicts the basic arrangement of what Schaie and Baltes (1975) have come to label as *cross-sectional* and *longitudinal sequences.* Cross-sectional sequences consist of successions of cross-sectional studies; longitudinal sequences of successions of longitudinal studies. When applied in combination, the two types of sequential designs produce, on a descriptive level, exhaustive information about age- and cohort-related change as well as about interindividual differences in change trajectories. The sequential design also permits the identification of punctuated historical effects, so-called period effects. In contrast to cohort effects, which extend over longer time spans of historical change (such as effects associated with mass education or the introduction of computer technology), the concept of period effects is typically applied to more transient historical events and their consequences, such as a natural catastrophe or a war.

There is much research in human development that has demonstrated the important role of historical cohort effects. Schaie (1996, 2005), for instance, has compared both in cross-sectional and longitudinal sequences the adult-age development of several birth cohorts from 1956 to the present and presented impressive evidence that, during middle adulthood, cohort effects can be as large as age effects. Schaie's work has also shown that the directionality of age and cohort gradients can differ. Similarly, J. R. Nesselroade and Baltes (1974), in an early application of longitudinal sequences to the study of adolescence, presented evidence that personality development during adolescence in such measures as achievement and independence evinced major cohort differences over time intervals as short as 2 years. Their interpretation focused on the role of the Vietnam War as the critical modulator variable and its impact on U.S. youth culture, including how adolescents changed in their developmental personality gradients.

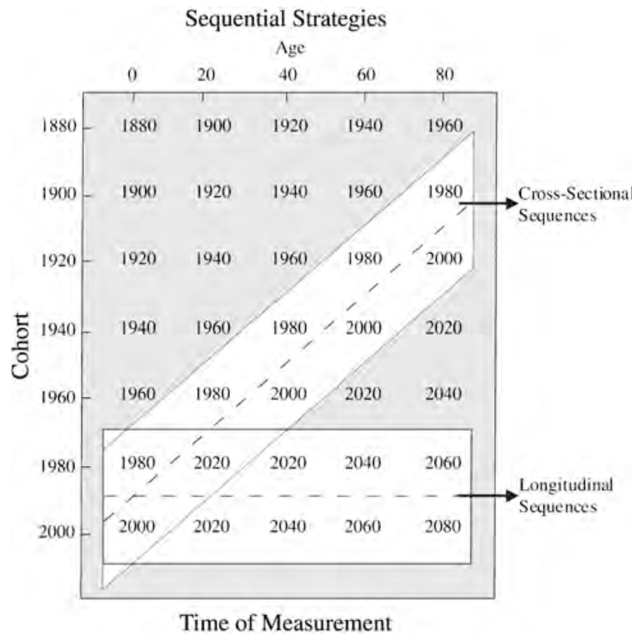

Figure 11.6 Illustration of cross-sectional and longitudinal sequences (bottom). *Source:* From "Longitudinal and Cross-Sectional Sequences in the Study of Age and Generation Effects" by P. B. Baltes, 1968, *Human Development, 11,* pp. 145–171; From "A General Model for the Study of Developmental Problems" by K. W. Schaie, 1965, *Psychological Bulletin, 64,* pp. 92–107.

Meanwhile, through application of sequential methods, there is a large body of evidence on cohort effects available in developmental psychology, but especially in comparative sociology; evidence that makes explicit one of the important ingredients to life span theory, namely, the interplay between individual development and a changing society (cf. Elder & Shanahan, Chapter 12, this *Handbook,* this volume; Settersten, 2005). Also important in this work is the growing recognition of when cohort effects are likely to be relevant and when not. For instance, life span researchers now distinguish between at least three types of cohort effects requiring different kinds of interpretative efforts (J. R. Nesselroade & Baltes, 1979): (1) cohort as a *theoretical process* denoting historical change that alters fundamental aspects of human ontogeny (e.g., changing gender roles); (2) cohort as a *dimension of quantitative generalization* (e.g., higher levels of cognitive skills due to an increase in education); and (3) cohort as a *transitory disturbance* (e.g., fluctuant changes in attitudes due to singular events as often reported in opinion survey research).

In part as a response to the growing availability of longitudinal and sequential data sets, methodologists from different research traditions including life-span psychology have refined and expanded statistical methods for the study of interindividual differences in developmental trajectories (Baltes, Reese, & Nesselroade, 1977; for a recent overview, see Hertzog & Nesselroade, 2003). Various longitudinal modeling techniques such as multilevel modeling, latent growth curve modeling, and latent difference score modeling allow researchers to examine the structure of interindividual differences in change (e.g., Ghisletta & Lindenberger, 2004). These methods attenuate complications commonly associated with change scores such as lack of reliability (e.g., Cronbach & Furby, 1970), and some of them, such as multivariate extensions of the dual change score model, permit testing of dynamic hypotheses linking one aspect of behavior to changes in another aspect (e.g., McArdle, Hamagami, Meredith, & Bradway, 2000; for applications to changes in intellectual and sensory functioning, see Ghisletta & Lindenberger, 2005). A related methodological development spurred on by life-course sociologists, in particular, concerns methods to organize and study the temporal flow, correlates, and consequences of life events. Models of event-history analysis and associated methods such as hazard rate analysis are especially important (Blossfeld, Hamerle, & Mayer, 1991; Blossfeld & Rohwer, 2001; Featherman & Lerner, 1985; Greve, Tuma, & Strang, 2001; Magnusson et al., 1991; Schaie, 1988; Willett & Singer, 1991). Note, however, that advanced statistical methods for analyzing multivariate longitudinal change often are based on strong assumptions such as sample homogeneity, in general, and cross-sectional/longitudinal convergence, in particular. Also, the psychometric properties of these methods have not yet been fully explored and understood (Hertzog, Lindenberger, Ghisletta, & Oertzen, 2004).

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The Experimental Simulation of Development. A further strategy developed primarily by life span researchers is the explicit use of simulation paradigms in the study of human development. Again, use of such an approach was enhanced by the fact that life span ontogenetic processes are time-extensive and, therefore, difficult to study without simulation (P. B. Baltes & Goulet, 1971; Lindenberger & Baltes, 1995b).

Table 11.4 summarizes the approach of developmental simulation. In a general sense, the experimental simulation approach is a theory-testing device that arranges for conditions thought to be relevant for the phenomenon of interest. Thus, experimental developmental simulations simulate or mimic variations that are thought to exist in real-time and real-world ontogenesis. As a research strategy, the design of developmental simulation consists of a coordinated sequence of seven steps that, however, do not need to be performed in the sequence specified. A developmental phenomenon is considered to be well understood if knowledge based on all steps is available.

In life span research, such simulations have been used, for instance, to examine the effects of aging-associated changes in sensory input. For this purpose, auditory and visual acuity of adults was reduced to the level of older

TABLE 11.4 The Logic of Experimental Simulation in the Study of Development: A Coordinated Sequence of Steps

1	Definition and description of target developmental phenomenon to be studied
2	Postulation of a causal hypothesis or causal structure about underlying mechanisms and contextual conditions
3	Experimental manipulation of relevant variables in the laboratory
4	Test of experimental data against target phenomenon: isomorphism check
5	Reexamination of causal hypothesis or causal structure (confirmation/rejection/modification) and search for alternative explanations
6	Evaluation of external validity: Descriptive evidence
7	Evaluation of external validity: Interventive evidence

Source: Modified from "Testing-the-Limits and Experimental Simulation: Two Methods to Explicate the Role of Learning in Development," by U. Lindenberger and P. B. Baltes, 1995b, *Human Development, 38,* pp. 349–360; and *Life-Span Developmental Psychology: Introduction to Research Methods,* by P. B. Baltes, H. W. Reese, and J. R. Nesselroade, 1988, Hillsdale, NJ: Erlbaum. Reprint of the 1977 edition.

persons and then tested for cognitive performance (Dickinson & Rabbitt, 1991; Lindenberger, Scherer, & Baltes, 2001). Another example is a research program by Margret Baltes on the many faces of dependency and autonomy in old age (1988, 1996; M. M. Baltes & Wahl, 1992). In this research program, the key questions were concerned with the conditions and range of autonomy and dependence including their multifunctional characteristics and plasticity.

The opening steps (1 to 3 in Table 11.4) of this research on autonomy and dependency in old age conducted by Margret Baltes and her colleagues were observations in the living environments of elders concerning their transactions with others. Negative aging stereotypes were assumed to play a major role in the observed age-associated emergence of dependent rather than independent behavior. To examine this hypothesis, a series of experimental laboratory studies were conducted to explore the effects of learning conditions (stimulus control, practice, reinforcement schedules) on self-care behavior in older adults. This work demonstrated that many aspects of older adults' dependent behaviors were found to be reversible, supporting the notion that environmental factors (e.g., behavioral contingencies) exert some influence on the aging-associated emergence of dependency or loss of autonomy. In subsequent work, reflective of steps 4 to 6 in Table 11.4, Margret Baltes and her colleagues observed the social conditions surrounding the occurrence of self-care in the elderly in the natural environment. Supportive of their position, a dependency-support script and an independence-ignore script were identified. In other words, social partners of older persons in the context of self-care exhibited a high frequency of behaviors indicative of support of dependence. Finally, research was conducted to manipulate the relevant causal variables in the natural environment of older persons. For this purpose, the researchers (see M. M. Baltes, 1996; M. M. Baltes, Neumann, & Zank, 1994) intervened in the social environment of older persons in nursing homes. This was done by training nursing home staff to downplay the dependence-support script, and to move toward an independence-support script. By and large, these changes in the natural environment resulted in the expected outcome. Older persons displayed a higher level of independence in self-care.

Researchers interested in more narrow age spectrums use similar strategies of experimental simulation of development (Siegler, Chapter 11, this *Handbook,* Volume 2). However, we claim that life span researchers are particularly dependent on the creative use of such arrangements; and, moreover, that life span researchers are especially aware of the many methodological limitations (such as lack of measurement equivalence, isomorphy, and external validity) associated with such and with other age-comparative research. The explicit use of the term of simulation to denote these limitations underscores this awareness.

Testing-the-Limits. An additional example of methodological innovations involves a strategy that life span researchers have developed to examine the scope and limits of behavioral *plasticity* (P. B. Baltes, 1987; Kliegl & Baltes, 1987), another key aspect of the family of propositions advanced in life span theory. This method is similar to efforts in child development to study the zone of proximal development, for instance, through methods of microgenetic analysis or cognitive engineering (Brown, 1982; Kliegl & Baltes, 1987; Kuhn, 1995; Siegler & Crowley, 1991).

Again, because of the long timeframe of life span ontogenesis, it is very difficult in life span research to identify the sources and scope of intraindividual plasticity (malleability) and its age-related changes. At the same time, one key question for life span researchers is: What is possible in principle in human development across the life span? One of the perennial questions of cognitive aging researchers, therefore, was whether aging losses in functions reflect experiential practice deficits with cognitive activities rather than effects of biological aging (P. B. Baltes & Labouvie, 1973; Denney, 1984; Salthouse, 1991; Willis & Baltes, 1980).

The resulting method has been labeled the *testing-the-limits paradigm* (Kliegl & Baltes, 1987; Lindenberger & Baltes, 1995b; Schmidt, 1971). In testing-the-limits research, the goal is to compress time by providing for high density developmental experiences; and by doing so to arrange for the best conditions possible and to identify asymptotes of performance potential (plasticity). These asymptotes, obtained under putatively optimal conditions of support, are expected to estimate the upper range of the age-specific developmental potentiality comparable to the traditional notion of the upper limit of the "norm of reaction." The use of testing-the-limits procedures has generated new insights into what is and what is not possible in development.

Testing-the-limits research, however, is not only relevant for the study of long-term ontogenetic processes. It is equally relevant for other important aspects of developmental research and theory. Two examples illustrate this. The first is the question of sex or gender differences in cognitive functioning. What would be most necessary is to depart from simple, noninterventive comparative research and to invest scientific resources into testing-the-limits work. A testing-the-limits approach would be based on the premise that the relevant information is knowledge about differences in asymptotic (peak) levels of functioning. Small, carefully selected samples could be used for this purpose (e.g., P. B. Baltes & Kliegl, 1992; Kliegl & Baltes, 1987; Lindenberger, Kliegl, & Baltes, 1992). The same perspective would hold true for another hotly debated topic; that is, research into genetic differences. Rather than investing most of the available resources into largely descriptive behavior-genetics studies, an alternative would be to expose smaller samples of participants to time-compressed experiential interventions and to search for interindividual differences at the upper or lower levels of functioning (e.g., S.-C. Li, Huxhold, & Schmiedek, 2004; Lindenberger & Oertzen, in press).

An Example of a Systemic and Overall Theory of Life Span Development: Selective Optimization with Compensation (Level 4)

Next, we take one further step toward a more psychological level of analysis of the nature of life span development. For this purpose, we describe a model of development, selective optimization with compensation (SOC), which Margret Baltes, Paul Baltes, and their colleagues have developed over the past decade (M. M. Baltes, 1987; M. M. Baltes & Carstensen, 1996; P. B. Baltes, 1987; P. B. Baltes & Baltes, 1980, 1990b; P. B. Baltes, Dittmann-Kohli, & Dixon, 1984; Freund & Baltes, 2002b; S.-C. Li & Freund, 2005; Marsiske et al., 1995; Riediger, S.-C. Li, & Lindenberger, in press; see also Featherman et al., 1990). This model offers a systemic view of human development across the life span involving many of the features of life span development presented in the previous sections. Heckhausen and Schulz (1995; Schulz & Heckhausen, 1996) developed a similar model. Finally, the notion of *vicariance,* prominent in francophone differential and developmental psychology (e.g., Lautrey, 2003; cf. Reuchlin, 1978), bears much resemblance to the notion of compensation in SOC theory.

The SOC model in its generality is still located at a level of analysis that is distant from specific theory. Thus, as the model is applied to specific domains of psychological functioning (such as autonomy or professional expertise), it requires further specification to be derived from the knowledge base of the domain of functioning selected for application (e.g., Abraham & Hansson, 1995; B. B. Baltes & Heydens-Gahir, 2003; M. M. Baltes & Lang, 1997; Featherman et al., 1990; Freund & Baltes, 1998, 2002b; S.-C. Li & Freund, 2005; Marsiske et al., 1995). At the same time, however, because of this generality in formulation, the model of SOC is rather open as to its deployability and domain-specific refinement.

In principle, the theory of SOC is considered a general theory of proactive and adaptive development (P. B. Baltes, 1997; Li & Freund, 2005). As a general theory of development, it pursues two objectives: First, an account of how developmental resources are *generated,* and second, how resources once they are developed are *allocated* to master the tasks of life including in situations where resources are insufficient.

Definition of Selection, Optimization, and Compensation

As mentioned earlier, we proceed from the assumption that any process of development involves selection and selective changes in adaptive capacity (P. B. Baltes, 1987; Featherman et al., 1990; Freund & Baltes, 2002b; Krampe & Baltes, 2003; Marsiske et al., 1995). Selection from a potential pool of developmental trajectories makes directionality in development and higher levels of functioning possible. We further assume that for selection to result in successful development (maximization of gains while minimizing losses), it needs to work in conjunction with processes of optimization and compensation.

If approached within an action-theoretical framework, which is only one of the many possible theoretical frames, the following characterizations of the three components hold: *Selection* involves goals or outcomes; *Optimization* involves goal-related means to achieve success (desired outcomes); and *Compensation* involves a response to loss in goal-relevant means in order to maintain success or desired levels of functioning (outcomes). Table 11.5 summarizes this approach and offers as illustrations items from a study on proverbs and items from a self-report measure developed to assess

TABLE 11.5 Selection, Optimization, and Compensation: Brief Definitional Frames and Examples from Proverbs and Questionnaire Items

Strategy	Role in Development	Sample Proverb (Freund & Baltes, 2002a)	Sample Questionnaire Item (Freund & Baltes, 2002b)
Selection1[a]	Concerns directionality and focus of developmental outcomes such as goals.	Jack-of-all-trades, master of none.	I always focus on the most important goal at a given time.
		Those who follow every path, never reach any destination.	When I think about what I want in life, I commit myself to one or two important goals.
		Between two stools you fall to the ground.	To achieve a particular goal, I am willing to abandon other goals.
Optimization	Concerns the acquisition and refinement of means and their coordinaton to achieve goals/outcomes.	Practice makes perfect.	I keep working on what I have planned until I succeed.
		If at first you don't succeed, try, try, and try again.	I keep trying until I succeed at a goal.
		Strike the iron when it's hot.	When I want to achieve something, I can wait for the right moment.
Compensation	Concerns maintenance of functioning by substitution of means in situation of losses of means.	Those without a horse walk.	When things don't work the way they used to, I look for other ways to achieve them.
		There are many hands; what one cannot do, the other will.	When things aren't going so well, I accept help from others.
		When there's no wind, grab the oars.	When things don't go as well as they used to, I keep trying other ways until I can achieve the same result I used to.

[a] Two facets of selection are distinguished in SOC theory: (1) elective selection and (2) loss-based selection, which encompasses restructuring of goal hierarchy, reducing the number of goals or various processes such as adjusting the level of aspiration, or developing new possible goals to match available resources.

the degree to which individuals report to use SOC-related behaviors. The resulting definitions of selection, optimization, and compensation may suggest that the relevant processes are often conscious and intentional. This is not necessarily so. Each of these elements or components can be active or passive, internal or external, conscious or unconscious.

Six additional characterizations help to place SOC into a larger perspective. First, we postulate that SOC is akin to a general-purpose mechanism of development. If available and well practiced, it will produce higher functioning in all domains of functioning. Second, we assume that SOC behaviors are universal processes generative of development. Third, we assume that SOC are inherently relativistic in that their phenotypic expressions depend on person- and context-specific features. Fourth, SOC in itself is a developmental construct. We assume that its peak expression is in adulthood. In childhood and adolescence, the system is acquired and honed, in old age, individuals work on maintenance (see Freund & Baltes, 2002b, for data on age trajectories). Fifth, we acknowledge that the functional utility of SOC is not given but remains a question of empirical validity. There are contexts where SOC may not be adaptive. Sixth, the function of the SOC components such as compensation in a given behavioral unit are not fixed. Their logical status can change, for instance, from active to passive. Similarly, a behavior that originally evolved in the context of a compensation for a loss may later be activated in a process where it serves as an optimizing means.

An everyday example may help to clarify the distinctions, drawn from the context of aging research that we used in our early efforts at developing the SOC model (P. B. Baltes, 1984). Into his late 70s and early 80s, the concert pianist Arthur Rubinstein continued to perform with great success. When asked how he managed to maintain such a high level of expert piano playing, he hinted in several interviews at the coordination of three strategies. First, he mentioned that he played fewer pieces (selection); second, he indicated that he now practiced these pieces more often (optimization); and third, he counteracted his loss in mechanical speed of playing by producing larger contrasts in speed so to make the faster pieces appear faster (compensation).

Selection: Elective and Loss-Based. As noted already, *selection involves directionality, goals, and specification of outcomes.* There are two kinds of selection: elective selection and loss-based selection. Elective selection involves directionality that is self-initiated and considered desirable. Its motivational force is agent-driven. Loss-based selection is the consequence of a loss in functioning and typically involves making adjustments such as changes in level of aspiration or a change in goal structures or goal priorities.

Strictly speaking, selection already begins in embryonic development with features of the sensory system, such as differential sensitivity to light and pattern configurations. Neurophysiological processing of information represents another fundamental example of selection and selection-based specialization. Selective pruning of cells in early biological development is another example. Another concrete illustration of selection in development can be associated with a concept from developmental biology: Selection as the "canalized" (Waddington, 1975) realization of a set of outcomes from the "potentialities of ontogenesis" (plasticity). Another example of selection is the goal system (ranging from skills to attitudes and values) that defines the social and personal frames of desirable development. Selection can also involve the avoidance of specific outcomes of development such as the undesired self. In fact, life span development can be seen as involving a systematic age-related shift in the relative weight and frequency of approach versus avoidance goals (Freund & Ebner, 2005).

Optimization. The focus of optimization is on goal- or outcome-relevant means or resources. Thus, while selection is a necessary condition for achieving development (defined as the maximization of gains and minimization of losses), selection is not a sufficient condition for development to become manifest.

In addition, conditions and procedural mechanisms of goal-attainment are required, that is, methods or means of optimization. Optimization, then, involves processes aimed at the generation and refinement of means-ends resources and motivational-goal explication to achieve development-oriented positive outcomes (goals). For a psychologist, means include such processes as the learning of a skill or the acquisition of the motivational ability to persist or delay gratification. In general, the complexity of the system of optimization depends on the goal or outcome pursuit. If these are complex, optimization is not the refinement of a single means. Rather, in more complex situations, optimization requires a mutually enhancing coalition of factors, including health, environmental, and psychological conditions.

As was true for selection, optimization can be active and passive, conscious and subconscious, internal or external. Moreover, optimization can be domain- and goal-specific as well as domain- and goal-general. The most domain-general notion of optimization is the generation of what in our work we have called *developmental reserve capacity* (P. B. Baltes, 1987; Kliegl & Baltes, 1987), or what developmental life scientists might call *general plasticity* at the neuronal, behavioral, and social level. Because of its investability into many activities, generating a high level of general plasticity is the perhaps most significant target for successful development.

Compensation. The component process called *compensation involves a functional response to the loss of goal-relevant means* (see also Brandtstädter & Wentura, 1995; Dixon & Bäckman, 1995). This definition of compensation is more specific or restricted than the one proposed by Bäckman and Dixon (1992)—that is, it restricts compensation to responses to losses of means (resources) once available for goal attainment.

Two main causes give rise to a compensatory situation (Freund & Baltes, 2002b; Marsiske et al., 1995). Compensation can be the consequence of the very fact of selection and optimization. For reasons of limited capacity of time and effort, selection of and optimization toward a given goal implies the loss of time and means-related resources, relevant for the pursuit of other goals. Development is always a gain-loss dynamic. When an athlete aims for a high level performance in the shot put, it is unlikely that comparable high levels of performance can be achieved in other types of sports such as gymnastics. Another example is negative transfer. The acquisition of a targeted expert skill system A can result in negative transfer to another skill system B (Ericsson & Smith, 1991).

A second category of causes of compensation stems from negative changes in biological, social, and environmental resources in the conditions that represent the foundation of resources and their use for development (see also Hobfoll, 2001, on resource theory). Changing from one environment to another may involve a loss in environment-based resources (means) or may make some acquired personal means dysfunctional. Losses due to the biology of aging are perhaps the best known age-associated negative changes in resources. With aging, there is a reduction in the rate and scope of plasticity (Cotman, 1985; Finch & Zelinski, 2005; S.-C. Li & Freund, 2005; Nelson, 2006; Reuter-Lorenz, 2002). As a result, the evolution of compensatory responses, in addition to loss-based selection, is a continuously changing dynamic of development in the second half of life.

Understanding this changing developmental dynamic is particularly important regarding the conceptual distinctiveness of optimization and compensation (Marsiske et al., 1995). At the point of origin, for instance, some behavior may have been compensatory (such as acquiring nonverbal techniques of communication due to a loss of foreign language proficiency), at later points in ontogeny or in different contexts these same compensation-based behavioral means (nonverbal techniques of communication) can be used as a technique of optimization, such as when improving one's performance as an actor. It is important, therefore, to specify the context and the developmental space in which a given behavioral event is considered when deciding about its category allocation to either selection, optimization, or compensation.

Because the model of SOC does not designate the specific content and form of desirable developmental outcomes, it is applicable to a large range of variations in goals and means of development. In this sense, then, SOC is at the same time *universal* and *relativistic.* Its universalism rests in the argument that any process of development is expected to involve components of selection, optimization, and compensation (P. B. Baltes & Baltes, 1990b; Marsiske et al., 1995). Its relativity lies in the variations of motivational, social, and intellectual resources, as well as in the criteria used to define successful development, which can be multivariate and involve both objective and subjective indicators (P. B. Baltes & Baltes, 1990a).

In the following two sections, which deal with life span developmental theory and research in two domains of functioning, we occasionally return to SOC-related interpretations. However, our intent is not to elevate that model or theory to the one overarching model of life span development. This would be inappropriate. In our view, the model of selective optimization with compensation is but one of the theoretical efforts that life span research and theory have spawned. However, we believe SOC to be a theory that displays much consistency across levels of analysis and can be usefully linked to other current theoretical streams in developmental psychology, such as to dynamic systems theory. Krampe and Baltes (2003) have illustrated in another area, the field of intelligence, how application of SOC theory leads to a different conceptualization of the structure and function of intelligence.

Empirical Evidence on SOC Theory

The articulation and testing of SOC theory is proceeding in a variety of domains. In general, the evidence has been supportive of the theoretical approach. People who report the use of SOC-related behaviors show higher levels of functioning. Moreover, on the behavioral level, research has shown that individuals manifest behaviors that are consistent with SOC theory. These outcomes carry a promissory note.

Age Gradients. Figure 11.7 summarizes evidence on cross-sectional age gradients. Young, middle-aged, and older adults answered a self-report instrument to assess preferred use of SOC strategies. As expected, the peak of using all SOC components was obtained for adults. In earlier and later phases of life, the SOC system seems less fully acquired, activated, or coordinated. In young adulthood, the task of life planning in a focused and concerted manner needs practice and refinement (e.g., J. Smith, 1999). Desires and volitions are less orchestrated. Similarly, in aging individuals, they need to master situations

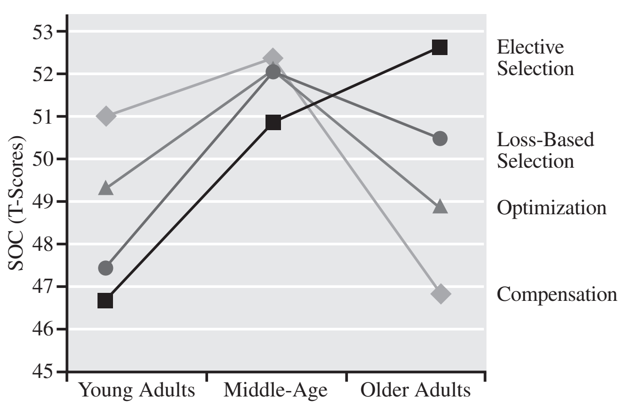

Figure 11.7 Age-group mean differences in four components of SOC (elective selection, loss-based selection, optimization, and compensation): Middle-aged adults report the highest and perhaps most integrated endorsement of SOC. *Source:* Modified from "Life-Management Strategies of Selection, Optimization, and Compensation: Measurement by Self-Report and Construct Validity" by A. M. Freund and P. B. Baltes, 2002b, *Journal of Personality and Social Psychology, 82,* pp. 642–662.

in which they have fewer resources. SOC behaviors themselves are effortful and require resources. Therefore, it is not surprising that older individuals show lesser frequency of use of optimization and compensation. As shown in Figure 11.7, the primary focus in older ages is on elective selection and loss-based selection.

Processes of selection, optimization, and compensation also are present in mental representations associated with the management of everyday lives. Freund and Baltes (2002a) have used proverbs to examine this question. They presented life problems to people and asked which proverb fits this situation best. Adults preferred proverbs that indicated SOC behaviors. Moreover, the choice reaction times of the oldest adults, when selecting the fitting proverb, was as fast as those of younger adults. Because reaction speed typically decreases with age during the age span studied, the finding suggests that SOC-based mental representations are well exercised.

Management and Mastery of Life Tasks. Another area of research is the management of the family career interface (B. B. Baltes & Heydens-Gahir, 2003; Wiese, Freund, & Baltes, 2002). Partners who reported higher use of SOC-related behaviors obtained higher scores on perceived developmental status in the two domains and higher levels of well-being; cross-sectionally and longitudinally. Similar findings were obtained with the task of college study behavior (Wiese & Schmitz, 2002). Regarding tasks of old age, work by Margret Baltes, Frieder Lang, and their colleagues is relevant (e.g., Lang, Rieckmann, & Baltes, 2002). They demonstrated that older individuals, especially when in situations of high difficulty, benefited from showing behaviors that were consistent with SOC theory. Another topic of life span research concerns the management of critical life events including illness. In this line of inquiry, Gignac, Cott, and Badley (2002) have shown that older people suffering from osteoarthritis managed their illness by use of behaviors that are consistent with selection, optimization, and compensation.

Dual-Task Research and Behavioral Indicators. An additional area where SOC theory turned out to be promising is dual-task research. Dual- or multiple-task research explores the degree to which individuals can perform several tasks concurrently and whether concurrent performance of several tasks (such as walking and memorizing) facilitates or interferes. Such multitask situations are prototypical of the ecology of everyday behavior. Moreover, with age children become better in handling multiple tasks simultaneously and minimize what is usually called dual-task costs. With aging, the reverse is true.

Dual-task research is a prime model to study development as a system of co-changing and collaborative processes, and of the process of differential allocation of resources. Several studies have tested SOC theory within this model or examined whether the findings are consistent with predictions from the theory. In a later section, we will describe these studies in more detail. Here, suffice it to briefly mention one series of studies.

In our laboratories, we focused on the joined performance of motor behavior (such as walking and keeping one's motor balance) and various processes of memory and solving cognitive tasks. Although older adults showed greater dual-tasks costs, they also exhibited clear preference in their task allocation. For instance, they invested a larger share of their resources into motor behavior (likely because falling is a high-risk in aging) and were more ready to de-invest from the cognitive task. Moreover, on the behavioral level, older adults were effective in using compensatory skills to maintain a higher level of performance (K. Z. H. Li, Lindenberger, Freund, & Baltes, 2001; Lindenberger, Marsiske, & Baltes, 2000).

These initial self-report and observational as well as experimental studies lend support to the perspective of the SOC theory of adaptive development. The pattern of findings suggests that individuals who select, optimize, and compensate are better able to *generate* new developmental resources and through effective *allocation* more effective available resources to manage the tasks of life. Thus, SOC functions like a development-enhancing and loss-preventing general-purpose mechanism. As a general theory of adaptive development, it characterizes a system of strategies that permits individuals to master the general tasks of life, including those that result from the overall life span script outlined earlier when we outlined a systematic change toward a greater proportion of dealing with losses rather than gains.

FIRST LEVEL 5 EXAMPLE: INTELLECTUAL FUNCTIONING ACROSS THE LIFE SPAN

In the following two sections, we focus on two broad areas of human development—intellectual functioning and personality—to present more specific life span research and theory. In general, our approach is to present this work such that the general theoretical perspectives outlined provide an umbrella under which this research can be positioned and interpreted. Throughout, we attempt to highlight also the pervasiveness of the concept of developmental biocultural co-constructivism (P. B. Baltes et al., 2006).

The productivity of a life span orientation to developmental change depends critically on articulating the theoretical propositions regarding the macroscopic overall landscape of the entire course of ontogeny with more microscopic research on specific developmental functions, processes, and age periods. Specifically, the knowledge bases generated by researchers interested in different aspects of infancy, childhood, adolescence, adulthood, and late life need to be combined and compared with each other, and organized by the themes and propositions that guide the life span approach. The resulting life span integration of perspectives and findings, in turn, is hoped to feed back into the more age- and process-specific developmental specialties, providing for larger interpretative frameworks and provoking the investigation of new or formerly neglected research questions (Lindenberger, 2001).

The field of *intellectual development,* that captured early (Hollingworth, 1927; Sanford, 1902) and continuing attention in life span psychology (e.g., Craik & Bialystok, in press) is ideally suited to demonstrate the potential of this dynamic. Central themes of intellectual development such as relative stability (i.e., covariance change over time), directionality (i.e., mean change over time), plasticity (i.e., the malleability of mean and covariance changes), and the role of knowledge-based processes in cognitive development also have played a prominent role in life span theorizing, and are well suited to exemplify the dynamics between specialized research contexts and overarching conceptions of life span development.

The Biology and Culture of Life Span Intellectual Development

Our proposed view of the overall landscape of ontogenesis as summarized in Figure 11.1 puts constraints on the possible form and content of theories about life span intellectual development. Foremost, any model or theory on life span intellectual development needs to recognize that ontogenesis is a co-construction of two intertwined streams of inheritance, the biological and the cultural (Durham, 1991; see also P. B. Baltes et al., 2006; S.-C. Li, 2003), and needs to provide a framework for the developmental investigation of these two streams of inheritance in different domains, and at different levels of analysis. Specifically, the model should be consistent with the three-fold characterization of the life span dynamics between biology and culture summarized in Figure 11.1, and with the family of theoretical propositions summarized in Table 11.3.

The Two-Component Model of Life Span Cognition: Mechanics versus Pragmatics

In the past, initiated by one of us (P. B. Baltes, 1987, 1993, 1997) but soon co-developed with others (e.g., P. B. Baltes et al., 1984; P. B. Baltes, Staudinger, & Lindenberger, 1999; S.-C. Li, 2002; Lindenberger, 2001), have proposed a theoretical framework for the study of intellectual development in which two main categories or components of intellectual functioning are set apart: The mechanics and the pragmatics of cognition. Juxtaposing the two does not imply that they are independent or exclusive; rather, they interact across ontogenetic and microgenetic time in the production of intelligent behavior. As a general principle, the cognitive mechanics, because of their evolutionary base, evolve earlier in human ontogeny, and are being "invested" into the acquisition of higher and knowledge-based cognitive functions (for similar assumptions in the context of Gf/Gc theory, see Cattell, 1971).

Historically, our views on the overall landscape of human development were developed in close connection with the broadening and systematization of the mechanic-pragmatic distinction (P. B. Baltes, 1987, 1997; P. B. Baltes, Lindenberger, & Staudinger, 1998; S.-C. Li, 2003). Specifically, we construe the mechanics of cognition as an expression of the neurophysiological architecture of the mind as they evolved during biological evolution (cf. Gigerenzer & Todd, 1999) and unfold during ontogeny (McClelland, 1996; W. Singer, 1995). In contrast, the pragmatics of cognition are associated with the bodies of knowledge available from and mediated through culture (see upper portion of Figure 11.8).

The Cognitive Mechanics. The mechanics of cognition are closely linked to biological including neurophysiological brain conditions, and the predominant age-graded ontogenetic pattern is one of maturation, stability, and aging-induced decline. Especially early and late in ontogeny, age-based changes in this component are assumed to primarily reflect factors closely related to biological brain status, albeit in fundamentally different ways (P. B. Baltes, 1997; S.-C. Li, Lindenberger, et al., 2004; Lindenberger, 2001). Early in ontogeny (i.e., during embryogenesis, infancy, and early

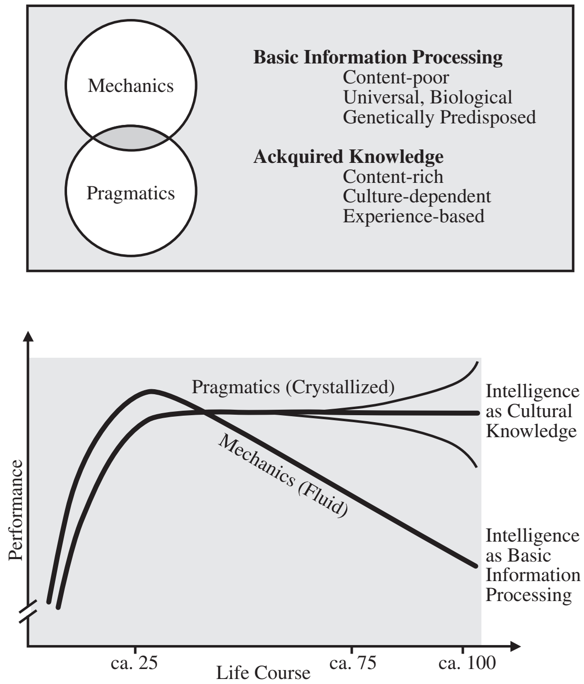

Figure 11.8 Life span research on two components of cognition: (1) fluid mechanics and (2) crystallized pragmatics. The top section defines the categories; the bottom section illustrates postulated lifespan trajectories. *Source:* Modified based on "Psychological Aspects of Aging: Facts and Frontiers" (pp. 427–459), by P. B. Baltes and P. Graf, in *The Life-Span Development of Individuals: Behavioural, Neurobiological and Psychosocial Perspectives,* D. Magnusson (Ed.), 1996, Cambridge, England: Cambridge University Press; From "Major Abilities and Development in the Adult Period" (pp. 44–99), by J. L. Horn and S. M. Hofer, in *Intellectual Development,* R. J. Sternberg & C. A. Berg (Eds.), 1992, New York: Cambridge University Press.

childhood), age-based changes in the mechanics are assumed to consist, for the most part, in the unfolding and active construction of more or less domain-specific and genetically predisposed processing capabilities (Elman et al., 1996; Wellman, 2003). In contrast, negative changes in the mechanics of cognition late in life presumably result from brain-related consequences of less effective phylogenetic selection pressures operating during this period (Kirkwood, 2003; Thaler, 2002; see "The Mechanics and Pragmatics in Very Old Age"). In that sense, the life span trajectory of level changes in the mechanics of cognition can be derived from the life span changes shown in the left panel of Figure 11.1.

The cognitive mechanics, then, reflect fundamental organizational properties of the central nervous system (W. Singer, 1995). In terms of psychological operations, we assume that the cognitive mechanics are indexed by the speed, accuracy, and coordination of elementary processing operations as they can be assessed in tasks measuring the quality of information input, sensory and motor memory, discrimination, categorization, and selective attention, as well as reasoning ability in highly overlearned or novel domains (Craik, 1986; Craik & Bialystok, in press; Craik & Salthouse, 2000; Hommel, Li, & Li, 2004; Salthouse & Kail, 1983). At the neuronal level, age-graded anatomical, chemical, and functional changes in the brain and their complex relations to the cognitive mechanics are being uncovered with increasing precision and scope (P. B. Baltes et al., in press; Cabeza, Nyberg, & Park, 2004; Craik & Bialystok, in press; Lindenberger, Li, & Bäckman, in press).

The Cognitive Pragmatics. In contrast to the mechanics, the cognitive pragmatics of the mind reveal the power of human agency and culture (Boesch, 1997; Cole, 1996; Valsiner & Lawrence, 1997; S.-C. Li, 2003; Shweder, 1991). The cognitive pragmatics also are at the center of socialization events that follow the principles of co-construction (P. B. Baltes et al., in press; S.-C. Li, 2003). Some of these events are normative but specific to certain cultures (e.g., formal schooling), others are more universal (e.g., mentoring), and still others are idiosyncratic or person-specific (e.g., specialized ecological and professional knowledge). In any case, the corresponding bodies of knowledge are represented both internally (e.g., semantic networks) and externally (e.g., books).

The pragmatics of cognition direct the attention of life span developmentalists toward the increasing importance of knowledge-based forms of intelligence during ontogeny (P. B. Baltes & Baltes, 1990a; Ericsson & Smith, 1991; Hambrick & Engle, 2002; Krampe & Baltes, 2003; Labouvie-Vief, 1982; Rybash, Hoyer, & Roodin, 1986). Typical examples include reading and writing skills, educational qualifications, professional skills, and varieties of everyday problem-solving, but also knowledge about the self and the meaning and conduct of life (P. B. Baltes & Staudinger, 2000; Blanchard-Fields, 1996; Bosman & Charness, 1996; Marsiske et al., 1995; Staudinger et al., 1995; see "Face and Facets of the Study of Personality Development across the Life Span"). Such bodies of pragmatic knowledge are acquired during ontogeny but may build on evolutionarily prestructured, domain-specific knowledge (Charness, 2005; Elman et al., 1996; Tomasello, 1999).

Divergence in Life Span Trajectories between Mechanics and Pragmatics. The preceding considerations imply specific predictions regarding the shape of ontogenetic trajectories for mechanic and pragmatic aspects of intellectual functioning (see lower portion of Figure 11.8). Specifically, two different sources of influence are assumed to govern the level of performance within these two categories: biological-genetic for the mechanics, and environmental-cultural for the pragmatics. The expected divergence in age trajectories is seen as a consequence of this difference in composition.

Empirical evidence in support of a two-component conceptualization of life span cognition comes from a great variety of different research traditions (see discussion that follows). Probably the most longstanding supportive evidence is the difference between maintained and vulnerable intellectual abilities (Salthouse, 1991; cf. Jones & Conrad, 1933). Abilities that critically involve the mechanics, such as reasoning, memory, spatial orientation, and perceptual speed, generally show a pattern of monotonic and roughly linear decline during adulthood, with some further acceleration of decline in very old age. In contrast, more pragmatic abilities, such as verbal knowledge and certain facets of numerical ability, remain stable or increase up to the 6th or 7th decade of life, and only start to evince some decline in very old age.

Figure 11.9, based on the fifth data collection of the Seattle Longitudinal Study (Schaie, 1996; see also Schaie et al., 2005), may serve as an illustration. It displays cross-sectional adult age gradients based on multiple indicators for six intellectual abilities (Schaie & Willis, 1993). Verbal ability and number ability peak during middle adulthood and show little or no age decrements before the age of 74, whereas perceptual speed, inductive reasoning, spatial orientation, and verbal memory show steady monotonic decline. Recent analyses based on longitudinal as well as longitudinal/cross-sectional convergence data provide additional and more direct support for a basic divergence between mechanic and pragmatic age gradients in adulthood and old age (Salthouse, 1991; Schaie, 1996; Schaie, Maitland, Willis, & Intieri, 1998; T. Singer, Verhaeghen, Ghisletta, Lindenberger, & Baltes, 2003).

In a recent cross-sectional study, Shu-Chen Li and colleagues (2004) investigated whether dissociations in age trajectories between mechanic and pragmatic intellectual abilities across can be observed across the entire life span, as life span psychology would predict. The authors administered a psychometric battery comprising fifteen tests assessing three marker abilities of the fluid mechanics (perceptual speed, reasoning, and fluency) and two

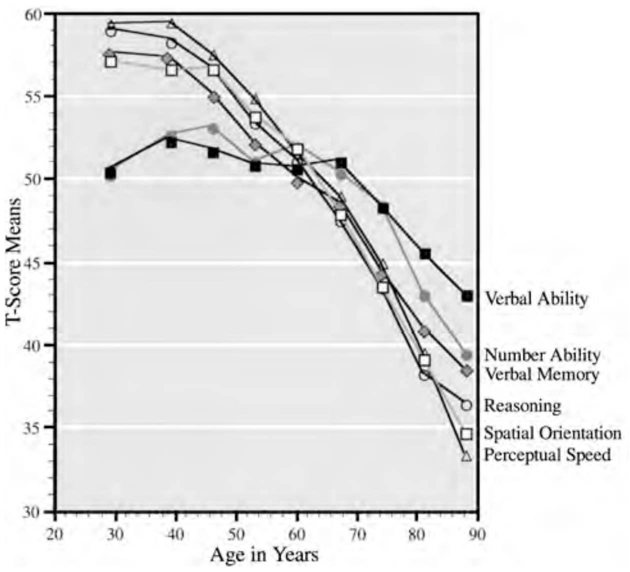

Figure 11.9 Cross-sectional age gradients in six primary mental abilities ($N = 1628$). Abilities were assessed with 3 to 4 different tests and are scaled in a T-score metric (i.e., *mean* = 50, *SD* = 10). Verbal ability and number ability peak during middle adulthood and show little or no age decrements before the age of 74. In contrast, perceptual speed, inductive reasoning, spatial orientation, and verbal memory show steady monotonic decline. This differential pattern of prevailing growth, maintenance, and subsequent loss supports two-component theories of life span intellectual development such as the distinction between fluid and crystallized intelligence made by Cattell (1971) and J. L. Horn (1982) or the juxtaposition of the mechanics and the pragmatics of cognition proposed by P. B. Baltes (1987, 1993). *Source:* From "Age Difference Patterns of Psychometric Intelligence in Adulthood: Generalizability within and across Ability Domains," by K. W. Schaie and S. L. Willis, 1993, *Psychology and Aging, 8,* pp. 44–55.

marker abilities of the crystallized pragmatics (verbal knowledge and fluency) to individuals aged 6 to 89 years. Participants were classified into six age groups, childhood (6 to 11 years), adolescence (12 to 17 years), early adulthood (18 to 35 years), middle adulthood (26 to 54 years), late adulthood (55 to 69 years), and old age (70 to 89 years). In addition, S.-C. Li et al. (2004) also administered basic reaction time tasks to index processing speed (i.e., a person's average speed of responding across the five tasks) and processing robustness (i.e., the inverse of a person's average within-task reaction-time fluctuation). As expected, the life span trajectories of the two information processing and the fluid-mechanic composite stood in contrast to the trajectory of the crystallized-mechanic composite (see Figure 11.10). Moreover, within the mechanic domain, the trajectories for the two

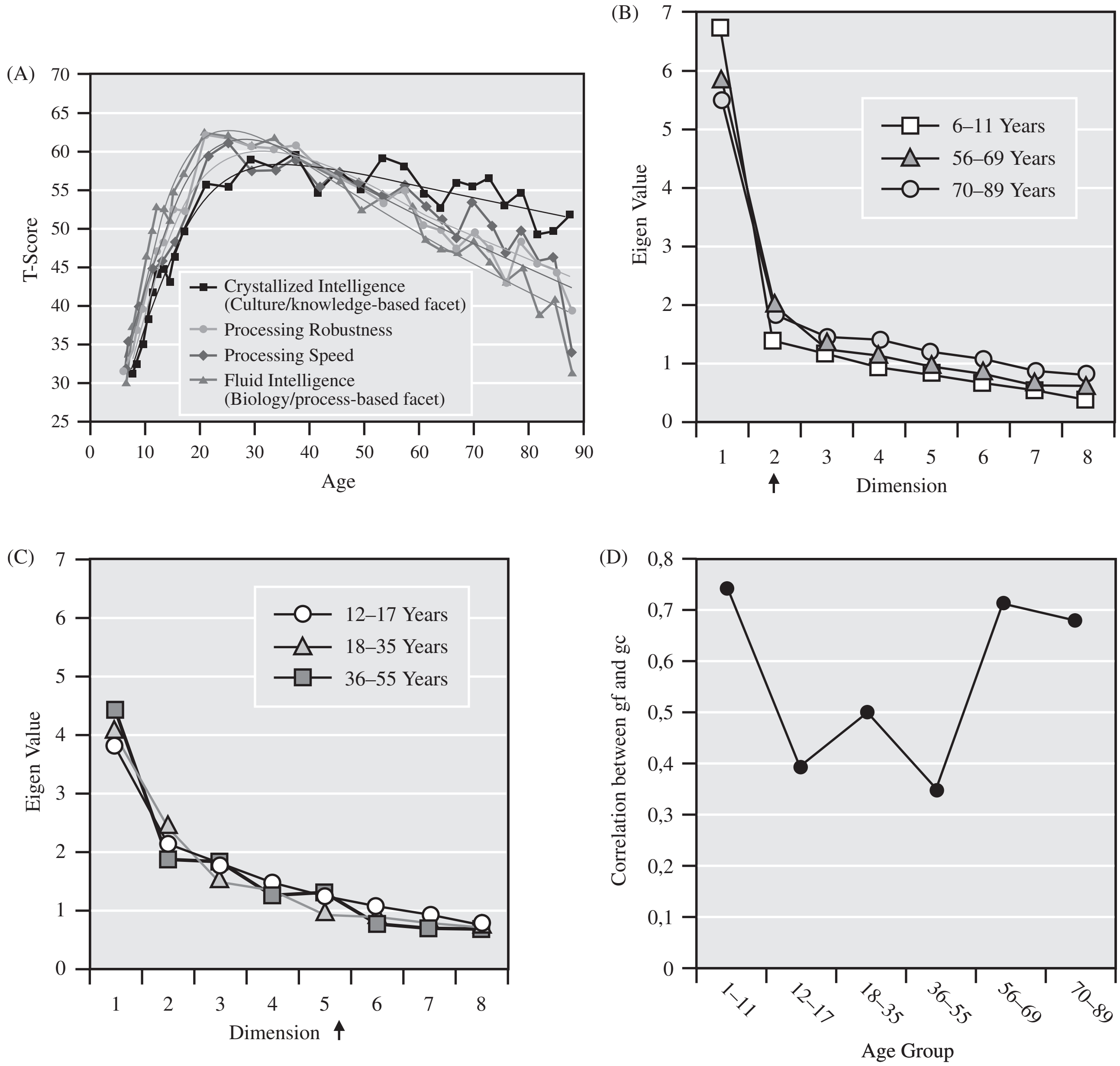

Figure 11.10 Intellectual abilities across the life span. (A) Cross-sectional age trajectories for crystallized intelligence, processing robustness, processing speed, and fluid intelligence. Crystallized intelligence represents the cognitive pragmatics, whereas processing robustness, processing speed, and fluid intelligence represent the cognitive mechanics. The divergence in age gradients between pragmatics and mechanics lends support to two-component theories of cognitive development. (B, C) Results from principal component analyses of 15 intellectual ability tests for each of six age groups. The arrows indicate the estimated number of principal components with eigenvalues greater than unity. (D) Correlations between broad fluid and crystallized intelligence for the same six age groups. Panels B-D support the hypothesis that the structure of intellectual abilities is less differentiated in childhood and old age than during adolescence and adulthood. *Source:* From "Transformations in the Couplings among Intellectual Abilities and Constituent Cognitive Processes across the Life Span" by S.-C. Li, U. Lindenberger, B. Hommel, G. Aschersleben, W. Prinz, and P. B. Baltes, 2004, *Psychological Science, 15,* pp. 155–163.

information-processing composites showed an earlier cross-sectional life span peak than the trajectory for the fluid-mechanic component, supporting the contention that the admixture of pragmatic variance contaminates standard assessments of broad fluid intelligence.

The Two-Component Model: Relations to Other Multiple-Component Theories

Arguably, Tetens (1777) provided the earliest comprehensive formulation of a two-component model of life span cognition (Lindenberger & Baltes, 1999); his definition of absolute and relative capacities closely approximated the definition of the mechanics and pragmatics of cognition, respectively. The closest relative, both conceptually and historically, to the two-component model of life span intellectual development is the theory of fluid (Gf) and crystallized (Gc) abilities by Cattell (1971) and Horn (1982; for comparative discussion, see P. B. Baltes et al., 1998; Lindenberger, 2001). Other approaches related to the two-component model include Ackerman's (e.g., 1996) process, personality, interests, and knowledge (PPIK) model, Hebb's (1949) distinction between intelligence A (i.e., intellectual power) and intelligence B (i.e., intellectual products), the encapsulation model of adult intelligence proposed by Rybash et al. (1986; Hoyer, 1987), and Sternberg's (1985) triarchic theory of intelligence, especially its developmental interpretation by Berg and Sternberg (1985a).

Here, the two-component model will be further elaborated in three separate sections: Mechanics, pragmatics, and their interrelations. The aim of these three sections is not to be comprehensive, but to further specify the two components of cognition as well as their interaction.

The Fluid Mechanics of Cognition

We start this section with a life span summary of research on constructs that have been proposed to cause or mediate age-based changes in the mechanics of cognition. We then argue that much of the available evidence about age-based changes in the mechanics derives from measures that are contaminated by pragmatic influence, and we underscore the need to arrive at more valid estimates of individual differences in upper limits of mechanic functioning. In line with the two-component model, we predict that age differences in the mechanics are magnified under purified measurement conditions and provide an empirical example from adulthood in support of this prediction.

The Search for Determinants of Mechanic Development

Despite a large overlap in approaches to the study of intellectual development, there are surprisingly few attempts to pursue the themes of infant and child development into adulthood and old age, or to identify thematic and predictive antecedents of adulthood and old age in childhood (see S.-C. Li, Lindenberger, et al., 2004). An important exception in this regard concerns work on age changes in general information-processing constraints on intellectual functioning across the life span, or what we would call research on the determinants of age-based changes in the mechanics of cognition. Researchers both in the fields of child development (Bjorklund, 1997; Case, 1992; McCall, 1994; Pascual-Leone, 1983) and cognitive aging (Birren, 1964; Cerella, 1990; Craik & Byrd, 1982; Hasher & Zacks, 1988; S.-C. Li, Lindenberger, & Sikström, 2001; Salthouse, 1996) have been trying to identify developmental determinants or "developables" (Flavell, 1992) that regulate the rate of age-based changes in cognitive and intellectual functioning. Some scholars have begun to link these two lines of inquiry by attempting to provide unified accounts of age-based changes in the structure and/or efficiency of information processing (e.g., Craik & Bialystok, 2006; Hommel, Li, & Li, 2004; S.-C. Li, Lindenberger, et al., 2004; Salthouse & Kail, 1983; Wellman, 2003).

In many cases, the central goal of these endeavors is to identify the number (dimensionality), nature, and causal dynamics of age-graded changes in the mechanics of cognition. Though this task seems conceptually straightforward, it is methodologically quite intricate (P. B. Baltes & Labouvie, 1973; Hertzog, 1985; Hertzog & Nesselroade, 2003; Lindenberger & Pötter, 1998; Reinert, Baltes, & Schmidt, 1966). Chronological age carries a multitude of causal agents with different and intertwined temporal dynamics and timescales such as distance from birth, distance from death, distance from disease inception, but also number of hours of practice or formal training. For instance, when two variables assumed to index two causal agents follow a similar path over ontogenetic time, this does not imply that the two causes are functionally related. Therefore, evidence about determinants of mechanic development needs to be evaluated with caution, especially if based on age-heterogeneous cross-sectional data sets (Lindenberger & Pötter, 1998).

In the following section, we selectively review research on possible determinants of life span changes in the mechanics of cognition. We start with three constructs located at the information-processing level of analysis, and end with a consideration of select age-graded changes at the neuronal level. Progress in understanding determinants of life span changes in the mechanics of cognition field will depend on integrating these two levels of analysis both empirically and conceptually (Buckner, 2004; Craik & Bialystok, in press; S.-C. Li, in press; S.-C. Li & Lindenberger, 1999; Lindenberger, Li, & Bäckman, in press).

At the information-processing level, processing rate (Cerella, 1990; Salthouse, 1996), working memory (Baddeley, 2000; Just, Carpenter, & Keller, 1996), and inhibition (Hasher & Zacks, 1988) have been studied most extensively. Apparently, functional levels of these three mechanisms follow the inverse U-shape pattern predicted by the two-component model for the mechanics of cognition. In principle, then, any combination of these mechanisms could act as a pacemaker of life span development in the mechanics of cognition.

Processing Speed. Across a wide variety of cognitive and perceptual tasks, speed of responding increases dramatically from childhood to early adulthood, and continuously decreases thereafter. This observation has led to the processing rate hypothesis of life span cognitive development. Probably, this hypothesis holds a more central place in cognitive aging research (e.g., Birren, 1964; Cerella, 1990; Salthouse, 1996; Welford, 1984) than in research on child development (e.g., Hale, 1990; Kail, 1996). In the case of cognitive aging, the general slowing-down of cognitive behavior with advancing age is portrayed as the consequence of a general decrement in information processing rate. In cross-sectional studies, psychometrically assessed perceptual speed accounts for most or all negative adult age differences in other intellectual abilities, even if these other abilities are assessed under time-relaxed or untimed testing conditions (for a summary, see Verhaeghen & Salthouse, 1997). However, psychometrically assessed perceptual speed is not a unitary construct or processing primitive but a factorially complex entity whose composition may change as a function of age. Also, attempts at identifying neuronal correlates of age-based differences in processing speed have yielded mixed results (e.g., Bashore, Ridderinkhof, & van der Molen, 1997).

Working Memory. Generally, working memory denotes the ability to preserve information in one or more short-term stores while simultaneously transforming the same or some other information (Baddeley, 2000; Just et al., 1996). Age differences in working memory have been invoked as a possible cause for intellectual growth during childhood (Case, 1985; Chapman & Lindenberger, 1992; Halford, 1993; Pascual-Leone, 1970), and for age-based decrements during adulthood and old age (Craik, 1983; Oberauer & Kliegl, 2001). With respect to childhood, Neo-Piagetian theorists have argued that changes in working memory are among the primary pacemakers of intellectual child development (e.g., Pascual-Leone, 1970).

Positive age differences during childhood and negative age differences during adulthood are more pronounced when demands on processing are increased (Mayr, Kliegl, & Krampe, 1996). Despite this supportive evidence, the explanatory power of the working-memory construct is difficult to judge. For instance, age-based changes in working memory are often explained by alluding to changes in processing efficiency or processing speed (Case, 1985; Salthouse, 1996). Another problem concerns our limited knowledge about a central function of working memory—the (conscious) control of action and thought. In the most influential working-memory model (Baddeley, 2000), this task is assigned to the central executive. Evidence from developmental psychology (Houdé, 1995; McCall, 1994), cognitive-experimental and differential psychology (Engle, Kane, & Tuholski, 1999), and the cognitive neurosciences (Miller & Cohen, 2001) suggests that the abilities to inhibit actions and thoughts and avoid interference from competing processing streams are crucial for the efficient functioning of this component, rather than working-memory capacity per se.

Inhibition and Interference. During the past decades, developmentalists from different traditions and fields of research have intensified their interest in mechanisms of inhibition and interference (Bjorklund, 1997; Engle, Conway, Tuholski, & Shishler, 1995; Hasher & Zacks, 1988; Houdé, 1995; McCall, 1994). Curvilinear life span age gradients that resemble those found for measures of perceptual speed have been obtained with typical tests of interference proneness such as the Stroop color-word test, suggesting that children and especially older adults have greater difficulties in suppressing currently irrelevant action tendencies than young adults (Dempster, 1992; Hommel et al., 2004; Mayr, 2001). However, it has proven difficult to separate inhibition-based explanations of this phenomenon from activation-based explanations of selective attention and working memory capacity (Engle et al., 1995; Hommel et al., 2004).

Cognitive Neuroscience Approaches to Mechanic Development: The Sample Case of Prefrontal Circuitry. The advent of brain imaging methods has allowed researchers to intensify empirical links between behavioral and neuronal levels of analysis. The conceptual and empirical implications of this trend for developmental psychology are discussed more fully elsewhere (e.g., P. B. Baltes et al., in press; Cabeza et al., 2004; Craik & Bialystok, in press; S.-C. Li, 2002; Lindenberger et al., in press). In the following discussion, we restrict our presentation to maturational and senescent changes in prefrontal circuitry. Available evidence suggests that these changes may contribute in important ways to changes in the cognitive mechanics during childhood and old age.

We begin with some evidence on regional brain development. In early ontogeny, prefrontal cortex and associated neural networks undergo profound anatomical, chemical, and functional changes that extend well into adolescence. Neural plasticity during corticogenesis entails the production and experience-dependent elimination of neuronal connections (Huttenlocher & Dabholkar, 1997). During brain development, the zone of maximum plasticity moves from primary sensory and motor over secondary association to prefrontal areas (Chugani, Phelps, & Mazziotta, 1987). Computational models suggest that later maturing areas require input from earlier maturing areas to represent higher-order concepts (Shrager & Johnson, 1996). Arguably, the gradual and orderly progression of the corticotrophic wave provides a chronotopic constraint for cerebral cortex organization.

In later adulthood, prefrontal cortex and the functionally connected basal ganglia also show greater and earlier signs of decline than most other areas of the brain. In a comprehensive review of the neuroanatomical literature, Raz (2000) reported average linear reductions in brain weight and volume of about 2% per decade during adulthood, which were more pronounced for anterior parts of the brain (for longitudinal evidence, see Raz, Lindenberger, et al., 2005). At the neurochemical level, changes in the catecholaminergic system, most notably dopamine, play a prominent role (Bäckman & Farde, 2004). Finally, neurofunctional studies point to profound age-associated changes in the functional organization of prefrontal cortex such as a reduction in the asymmetry of hemispheric activation (e.g., Cabeza, 2002).

The links between behavioral development and regional brain differentiation are only beginning to emerge (e.g., Lindenberger et al., in press), and the precise relations between life span changes in prefrontal circuitry and behavioral changes remain to be uncovered. Functions similar to working memory and typically subsumed under the heading of "executive functions" or "cognitive control" appear to be involved (Engle et al., 1999; Kliegl, Krampe, & Mayr, 2003). Situations deemed to be particularly dependent on prefrontal circuitry require the coordination of multiple tasks or task components. Typical examples include the suppression of stimulus-driven action tendencies (Metcalfe & Mischel, 1999; Salthouse & Meinz, 1995), multitasking (Mayr et al., 1996; Salthouse, Hambrick, Lukas, & Dell, 1996) and response selection under high stimulus ambiguity (Kramer, Hahn, & Gopher, 1999; Kray & Lindenberger, 2000). Differential susceptibility to coordinative demands may help to explain why life span age differences in marker tests of fluid intelligence such as Raven's matrices tend to persist when participants are given unlimited amounts of time to solve the items (cf. the simultaneity mechanism in Salthouse, 1996).

Future research needs to explicate the link between life span changes in prefrontal circuitry and the mechanics of cognition with greater precision. Given the fundamentally different etiology of changes in prefrontal circuitry early and late in ontogeny, and given that late-life changes are taking place in a cognitive system with a rich and idiosyncratic learning history, any expectation of a close resemblance between brain-behavior mappings early and late in life seems unwarranted.

Age-Based Differences in the Mechanics of Cognition: The Need for Purification of Measurement

Observed age differences or age changes on intellectual tasks and tests, as obtained in standard cross-sectional and real-time longitudinal research, cannot be regarded as direct and pure reflections of age-based changes in the mechanics of cognition. Rather, in addition to the mechanics, such differences or changes are influenced by a wealth of additional factors, ranging from pragmatic components of cognition (e.g., task-relevant preexperimental knowledge) to other person characteristics (e.g., test anxiety or achievement motivation; cf. Fisk & Warr, 1996). A likely indication for this admixture of pragmatic variance to supposedly mechanic measures is the secular rise in performance on typical psychometric marker tests of fluid intelligence (cf. Flynn, 1987; Schaie et al., 2005). In our view, it seems an open question whether the preferred interpretation by Flynn that these historical changes reflect changes in fluid intelligence per se is correct. Unless more pure measures of basic fluid intelligence were included, we hold it more likely that these historical changes are changes in the pragmatics rather than the mechanics (see also Schaie et al., 2005).

The need for better estimates of individuals' performance potential in the mechanics of cognition is further nurtured by the life span proposition that epigenesis is probabilistic but not random; hence, plasticity is more or less constrained (P. B. Baltes, 1987; Gottlieb, 1998; Hagen & Hammerstein, 2005; R. M. Lerner, 1984; see Table 11.3). If the goal is to separate the possible from the impossible over age, and to solidify the evidence on age differences in the mechanics of cognition, the context of measurement needs to be moved toward upper limits of performance potential. This line of reasoning resembles claims made by other research traditions, such as clinical and developmental diagnostics (Carlson, 1994; Guthke & Wiedl, 1996), the differentiation between performance and competence, gestalt and cultural-historical theoretical orientations (Vygotsky, 1962; H. Werner, 1948), and early work on life span differences in learning (B. Levinson & Reese, 1967). Discrepancies in epistemology and purpose notwithstanding, all these traditions are inspired by an interest in exploring individuals' upper limits of intellectual performance.

Testing the Limits of Age Differences in the Mechanics of Cognition. Within life span developmental psychology and as alluded to earlier, the testing-the-limits paradigm has been introduced as a research strategy to uncover age differences in the upper limits of mechanic functioning across the life span (P. B. Baltes, 1987; Kliegl & Baltes, 1987; Lindenberger & Baltes, 1995b). The main focus of this paradigm is to arrange for experimental conditions that produce maximum (i.e., asymptotic) levels of performance. Thus, similar to stress tests in biology and medicine (M. M. Baltes, Kühl, Gutzmann, & Sowarka, 1995; Fries & Crapo, 1981), testing-the-limits aims at the assessment of age differences in maximum levels of cognitive performance by providing large amounts of practice and/or training combined with systematic variations in task difficulty. Furthermore, and in line with the microgenetic approach to the study of change (Siegler & Crowley, 1991; Siegler, Chapter 11, this *Handbook,* this volume), the testing-the-limits paradigm is based on the assumption that the study of microgenetic change and variability may help to identify mechanisms underlying ontogenetic change (see H. Werner, 1948). Thus, in addition to the more general goal of measurement purification, the detailed analysis of time-compressed developmental change functions is assumed to enhance our understanding of the mechanisms and the range of medium- and long-term developmental changes (Hultsch & MacDonald, 2004; S.-C. Li, Huxhold, et al., 2004; Lindenberger & von Oertzen, in press).

A Prototypical Example: Adult Age Differences in Upper Limits of Short-Term Memory (Serial Word Recall)

Figure 11.11 shows the result of a study involving a total of 38 sessions of training and practice in the Method of Loci, a mnemonic technique for the serial recall of word lists. Two findings from this study are noteworthy. First, adults in both age groups greatly improved their memory performance. This finding confirms earlier work on the continued existence of cognitive plasticity in cognitively healthy (i.e., nondemented) older adults (P. B.

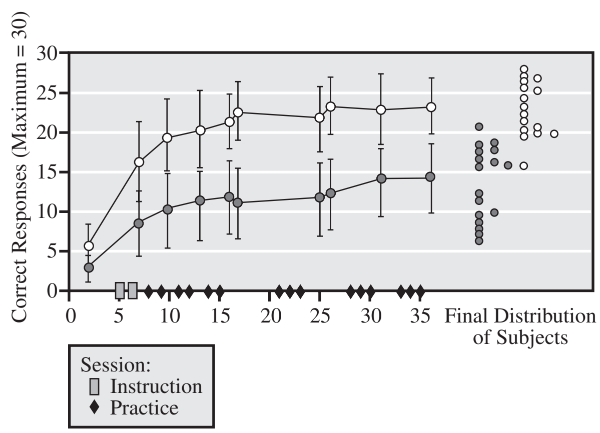

Figure 11.11 Testing-the-limits research, which is aimed at the identification of asymptotes of performance potential, suggests the existence of robust age-related losses in the mechanics of cognition. The example given involves a memory technique, the Method of Loci. After 38 sessions of training, most older adults did not reach the level of performance reached by younger adults after only a few sessions. In the final distribution, no older person was performing above the mean of the young adults. Adapted from P. B. Baltes & Kliegl, 1992.

Baltes & Lindenberger, 1988; P. B. Baltes & Willis, 1982; Verhaeghen, Marcoen, & Goossens, 1992). Second, practice and training resulted in a close-to-perfect separation of the two adult age groups, thereby demonstrating the existence of sizeable negative age differences at limits of functioning. Even after 38 sessions of training, the majority of older adults did not reach the level of performance that young adults had reached after only a few sessions. Moreover, at the end of the study, not a single older person functioned above the mean of the young-adult group. A more recent investigation has shown that upper limits of performance are further reduced in very old age (T. Singer, Lindenberger, & Baltes, 2003).

The findings obtained with the testing-the-limits paradigm are consistent with our general notion that the mechanics of cognition decrease during adulthood and old age. Given our assumptions regarding life span changes in adaptive capacity of the mechanics of the mind and the knowledge-contaminated nature of standard assessments, we predict that life span peaks in performance levels are shifted toward younger ages when individuals are given the opportunity to come close to their upper limits of mechanic potential. Results from a recent experimental study have confirmed these expectations (Brehmer, Li, Müller, Oertzen, & Lindenberger, 2005).

In addition to encompassing wide age ranges, future explorations of life span differences in behavioral plasticity may also include functional and anatomical neural measures to identify life span differences in the relation between behavioral and neuronal plasticity (for exemplary work, see Kramer et al., in press; Nyberg et al., 2003). Also, the focus on age differences in maximum level should be complemented by an emphasis on age-differential changes in variances and covariances with practice (Hertzog, Cooper, & Fisk, 1996; Labouvie, Frohring, Baltes, & Goulet, 1973). Specifically, to better understand neuronal correlates of age differences in the acquisition of expertise, it seems productive to study life span differences in the brain's adaptation in response to intensive training programs.

At present the major conclusion regarding the plasticity of the mechanics across the lifespan is that plasticity may be substantial in childhood, that it decreases markedly with age, and that it's demonstrated plasticity after middle adulthood is modest at best. This conclusion holds especially, if one defines a high threshold for assessing whether a given training program resulted in a true improvement of the mechanics themselves (Baltes & Lindenberger, 1988). For instance, it is not easy to argue against alternative interpretations, such as that the improvement in the cognitive system is due to adding pragmatic rather than mechanical components to the solution process. We would need more purist measures of the cognitive mechanics than are currently available. Moreover, issues of transfer and maintenance are at stake. If the results were an improvement in the mechanics themselves, the evidence should include the demonstration of improvement in learning gains across a wide range of new tasks, or at least within the "modularity" class within which the training tasks are putatively located. The absence of such evidence my be due to the fact that many training programs are behavioral in origin. It will be interesting to see whether biochemical interventions, such as memory pharmaceuticals to improve the transmission from primary to secondary memory might be more powerful in improving the cognitive mechanics in a more direct manner. Here, the newly evolving cooperation between biochemically oriented neuroscientists and behaviorally-oriented learning psychologists may offer a new window on the plasticity of the cognitive mechanics during adulthood as well (see also Goldberg & Weinberger, 2004; Kempermann, 2006).

The Crystallized Pragmatics of Cognition

We now direct our attention to the ontogeny of the cognitive pragmatics, or the cultural and knowledge-rich dimension of intellectual life span development. First, we discuss the relation between mechanics and pragmatics from an evolutionary perspective. Then, we introduce the distinction between normative and person-specific forms of pragmatic knowledge, and discuss stage- and knowledge-oriented approaches. We end this section with examples from our own research on expert knowledge about the fundamental pragmatics of life (wisdom).

Mechanics and Pragmatics in Evolutionary Perspective

In recent decades, nativist approaches to infant cognitive development have revealed the evolutionary informed nature of the human processing system (e.g., Spelke, Vishton, & von Hofsten, 1995). Through innovative advances in experimental methodology, it has become increasingly clear that infants and young children cannot be considered a cognitive tabula rasa, as extreme interpretations of constructivist (e.g., Piaget, 1967/1971, but see Piaget, 1980, pp. 11–12) or behaviorist (e.g., B. F. Skinner, 1966) theorizing may suggest. Rather, not unlike members of other species, humans begin their extra-uterine lives with a well-orchestrated set of domain-specific constraints and expectations that guide behavior and form the basis for later acquisitions (Elman et al., 1996; Saffran, Aslin, & Newport, 1996).

We assume that the pragmatics of cognition, or the bodies of knowledge provided by culture build on, extend, and reorganize these prestructured core domains, both during evolution and during ontogeny (Gigerenzer, 2003; Wellman, 2003). These processes of extension and transformation eventually give rise to forms of knowledge and behavior that are, in part by virtue of necessity, *compatible* with the biological architecture of the mind, but cannot be characterized as the *direct consequence* of evolutionary selection pressures.

The resulting potential of human ontogeny to create and adapt to the new (Gottlieb, 1998), or the productive tension between current functions and evolutionary history, has been referred to as exaptative generalization or *exaptation* (Gould & Vrba, 1982). As a mechanism of biocultural co-construction, exaptation helps to explain why members of the human species are good at doing things that were certainly not directly at the focus of natural selection, such as reading a book or driving a car (Sherry & Schacter, 1987). Put more generally, exaptation reminds us that the evolution of culture must reflect some degree of match with, and reciprocal influence on, evolution-based genetic disposition (Durham, 1991; Gottlieb et al., Chapter 5, this *Handbook,* this volume). For instance, pragmatic knowledge may evolve from and/or mimic predisposed knowledge in evolutionarily privileged domains but come with the advantage of being tuned to the idiosyncratic demands of specific cultures, biographies, and contexts (Siegler & Crowley, 1994).

Note, however, that culture sometimes appears to have produced bodies of knowledge that are antithetical, disconnected, or at least not easily articulated to biological predispositions. For instance, Gigerenzer and Todd (1999) have argued that formal-logical expressions such as Bayes' theorem do not take advantage of humans' predisposition to base judgments about feature conjunction probabilities on frequency counts. Put differently, mathematical formalisms about conditional probabilities do not build on mechanisms of perception and action that directly support the detection of conjunctive feature frequencies; rather, such formalisms are cultural products whose acquisition requires specialized instruction. Another example from a completely different field is the need to culturally countershape the manifestation of evolution-based aggressive and interpersonal power tendencies.

Normative versus Person-Specific Pragmatic Knowledge

An important, albeit necessarily imperfect, distinction within the pragmatics of cognition concerns normative versus person-specific knowledge. Normative bodies of knowledge are of general value to a given culture. Typical examples include verbal ability, number proficiency, and basic general knowledge about the world (e.g., Ackerman, Beier, & Bowen, 2000). Individual differences in these domains are closely linked to years of education and other aspects of social stratification, and are amenable to psychometric testing (Cattell, 1971). In contrast, person-specific bodies of knowledge that branch off from the normative knowledge-acquisition path are less closely tied to mandatory socialization events, and result from specific combinations of experiential settings, personality characteristics, motivational constellations, and cognitive abilities or talent (Marsiske et al., 1995). As a consequence, these bodies of knowledge often escape psychometric operationalization, and are more amenable to study within the expertise paradigm (Ericsson & Smith, 1991; Gobet et al., 2001; Krampe & Baltes, 2003). Therefore, psychometric research on crystallized abilities needs to be supplemented by approaches with a more explicit focus on knowledge acquisition and utilization to more fully capture the diversity and specificity of pragmatic knowledge.

For the most part (but see Brown, 1982; Chi & Koeske, 1983; Schneider & Bjorklund, 2003; Weinert & Perner, 1996; Wilkening & Anderson, 1990), developmental research on person-specific bodies of knowledge has been undertaken with adults. A typical approach has been to identify the effects of domain-specific knowledge by comparing the performance of experts and novices both inside and outside their domain of expertise. Examples include the classical domains of expertise research such as chess (Charness, 1981) and card games (Bosman & Charness, 1996), but also domains such as baseball knowledge (Hambrick & Engle, 2002) or professional expertise (e.g., Salthouse, 2003; for an overview, see Charness, 2005).

Two main conclusions can be drawn from this research. First, expertise effects, or the consequences of specific bodies of declarative and procedural knowledge, rarely transcend the boundaries of the target domain. Specifically, there is little evidence to suggest that the mechanics of cognition are transformed by domain-specific knowledge (Salthouse, 2003). Whenever there is evidence for effects of a more general kind, at least after the age periods of childhood and adolescence, transfer of pragmatic knowledge (positive or negative) appears to be a more plausible explanation than a basic change in the mechanics. One example comes from longitudinal work by Kohn and Schooler (1983; Schooler, Mulatu, & Oates, 1999) on the relationship between the substantive complexity of work and ideational flexibility. Kohn and Schooler found that work complexity predicts increments in ideational flexibility over a period of 10 years, even after controlling for initial differences in ideational flexibility. A related finding is the recent observation that social participation attenuates decline in the cognitive mechanics in old and very old age (Lövdén, Ghisletta, & Lindenberger, 2005). Note, however, that the interpretation of findings of this type in terms of experiential factors is complicated through nonrandom placement of individuals into experiential settings and the fact that the measures of the cognitive mechanics used include crystallized pragmatic components (Scarr & McCartney, 1983).

The second major conclusion concerns the power of pragmatic knowledge to make up for losses in the mechanics within the domain of expertise (Charness, 2005; Krampe & Baltes, 2003). Here, the results from several studies suggest that acquired knowledge endows aging individuals with a form of natural and local (e.g., domain-bound) ability to withstand or at least attenuate the consequences of aging-induced losses in the mechanics. This finding is of central importance for the issue of successful intellectual aging, and supports the general life span theory of selective optimization with compensation (P. B. Baltes, 1993; Freund & Baltes, 2000; Staudinger et al., 1995). The postulate of a compensatory relation between pragmatic knowledge acquisition and mechanic decline receives additional support by attenuated adult age differences in knowledge-rich domains of everyday relevance. For instance, compared to standard psychometric or cognitive-experimental assessments, negative adult age differences tend to be less pronounced or absent in practical problem solving (Sternberg, Wagner, Williams, & Hovath, 1995), social intelligence (Blanchard-Fields, 1996), memory in context (Hess & Pullen, 1996), and interactive-minds cognition (P. B. Baltes & Staudinger, 1996b; Dixon & Gould, 1996; T. Singer et al., 2004; Staudinger, 1996; Staudinger & Baltes, 1996).

Intellectual Growth during Adulthood: Stage Conceptions versus Functionalist Approaches

Historically, much of the search for more advanced forms of reasoning and thought in adulthood originated from Piaget's theory of cognitive development (Chapman, 1988b; Pascual-Leone, 1983; Piaget, 1970; Riegel, 1976), positing the emergence of one or more postformal or dialectical stages of cognitive development after the advent of formal operations. The conceptual description of these stages often connects personality development (e.g., generativity in the Eriksonian sense) with logical considerations (e.g., awareness and acceptance of contradiction). As a consequence of this particular linkage, the emergence of such stages is assumed to bring about increments in reflexivity and general awareness for the human condition (see the next section). Evidence in support of such stages is scarce, which is not surprising given the difficulties in obtaining reliable indicators of stage-like cognitive change (e.g., Molenaar, 1986; L. B. Smith & Thelen, 2003).

Despite his constructivist and dialectical epistemology (e.g., Chapman, 1988; Lourenço & Machado, 1996; Piaget, 1980), Piaget himself was reluctant to posit any stages beyond formal operations. Instead, he argued on one occasion (Piaget, 1972) that the notion of horizontal décalage gives sufficient room to adult intellectual growth and variability within his theory. Specifically, he expected that late adolescents and adults would exhibit formal-operational reasoning within their areas of expertise but not necessarily across all possible domains of knowledge. This view seems consistent with the two-component model of fluid-crystallized or mechanic-pragmatic intelligence in that the potential for adult intellectual growth is linked to factors operating within rather than across domains (Flavell, 1970; Krampe & Baltes, 2003).

Nevertheless, the quest for identifying structural transformations in the organization of thought and action in the course of life span development continues to be of great theoretical appeal (L. B. Smith & Thelen, 2003). To ease the detection of such transformations, if they exist, it seems advisable to increase the density of observations within persons, and to use data-analytic tools as well theoretical approaches that highlight rather than cover the structural dynamics one seeks to identify (e.g., Lindenberger & von Oertzen, in press; Molenaar, Huizenga, & Nesselroade, 2003; C. S. Nesselroade & Schmidt McCollam, 2000). Empirically, the emergence of automaticity during skill acquisition provides perhaps the best evidence for structural change (e.g., Ackerman & Cianciolo, 2000), albeit of a different kind than envisioned by structuralist life span theoreticians.

Expanding the Concept of Cognitive Pragmatics: Wisdom as Expertise in the Fundamental Pragmatics of Life

Individual differences in intellectual functioning also reflect and influence individual differences in personality and motivation. In the child development literature, a good example is school achievement, which is studied in relation to ability, effort, and other personality characteristics. In life span psychology, such a view becomes conspicuous when attempting to understand expert levels of intellectual performance, for instance, by means of models of expertise (Ericsson & Smith, 1991). Similarly, investment theories of intelligence emphasize that cognition pervades cognitive, motivational, and emotional aspects of behavior (Krampe & Baltes, 2003).

To illustrate the point of viewing intelligence in a larger context of human functioning, we use research on wisdom (see also P. B. Baltes & Kunzmann, 2004; Kunzmann & Baltes, 2003a). Wisdom is close to conceptions of intelligence broadly conceived, as it denotes a high level of performance in the domain of practical and social intelligence. At the same time, wisdom also is a personality characteristic since its acquisition and expression depends on values and motivation. For instance, it is part of wisdom-related knowledge to understand that wisdom is oriented simultaneously toward the well-being of oneself and that of others. This commitment to the common good highlights the constituent role of personality and motivation in wisdom-related thought and behavior. Hence, we see wisdom as an ideal combination of mind and virtue (P. B. Baltes & Kunzmann, 2004; P. B. Baltes & Smith, 1990; P. B. Baltes & Staudinger, 2000). Cognitive, motivational, and emotional attributes need to converge to produce wisdom as the highest form of human excellence in mind and character. Thus, strictly speaking, intelligence is only a part of wisdom, unless one was to expand the concept of intelligence production to cover personality as well (for a further discussion of these issues, see Ardelt, 2004; Aspinwall & Staudinger, 2003; P. B. Baltes & Kunzmann, 2004; Krampe & Baltes, 2003; Sternberg, 2004).

In the Berlin work on wisdom (e.g., P. B. Baltes & Kunzmann, 2004; P. B. Baltes & Smith, 1990; P. B. Baltes & Staudinger, 2000), we treat wisdom as the highest form of knowledge and judgment about human excellence involving the meaning and conduct of life. Specifically, we define wisdom as "an expertise in the fundamental pragmatics of life permitting exceptional insight and judgment involving complex and uncertain matters of the human condition including its developmental and contextual variability, plasticity, and limitations." Operationally, this definition corresponds to a family of five criteria, factual knowledge, procedural knowledge, contextualism, value relativism, and uncertainty. Clearly, advances along these dimensions require the joint operation of cognitive, motivational, and emotional factors.

Thus far, our main methodological strategy in investigating wisdom as an expertise in the fundamental pragmatics of life has been to ask persons to think aloud about difficult life problems such as, "Imagine a 14-year-old girl who wants to leave home and get married, what should one think about this?" The think-aloud responses to such or similar life problems are then evaluated on the five wisdom-related criteria by a trained rater panel. Figure 11.12 displays the results of one of these studies (P. B. Baltes, Staudinger, Maercker, & Smith, 1995). In the figure, an overall wisdom score

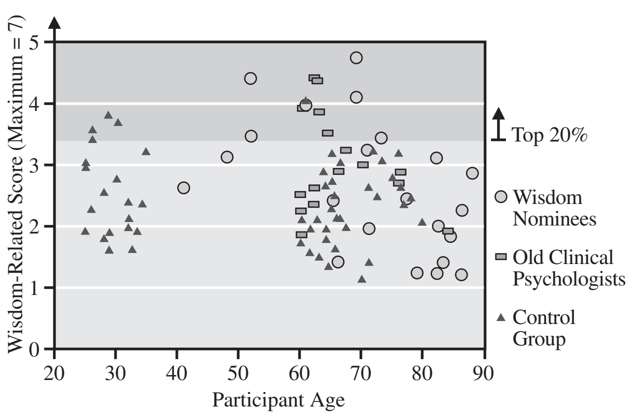

Figure 11.12 Wisdom-related performance of four different groups of individuals averaged across two wisdom-related tasks and five evaluative criteria (factual knowledge, procedural knowledge, contextualism, relativism, and uncertainty). There were no age differences in the age range from 25 to 80 years. In addition, wisdom nominees and clinical psychologists provided significantly more high-level (top 20%) performances than the old control group. Max. = maximum. *Source:* From "People Nominated as Wise: A Comparative Study of Wisdom-Related Knowledge," by P. B. Baltes, U. M. Staudinger, A. Maercker, and J. Smith, 1995, *Psychology and Aging, 10,* pp. 155–166.

based on all five criteria is plotted against age for four different groups: Wisdom nominees (i.e., distinguished individuals nominated as being wise in a two-step Delphi technique), experienced clinical psychologists, and two control groups involving adults with comparable advanced levels of education (young and old).

Two findings are noteworthy. First, there was no indication of a negative age trend in wisdom-related performance when comparing adults of about 25 to 75 years of age. This finding has been replicated in five other studies (Staudinger, 1999a). Second, older persons with wisdom-facilitative experiences (e.g., older clinical psychologists and wisdom nominees) contributed a disproportionately large share to the top responses (see also J. Smith, Staudinger, & Baltes, 1994; Staudinger, Smith, & Baltes, 1992). Both findings stand in clear contrast to the negative age gradients observed for the cognitive mechanics (see Figure 11.10, both panels), thereby providing further support for the two-component model.

The findings also underscore that living long (age) in itself is not a sufficient condition for the development of wisdom (or for any other form of expertise). Rather, as suggested by our working model of wisdom ontogeny (see Figure 11.13), it appears that favorable macrostructural contexts (e.g., historical period), expertise-specific factors (e.g., experience and training in the fundamental pragmatics of life, strive for excellence, mentorship), and general person factors (e.g., fluid mechanics, cognitive style, openness to experience) need to work in coalition to move people toward wisdom (e.g., Staudinger, 1999b). Some of these wisdom-facilitative factors, such as generativity, are age-associated; however, there are also wisdom-debilitating influences, such as rigidity and decrease in the cognitive mechanics, that might come with age. On average, the net result of age-related facilitators and debilitators seems to equal out. Only under favorable conditions, facilitators outweigh debilitators and permit increase of wisdom-related performance with age.

The theoretical framework of our work on wisdom, and its close connection with dimensions of personality and emotionality, has been supported by a variety of findings (P. B. Baltes & Kunzmann, 2004; P. B. Baltes & Staudinger, 2000; Kunzmann & Baltes, 2003b). For instance, in adulthood, personality and cognitive style measures are more important predictors of wisdom-related performance than traditional measures of intelligence (Staudinger, Lopez, & Baltes, 1997; Staudinger,

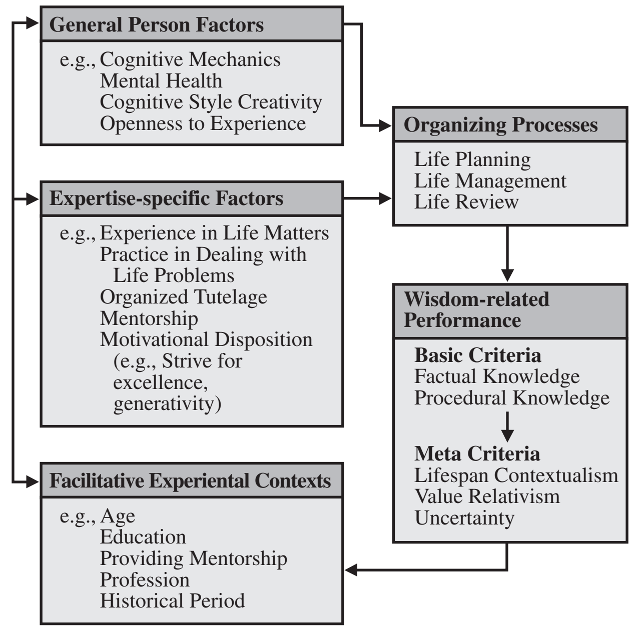

Figure 11.13 A research framework describing antecedent factors and mediating processes for the acquisition and maintenance of wisdom-related knowledge and skills across the life span. The likelihood of attaining expert levels of performance in this prototypical domain of the cognitive pragmatics is assumed to depend on an effective coalition of experiential, expertise-specific, and general person-related factors (modified after Baltes & Smith, 1990; Baltes & Staudinger, 2000). Adapted from "The Psychology of Wisdom and Its Ontogenesis" (pp. 87–120), by P. B. Baltes and J. Smith, 1990, in *Wisdom: Its Nature, Origins, and Development,* R. J. Sternberg (Ed.), New York: Cambridge University Press; and "Wisdom: A Metaheuristic to Orchestrate Mind and Virtue Towards Excellence," by P. B. Baltes and U. M. Staudinger, 2000, *American Psychologist, 55,* pp. 122–136.

Maciel, Smith, & Baltes, 1998). In contrast, intelligence is a more salient predictor in adolescence, when intellectual prerequisites for wisdom-related characteristics such as the abilities to self-reflect and decenter are undergoing rapid developmental advances (Pasupathi, Staudinger, & Baltes, 2001). To embed wisdom into a more holistic context involving personality and the self, we also examined the correlation between wisdom-related knowledge and virtue-related outcomes such as prosocial values and interpersonal conflict-resolution styles (Kunzmann & Baltes, 2003b; see also Sternberg, 1998). People high on wisdom-related knowledge exhibited a more complex and modulated structure of emotions and preferred conflict resolution strategies that are based on dialogue rather than power. Of special interest is that high wisdom-related knowledge correlates negatively with the search for personal enjoyment and material happiness.

In addition to illustrating how the pragmatics of cognition are intertwined with other sectors of human development, our research on wisdom also illustrates how culture and culture-based activities shape development during adulthood. During normal adulthood, the biology of the body and brain is sufficiently developed and ready for investment. It is culture-based learning and development that defines the agenda (see also P. B. Baltes, Freund, & Li, in press; Lachman, 2001). In this sense, work on wisdom serves to highlight the *relative independence of the pragmatics of cognition vis à vis the biology-based mechanics.* Within the normal range of adult mechanic functioning, the mechanics' contribution to individual differences on wisdom-related tasks is small, both in absolute terms and relative to other factors such as personality and task-relevant life experience. The most important contributors to wisdom-related performance during the adult life span tend to be personality characteristics as measured by the Neuroticism Extraversion Openness Questionnaire (NEO) as well as wisdom-relevant professional training and the nature of lifetime experience, rather than psychometrically assessed intelligence or chronological age. In very old age, however, the mechanics of cognition again appear to delimit wisdom-related performance if they fall below a critical threshold of functional integrity (P. B. Baltes et al., 1995).

Varieties of Mechanic/Pragmatic Interdependence

As has become clear by now, the mechanics and pragmatics of life span intellectual development are intertwined in many ways and at various levels of analysis (cf. Charness, in press; Salthouse, 2003), both among each other and with other aspects of behavior. Phylogenetically, they are connected in the sense that members of the human species are biologically predisposed to acquire cultural knowledge (e.g., Plessner, 1965; Wellman, 2003). Ontogenetically, the interdependence also runs both ways. For instance, the potential to acquire and use pragmatic knowledge is conditioned by the development of the mechanics. At the same time, mechanics alone are of little use for problem solving in highly specialized domains of knowledge; in many cases, domain-specific knowledge is critical (Gobet et al., 2001).

In the following discussion, we further elucidate different facets of this interdependence. This approach is in line with the view of biocultural co-construction (P. B. Baltes et al., 2006; S.-C. Li, 2003) mentioned earlier. We then argue, with respect to the overall landscape of life span development, or the ontogenetic dynamics of gains and losses, that the mechanic-pragmatic interdependence converges on the notion of a *compensatory relation between mechanic efficiency and pragmatic knowledge.* As SOC theory suggests, this compensatory relation is reciprocal and part of the entire life course. However, we submit that the role of compensation increases in importance and culminates in old age.

The Mechanic-Pragmatic Interdependence: Evidence at the Cortical Level

An early neurocognitive demonstration for the interdependence between mechanic and pragmatic development concerns the increased cortical representation of the left hand in players of string instruments (Elbert, Pantev, Wienbruch, Rockstroh, & Taub, 1995; for other examples, see Draganski et al., 2004; Petersson & Reis, in press). Compared to normal individuals, areas of the somatosensory cortex representing the fingers of the left hand occupy more space in string players. Most likely, this increase in cortical representation has been induced by large amounts of goal-directed and deliberate practice (cf. Ericsson, Krampe, & Tesch-Römer, 1993). In line with the notion of a bio-culturally co-constructed brain (P. B. Baltes et al., in press; S.-C. Li & Lindenberger, 2002), this research finding illustrates the potential of individuals to acquire and represent pragmatic knowledge.

Elbert et al. (1995) also provided evidence in support of age-graded differences in cortical plasticity. Specifically, the brain's physiological aptness to provide more cortical space for the fingers of the left hand was found to depend on the chronological age at inception of musical practice. As this example illustrates, the ability to acquire pragmatic knowledge (e.g., the potential for developmental change in the pragmatic component) is conditioned by the age-graded status of the mechanics (Güntürkün, in press; Kempermann, in press).

The Age of Peak Performance in Complex Skills

The mechanics of cognition not only condition the acquisition but also the expression of pragmatic knowledge, especially at high levels of performance (Bosman & Charness, 1996; Hambrick & Engle, 2002; Molander & Bäckman, 1993). A good example is the difference in peak age for tournament versus correspondence chess (Charness, in press). The mean age at which a world championship is first won is about 46 years of age for correspondence chess, but about 30 years of age for tournament chess. In correspondence chess, players are permitted 3 days to deliberate a move; in tournament chess, deliberation averages three minutes per move. Thus, the difference in peak age between the two activities seems to reflect differences in the relative importance of cognitive/perceptual speed and knowledge (e.g., Burns, 2004).

This example points to a general dilemma governing the relation between the mechanics, the pragmatics, and age/time. The acquisition of expertise takes time. For instance, Simon and Chase (1973) argued that 10 years of deliberate practice are needed to reach excellence in a particular domain of functioning. For this reason alone, experts tend to be older than novices (cf. Lehman, 1953). On the other hand, decrements in certain aspects of the mechanics, such as perceptual speed, can be reliably identified by age 30 (S.-C. Li, Lindenberger, et al., 2004; Salthouse, 1991). Therefore, differences in peak age across domains can be seen as ontogenetic compromises between biology and culture, and are probably good indicators of the relative importance of pragmatic knowledge and mechanic processing efficiency.

An exclusive focus on ages of peak productivity or peak achievement would hide essential and unique features of late-life intellectual growth. For instance, some exceptional individuals seem to escape mechanic decline well into the 9th decade of their lives. If these individuals also happen to be experts in a particular domain, they can produce outstanding works throughout their life. One example would be Sophocles (497–406 B.C.), who won his first prize for the best drama of the year at age 28, wrote over 120 dramas, and developed a new dramatic style in his 80s. Commenting on his own late-life artistic development, Sophocles said that he finally had liberated himself from the artificiality of his earlier style, and had found a language that was the best and the most ethical (Schadewaldt, 1975, p. 75; for related evidence on classical composers, see Simonton, 1988, 1989).

A Third Prototypical Example: Speed and Knowledge in Aging Typists

A good empirical demonstration of the gain/loss dynamic between the cognitive mechanics and the cognitive pragmatics comes from a study on aging typists using the so-called molar equivalence/molecular decomposition approach (Salthouse, 1984). In this paradigm, adults of different ages are equated in general (e.g., molar) task proficiency to investigate whether equal levels of criterion performance are attained through age-differential profiles of "molecular" component processes (Charness, 1989). Thus, age differences at the molecular level of analysis are seen as a reflection of age-based changes in the relative contribution of knowledge and basic processing efficiency to criterion performance.

Salthouse (1984) studied a total of 74 transcription typists ranging from 19 to 72 years of age. Figure 11.14 displays an interpretation of the main findings of this study in terms of the two-component model. In this sample, age and level of typing skill (i.e., net words per minute) were uncorrelated (e.g., molar equivalence). Age was negatively related to measures of perceptual/motor speed (e.g., tapping speed), but positively related to eye-hand span. In other words, older typists were slower in tapping speed but looked further ahead in the text to be typed. These findings are consistent with the interpretation that aging typists extend their eye-hand span to counteract the consequences of aging losses in perceptual/motor speed, and illustrate the compensatory relationship between knowledge and speed.

To the extent that selective attrition does not play a prominent role, the performance pattern of older typists may, in part, reflect *loss-induced development,* or compensation in the strict sense of the term (P. B. Baltes & Baltes, 1990b; Dixon & Bäckman, 1995; Salthouse, 1995). With respect to methods, this example

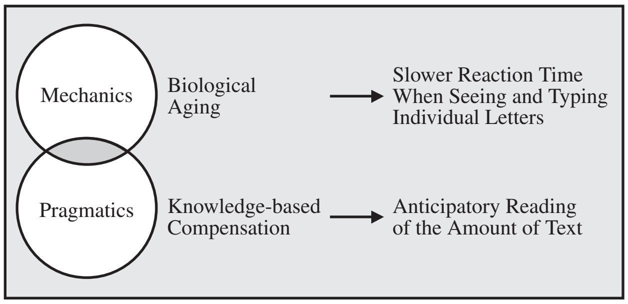

Figure 11.14 Older typists can maintain a high level of functioning by reading farther ahead in the text to be typed, despite a loss in reaction time when typing individual letters. The example illustrates the compensatory relationship between the pragmatics and the mechanics of cognition and suggests that selective optimization with compensation may play an important role in successfully adapting to aging-induced losses in the mechanics of cognition. *Source:* From "Effects of Age and Skill in Typing," by T. A. Salthouse, 1984, *Journal of Experimental Psychology: General, 113,* pp. 345–371.

demonstrates how the combination of expertise and information-processing approaches may lead to a better understanding of the compensatory relation between acquired bodies of cultural knowledge and basic aspects of information processing efficiency (cf. Abraham & Hansson, 1995; Lang et al., 2002).

Malleability (Plasticity) in Intellectual Functioning across Historical and Ontogenetic Time

As is true for development in general, life span changes in intellectual functioning represent the overdetermined antecedents, correlates, and outcomes of a large variety of different sources of influence (e.g., mechanics, pragmatics, motivation, personality, societal opportunity structures). Therefore, differences in level of intellectual performance reflect, within the age-graded boundaries provided by the mechanics, variations in physical and sociocultural aspects of environmental conditions (P. B. Baltes et al., in press; Klix, 1993). In the following, we report two interrelated lines of research in support of this contention. The first line of research addresses environmental change at a large (i.e., historical) time scale. The second example refers to the malleability of adult-intellectual functioning in the context of cognitive intervention studies.

Cohort Effects, Period Effects, and Environmental Change

As expected on the basis of life span contextualism, ontogenetic processes unfold in a constantly changing social and cultural environment. As a consequence, age gradients in intellectual abilities are not fixed but reflect history-graded systems of influence, such as enduring differences between individuals born at different points in historical time (cohort effects), specific influences of historical events across chronological age (period effects), or generalized and enduring shifts in the environment affecting individuals of all ages and subsequent cohorts (general environmental change). For methodological reasons, discriminating among these varieties of environmental change is not easy (P. B. Baltes, 1968; P. B. Baltes et al., 1979; Lövdén, Ghisletta, & Lindenberger, 2004; Magnusson et al., 1991; Schaie, 1965, 1994, 2005).

A first step to discern effects of large-scale environmental change is to compare the performance of same-aged individuals across historical time (i.e., time-lagged comparisons). With some exceptions (e.g., number ability; cf. Schaie, 1989; Schaie et al., 2005), the general picture resulting from such comparisons is that higher test scores are obtained at more recent times (Flynn, 1987; Schaie, 1996). Probably, this historical increase in test scores across historical time is not due to changes in the genetic composition of the population or differential sampling bias, but reflects some general change (i.e., improvement) in health- and education-related conditions. The magnitude of these effects can be quite large. For the U.S. population during the twentieth century, for instance, they sometimes exceeded a standard deviation within a 30-year range of historical change (Schaie, 1996). It should be cautioned, however, that we do not know whether environmental-change effects of the same order of magnitude would be observed with pure indicators of the mechanics of intelligence. For instance, much of the measures used in the battery of the Seattle Longitudinal Study (Schaie, 1996) have a strong cultural-knowledge component, and are more likely to be affected by historical change and dissipation than other, less knowledge-loaded measures of brain efficiency. With respect to the Seattle Longitudinal study (Schaie, 1996), the convergence between cross-sectional and independent-sample same-cohort comparisons suggests that the more positive age gradients found with longitudinal samples may be partly due to practice effects and selective attrition (see also Salthouse, 1991). Analyses of longitudinal data from the Berlin Aging Study (BASE) are fully consistent with both predictions (Lindenberger, Singer, & Baltes, 2002; Lövdén, Ghisletta, & Lindenberger, 2004; T. Singer, Verhaeghen, et al., 2003).

Theoretically, the direction and precise magnitude of historical-change effects is generally of little importance. From a history-of-science point of view, however, such effects, and especially their interpretation as culture-based cohort effects, were instrumental in pointing to the substantial malleability (plasticity) of intellectual performance during all periods of the adult life span (P. B. Baltes, 1973). The resulting growth in awareness for the existence of life span plasticity eventually led to advances in life span theorizing, and to more controlled investigations into the range of intellectual plasticity and its age-based limits (P. B. Baltes & Kliegl, 1992; P. B. Baltes & Lindenberger, 1988; P. B. Baltes & Willis, 1982; T. Singer, Lindenberger, & Baltes, 2003; Willis, 1990). Specifically, multidirectional cohort differences in intellectual trajectories may entice interdisciplinary collaboration with medicine and nutritional sciences, educational neuroscience, and sociology to understand their proximal antecedents and consequences (Schaie et al., 2005).

Cognitive Intervention Work: Activation of Learning Potential among Older Adults

Intervention work (P. B. Baltes & Willis, 1982; Kramer & Willis, 2002; Willis, 2001) is a more direct (i.e., experimentally controlled) way to explore the degree of plasticity in intellectual functioning than cohort-comparative research. In the field of adult development and aging, intervention studies have been undertaken to examine whether age-based decrements in standard psychometric tests of intellectual functioning are reversible, in full or in part, through training and practice (Willis & Nesselroade, 1990). For the most part, interventions involved older adults only, and focused on tests from the broad fluid domain.

The major results of this cognitive intervention work can be summarized in five points (e.g., P. B. Baltes & Lindenberger, 1988; Kramer & Willis, 2002): (1) Training gains in the practiced tests among healthy older adults are substantial (i.e., they roughly correspond to the amount of naturally occurring longitudinal decline between 60 and 80 years of age); (2) transfer, however, is limited to similar tests of the same ability; (3) training gains are maintained over lengthy periods of time up to several years (Neely & Bäckman, 1993; Willis & Nesselroade, 1990); (4) the factor structure of the ability space is not altered substantially through training (Schaie, Willis, Hertzog, & Schulenberg, 1987); and (5) in persons at risk for Alzheimer's disease or afflicted by other forms of brain pathology, training gains have been found to be restricted to experimental conditions of high external support (Bäckman, Josephsson, Herlitz, Stigsdotter, & Viitanen, 1991) or to be nonexistent (M. M. Baltes et al., 1995; M. M. Baltes, Kühl, & Sowarka, 1992).

These results indicate that the majority of healthy older adults, including those who display the typical pattern of age-related losses in the mechanics of cognition (e.g., fluid abilities) under untrained conditions, are able to greatly improve their performance after a few sessions of task-related training or practice. Thus, among healthy older adults, the mechanics of cognition are sufficiently preserved to permit the acquisition of task-relevant declarative and procedural knowledge. However, there is little evidence to suggest that training gains generalize to related abilities or to everyday functioning. Moreover, the results of testing-the-limits research presented above clearly indicate that the *amount* (scope) of plasticity decreases with advancing age, at least during adulthood. At limits of mechanic functioning, older adults definitely display less potential. To what degree such cognitive training in older adults changes the mechanics themselves is unclear but possible (Kempermann, 2006).

A related line of intervention research has found that aerobic fitness attenuates age-related decrements in cognitive control (e.g., multitasking) in later adulthood (Kramer et al., 1999). This finding can be explained in at least two ways. First, from the perspective of SOC theory, increasing bodily fitness may reduce older adults' needs to continuously invest portions of their cognitive resources into the coordination of their increasingly fallible sensory and motor functions (e.g., Lindenberger et al., 2000). In other words, training the sensamotor function required for bodily functioning "frees" up resources for other cognitive tasks. Second, recent brain-imaging evidence suggests that aerobic fitness has direct beneficial effects on prefrontal cortex functioning (Colcombe et al., 2003), which may enhance performance on cognitive tasks that put high demands on cognitive control. Clearly, the two explanations are not mutually exclusive.

Relative Stability in Intellectual Functioning across the Life Span

The issue of continuity and discontinuity, or stability and change, has a long tradition within developmental psychology at large (Kagan, 1980), and life span intellectual development, in particular (P. B. Baltes & Smith, 2003; Hertzog, 1985; Lövdén & Lindenberger, 2004; McArdle & Epstein, 1987; J. R. Nesselroade, 1991; Schaie, 1965). Different forms of stability, such as stability in level, rank order, and profiles, have been set apart (Caspi & Bem, 1990). The main emphasis of the following life span synopsis of intellectual development is on interindividual rank order, or on what Kagan (1980) has called relative stability, which denotes the extent to which individual differences during later periods of ontogeny can be predicted on the basis of individual differences observed during earlier periods.

In most cases, evidence on the relative stability after infancy is based on undifferentiated measures of general intelligence, or IQ tests. We agree with others that an exclusive focus on these omnibus measures hides essential features of life span intellectual development and the structure of intelligence (Cattell, 1971; Horn, 1989). Specifically, such measures can be seen as mixtures of mechanic and normative-pragmatic components of intellectual functioning that approximate, to varying degrees, the centroid of the intellectual ability factor space (i.e., Spearman's g). With this qualification in mind, we restrict the following discussion, with one exception (i.e., infant development), to undifferentiated or IQ-like measures of intellectual functioning.

Predicting Childhood Intelligence on the Basis of Infant Behavior

Until the 1950s, it was generally believed that intelligence was an immutable characteristic of the individual, which led to the unchallenged assumption that individuals maintain their rank order on measures of intellectual functioning throughout life. Starting in the 1960s, however, it was found that stability in early mental test performance was low (McCall, 1979). On the basis of this evidence, it was concluded that standardized tests of infant development do not predict later intelligence at useful levels of prediction until after 18 to 24 months of age. This majority view of ontogenetic instability of interindividual differences during infancy was again challenged and ultimately replaced by more recent research using habituation and recognition-memory paradigms. In contrast to standardized infant tests of sensorimotor capacities, these two paradigms were originally based on operant-conditioning and/or information-processing perspectives, and refer to infants' tendency to change their behaviors as a function of prior exposure to a stimulus (e.g., decrements in attention in the case of habituation, or novelty preference in the case of recognition memory). On average, individual differences in habituation and recognition memory performance between 2 and 8 *months* were found to be moderately correlated with standard tests of intelligence such as the Wechsler, Bayley, or Binet administered between 1 and 8 *years* (median correlation, $r = .45$; after attenuation for unreliability, $r = .70$; Bornstein, 1989; McCall & Carriger, 1993; for recent evidence, see F. Smith, Fagan, & Ulvund, 2002). A more recent meta-analysis has confirmed these results (Kavsek, 2004). Behavior-genetic research suggests that individual differences in at least some of the measures used for prediction have a genetic component (Benson, Cherny, Haith, & Fulker, 1993; Cardon & Fulker, 1991).

Both relative change *and* relative stability shape life span intellectual development from its very beginning. According to one interpretation (e.g., Bornstein, 1989), infants who habituate more efficiently, and who tend to look at the novel object, rather than the old, are better able to inhibit action tendencies associated with already existing representations (e.g., Diamond, 2002; McCall, 1994). The hypothesis that inhibition may mediate the predictive link is consistent with neuropsychological investigations of infants' recognition memory (e.g., Diamond, 2002; Johnson, Posner, & Rothbart, 1991). It also supports the more general claim that inhibition ability and novelty preference are central features of intelligence (Berg & Sternberg, 1985a).

Relative Interindividual Stability after Infancy

For reasons that are not yet well understood (Cardon & Fulker, 1991; McCall & Carriger, 1993), the magnitude of the correlation between infant measures of habituation (i.e., 2 to 8 months) and childhood measures of intelligence (i.e., 1 to 12 years) is temporally stable or even increasing (Cardon & Fulker, 1991), rather than decreasing over time. In contrast, relative stability after infancy is rather well described on the basis of quasi-simplex assumptions (Humphreys & Davey, 1988; Molenaar, Boomsma, & Dolan, 1991). Thus, adjacent time points in ontogeny tend to be more highly correlated than more distant time points In addition, stability coefficients computed over identical lapses of time show a considerable increase in magnitude from childhood to adolescence into middle adulthood and early old age (Hertzog & Schaie, 1986, 1988; Humphreys & Davey, 1988; for review, see Lövdén & Lindenberger, 2004).

In agreement with others (e.g., Humphreys & Davey, 1988; Molenaar, Boomsma, & Dolan, 1993), we propose that these *age-based changes in relative interindividual stability should be interpreted in connection with age-based changes in level* (e.g., Lövdén & Lindenberger, 2004). According to this line of reasoning, interindividual differences change more rapidly early in development because the intellectual repertoire is smaller but growing faster than at later points during ontogeny, thereby giving room for larger amounts of new variance per unit time (both environmental and genetic). By the same token, aging-induced losses and age-associated pathologies (e.g., Alzheimer's disease) may not only lead to decrements in level but also to a reshuffling of individual differences in very old age (Mitrushina & Satz, 1991; cf. P. B. Baltes & Smith, 2004).

Changes in Heritability across the Life Span

We now turn to the study of age-based changes in the contribution of genetic and environmental sources of interindividual variability to individual differences in intelligence. We start with a consideration of general and ability-specific effects, and then turn our attention to life span changes in heritability estimates for general (i.e., undifferentiated) measures of intelligence across the life span.

A Note on the Nature of Behavior-Genetic Evidence

Before we summarize the relevant evidence, we will sketch out our views on the meaning, strength, and limitations of the behavior-genetics approach (P. B. Baltes et al., 1988). Given the critical debates surrounding the interpretation of behavior-genetic data (e.g., Bronfenbrenner & Ceci, 1994; Gottlieb et al., Chapter 5, this *Handbook,* this volume; R. M. Lerner, 1995; Molenaar et al., 2003; Scarr, 1993), such a note may help to avoid possible misunderstandings. We restrict our comment to three points that are relevant both for the following section on intellectual functioning as well as on personality and the self. More detailed treatment is provided in P. B. Baltes et al. (1998).

First, heritability coefficients in human research (where selective inbreeding and exposure to extreme environments is limited) are statements about the scope of interindividual differences more so than statements about the processes and mechanisms of genetic expression at the individual and intraindividual level of analysis. In other words, population-based behavior genetics provides clues about the existence of genetically based variation in a given population but does not provide direct evidence about gene locations or epigenetic events producing this variation (for emerging links between behavior and molecular genetics, for example, Dick & Rose, 2002; de Geus & Boomsma, 2002).

Second, standard behavior-genetic models do not provide the best test of the overall role of environmental forces. The power of such forces is better tested by studies that examine the role of the impact of environmental factors across the population and across interindividual differences in genetic make-up. Specifically, high heritability estimates do not preclude the existence of environmental factors that alter performance levels in all individuals of a given sample (for an experimental demonstration, see Fox, Hershberger, & Bouchard, 1996).

Third, heritability estimates are fixed-level statistics (P. B. Baltes et al., 1988; Plomin & Thompson, 1988), indicating what consequences (phenotypic expressions) are produced under a given and specific set of interindividual differences in genetic and environmental conditions. Strong evidence demonstrating the environmental malleability of heritability estimates comes from data on 7-year-old twins participating in the National Collaborative Perinatal Project (Turkheimer, Haley, Waldron, D'Onofrio, & Gottesman, 2003). A substantial proportion of the twins in this sample were raised in families living near or below the poverty level. The authors found that the proportions of IQ variance attributable to genes and environment varied nonlinearly with socioeconomic status. In impoverished families, the shared environment accounted for 60% of the variance in IQ, and the contribution of genes was close to zero. In affluent families, the result was almost exactly the reverse. Apparently, factors associated with low socioeconomic status such as deprivation from developmental opportunity structures hindered the behavioral expression of genetically based interindividual differences in intellectual functioning.

Despite these qualifications, behavior-genetic evidence provides important information about sources of interindividual differences in life span development, especially if linked to molecular research on specific genetic polymorphisms (Goldberg & Weinberger, 2004), to intermediate phenotypes at the level of brain organization (e.g., Anokhin et al., in press), or both. Such findings, especially if based on longitudinal (e.g., Finkel, Pedersen, McClearn, Plomin, & Berg, 1996), experimental (e.g., Fox et al., 1996), and cross-cultural (e.g., Turkheimer et al., 2003) data, provide *estimates* of the degree to which, on a population level of analysis, *interindividual differences in developmental outcomes* are co-determined by interindividual differences in genetic predispositions and extant environmental variations. Thus, everything else being equal, high heritability estimates of a given behavioral outcome suggest that *interindividual differences* in this behavioral outcome and in this "life space" are strongly genetically determined than *interindividual differences* in behavioral outcomes with low heritability estimates.

Genetic and Environmental Influence over Ontogenetic Time: Specific and General Effects

Numerous studies have shown that genetic and environmental influences can be operative in the regulation of individual differences at both ability-specific and more general levels (e.g., Cardon & Fulker, 1994). In longitudinal analyses of hierarchically organized intellectual abilities obtained from genetically informative data sets, it is possible to determine the genetic and environmental contributions to stability and change in rank order and mean level both at the level of specific abilities and at the level of a general factor (e.g., Cardon & Fulker, 1994). An interesting example for the class of findings that can be obtained with this method comes from child cognitive development. Specifically, data from the Colorado Adoption Project indicate that strong novel contributions of genetic variance at the level of general ability emerge at the ages of three and seven but seem to be absent during the transition from childhood to adolescence, when genetic variance contributes exclusively to continuity of individual differences.

Estimates of Heritability of Interindividual Differences across the Life Span

Similar to life span changes in stability, heritability in intellectual functioning (e.g., the amount of interindividual variance attributable to genetic differences) increases from about 20% to 50% during childhood and adolescence to about 80% in early and middle adulthood (e.g., McGue, Bouchard, Iacono, & Lykken, 1993). Interestingly, in old age (e.g., beyond age 75), heritability tends to decrease to values around 60% (e.g., McClearn et al., 1997). In contrast, shared environmental influences on interindividual differences generally do not persist beyond the period of common rearing (McGue, Bouchard, et al., 1993). As stated before, these findings are based on samples representing the normal range of environments and genes, and cannot be generalized beyond this normal range (e.g., to extremes of environmental deprivation or reshuffled environments). Within this normal range, however, the life span increase in heritability of interindividual differences is consistent with the notion that adolescents and adults have more of a chance to actively select environments that match their genes than infants and children (Scarr & McCartney, 1983).

Based on the preceding summaries, it appears that relative stability and heritability exhibit similar life span age gradients (see Plomin & Thompson, 1988). More multivariate and longitudinal behavior-genetic evidence is needed to fully understand the covariance dynamics of this life span parallelism. One possibility would be that individual differences in intellectual functioning around middle adulthood are highly stable because the genetic variance component has stabilized at a high level (e.g., not much new genetic variance is added over time), and because environments (which, in part, have been selected on the basis of genetic endowment) also tend to be stable during this period of the life span. Similarly, the breakdown of well-orchestrated genome expression in very old age may cause late-life decrements in level, relative stability, and heritability. Note, however, that selective mortality may counteract the identification of these trends at the population level in very old age (T. Singer, Verhaeghen, et al., 2003).

The Mechanics and Pragmatics in Very Old Age

So far, our discussion of life span intellectual development was organized around topics, rather than age periods. In this last section, we deviate from this practice by giving special attention to the life period of very old age. In our view, this last phase of life merits such attention because it represents a natural boundary condition for the validity of the two-component model of intelligence and cognition. Specifically, we expect that an increasing portion of the very old population eventually attains levels of mechanic functioning that are sufficiently low to impair intellectual functioning in a relatively global manner. A number of recent empirical cross-sectional and longitudinal observations from the BASE (P. B. Baltes & Mayer, 1999; P. B. Baltes, Mayer, Helmchen, & Steinhagen-Thiessen, 1993) support and qualify this prediction (for a detailed summary, see Lövdén et al., 2004). Three results from this very old sample are most pertinent to the two-component model (P. B. Baltes & Lindenberger, 1997; Lindenberger & Baltes, 1995a).

Covariance Dedifferentiation

First, ability intercorrelations both between and within fluid-mechanic and normative-pragmatic domains were of much higher magnitude in old age than corresponding ability intercorrelations during middle and early adulthood. Based on these data, the amount of covariation among interindividual differences in intellectual abilities, or the prominence of *g,* seems to increase in very old age (P. B. Baltes & Lindenberger, 1997). The idea that *g* may vary as a function of age and/or ability level dates back to Spearman (Deary & Pagliari, 1991), and has led to the differentiation/dedifferentiation hypothesis of life span intelligence (Garrett, 1946; Lienert &

Crott, 1964; Reinert, 1970). Despite methodological difficulties in testing this hypothesis (J. R. Nesselroade & Thompson, 1995), the evidence obtained so far seems generally supportive (for a summary, see Lövdén & Lindenberger, 2004). For instance, Li, Lindenberger, et al. (2004) performed life span-comparative exploratory principal component analyses of fifteen intellectual ability tests. The results of these analyses are shown in the lower panel of Figure 11.10. In childhood, late adulthood, and old age, only two components with eigenvalues greater one were extracted, but in adolescence, young, and middle adulthood, five components displayed eigenvalues greater than unity. Also, fluid and crystallized intelligence were more highly correlated in childhood, late adulthood, and old age than in adolescence, young, and middle adulthood.

From the perspective of the two-component model of cognitive development, the decrease of ability intercorrelations during childhood and the increase of intercorrelations in very old age point to age-based changes (i.e., decrements and increments) in the importance of domain-general processing constraints. Cross-sectional data from the BASE (P. B. Baltes & Lindenberger, 1997; Lindenberger & Baltes, 1994) suggest that old-age dedifferentiation transcends the cognitive domain, and also affects sensory functioning (e.g., Ghisletta & Lindenberger, 2005) and sensorimotor functioning (e.g., balance/gait). In line with these correlational findings, recent neurocognitive evidence demonstrates that processing pathways and brain activation patterns are less differentiated in older adults than in young adults (Cabeza et al., 2004; Park et al., 2004).

Directionality Dedifferentiation

The second finding from the BASE concerns the directionality of the age gradients (Lindenberger & Baltes, 1997). In very old age, differences in the directionality of cross-sectional age gradients between mechanic and normative-pragmatic abilities are on the wane. Instead, gradations of negativity have been observed, with perceptual speed showing the strongest and verbal knowledge the weakest negative age relations.

These cross-sectional observations have been corroborated and qualified by longitudinal evidence (T. Singer, Verhaeghen, et al., 2003). Using latent growth curve modeling (see McArdle, Hamagami, Ellias, & Robbins, 1991), T. Singer, Verhaeghen, et al. (2003) compared cross-sectional and longitudinal age gradients under three different data selection conditions: (1) the cross-sectional/longitudinal convergence age gradients for the T4 longitudinal sample ($n = 132$) using all available data points (i.e., T1, T3, and T4 data); these gradients combine cross-sectional and longitudinal information over chronological age (hence convergence); (2) the cross-sectional T1 gradient of the T4 longitudinal sample (i.e., the same sample as before; $n = 132$); here, the T1 cross-sectional age gradient was examined for individuals who survived and participated up to T4; and (3) the cross-sectional T1 gradient of the original T1 sample ($n = 516$). The three age gradients are shown in Figure 11.15.

With respect to both fluid mechanics and crystallized pragmatics, age-associated decrements in cognition were less pronounced for the longitudinal sample at T1 than for the full cross-sectional sample at T1. Specifically, negative gradients prevailed for all four abilities in the full T1 sample but verbal knowledge did not decline significantly in the longitudinal sample. This pattern of age gradients suggests that decline in the fluid mechanics is normative and age-based, whereas decline in verbal knowledge appears to be partially or primarily associated with closeness to death. The third class of age gradients, the longitudinal convergence gradients for the T4 sample, reinforces this impression.

Maintenance of Divergence in Explanatory Correlational Patterns

Given the two preceding findings, one may begin to wonder whether the distinction between the mechanics and the pragmatics of cognition loses all of its empirical foundation in very old age. Figure 11.16 that compares the correlational patterns of perceptual speed, a fluid-mechanic ability, and verbal knowledge, a normative-pragmatic marker, with variables related to individual differences in sociostructural-biographical or biological status suggests that this is not the case.

Without exception, correlations to indicators of biological functioning were more pronounced for perceptual speed (e.g., the mechanics) than for verbal knowledge (e.g., the pragmatics). The reverse was also true: Correlations to sociostructural-biographical markers were more pronounced for verbal knowledge than for perceptual speed. Apparently, then, the mechanic-pragmatic distinction does not dissolve completely in very old age, but is maintained in the guise of divergent relations to biological and cultural systems of influence.

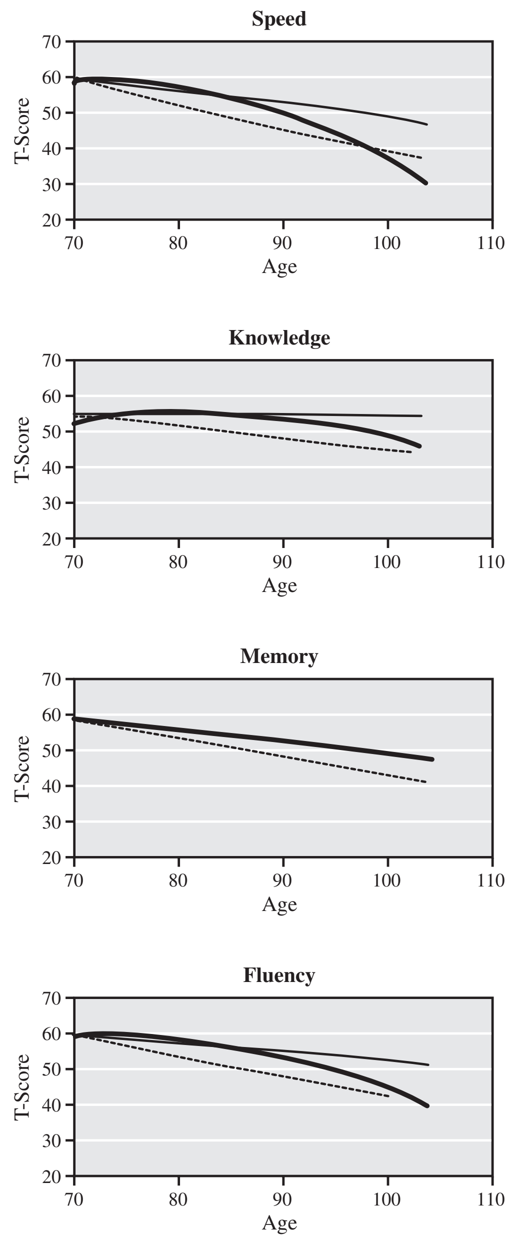

Figure 11.15 Intellectual ability age gradients observed in the Berlin Aging Study as a function of sample and measurement occasion. Thick solid lines represent cross-sectional/longitudinal convergence gradients of the longitudinal sample ($n = 132$), and encompass measurements from T1, T3, and T4, which encompass an average longitudinal observation period of 6 years. Thin solid lines represent cross-sectional gradients of the same longitudinal sample ($n = 132$), and are based on measurements taken at T1. Finally, dashed lines represent cross-sectional gradients for the total T1 sample ($n = 516$). *Source:* From "The Fate of Cognition in Very Old Age: Six-Year Longitudinal Findings in the Berlin Aging Study," by T. Singer, P. Verhaeghen, P. Ghisletta, U. Lindenberger, and P. B. Baltes, 2003, *Psychology and Aging, 18,* pp. 318–331. Copyright © 2003 by the American Psychological Association. Adapted with permission.

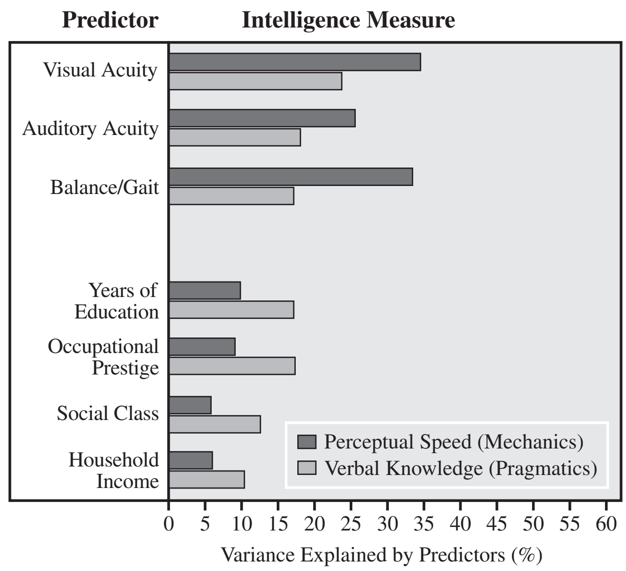

Figure 11.16 The divergent validity of the two-component model of life span intellectual development continues into very old age. The figure displays differential correlational links of perceptual speed, a marker of the fluid mechanics, and verbal knowledge, a marker of the crystallized pragmatics, to indicators of sociostructural-biographical and biological (e.g., sensory) status. Perceptual speed was more highly correlated with biological indicators than verbal knowledge, and verbal knowledge was more highly correlated with sociostructural-biographical indicators than perceptual speed. Thus, despite a general tendency toward dedifferentiation due to age-based losses in the mechanics, the two components of life span cognition continue to show signs of divergent external validity. Data are taken from the Berlin Aging Study ($N = 516$, *age range* $= 70$–103 years). *Source:* From "The Fate of Congition in Very Old Age: Six-Year Longitudinal Findings in the Berlin Aging Study," by T. Singer, P. Verhaeghen, P. Ghisletta, U. Lindenberger, and P. B. Baltes, 2003, *Psychology and Aging, 18,* pp. 318–331.

LIFE SPAN INTELLECTUAL DEVELOPMENT: CONCLUSIONS

Based on the foregoing (admittedly selective) review of research and theory, we would like to propose the following synopsis of the overall ontogenetic landscape of life span intellectual development.

1. To capture the life span dynamics and biocultural co-construction between biology and culture in the domains of intelligence and cognition (P. B. Baltes, 1987, 1997; P. B. Baltes et al., 1998), we contrasted the mechanics with the pragmatics, and propose a two-component model of intellectual development. This model is inspired by the psychometric theory of fluid and crystallized intelligence (Cattell, 1971; Horn, 1970, 1989; cf. Tetens, 1777) but calls for a wider range of conceptualization, including evolutionary-psychological, cognitive-experimental, expertise, and neuroscience approaches, to arrive at more valid and comprehensive representations of life span intellectual development. The two-component model accurately predicts a relatively late life span peak followed by maintenance for the knowledge-saturated cognitive pragmatics, and a much earlier life span peak followed by monotonic decline for the cognitive mechanics. It also accurately predicts differential ontogenetic sources of explanation.

2. In terms of mechanisms, age-related changes in information processing rate, working memory capacity, and the inhibition of irrelevant information are among the most prominent candidates for the explanation of life span changes in the mechanics of cognition. At present, these constructs tend to suffer from a lack of formalization, a lack of direct evidence at the physiological level, and from difficulties in making differential predictions. Closer links to the cognitive neurosciences, in particular to chemical, anatomical, and functional life span changes in prefrontal functions, are expected to foster further progress in this area of research.

3. Extant measures of mechanic functioning tend to be contaminated by pragmatic influences. To arrive at more accurate descriptions of life span gradients in the mechanics of cognition, and to move toward explanation in terms of critical components and mechanisms, measurement needs to be purified through the utilization of methods that are better able to assess individuals' upper limits of functioning. As predicted by theory, the use of such methods (e.g., testing-the-limits) results in cleaner separations of individuals from different ages than the use of standard measures (see Figure 11.9).

4. In contrast to the mechanics, the knowledge- and culture-based pragmatics of cognition offer the potential for positive change during adulthood and old age. Within the pragmatic domain, we proposed the distinction between normative and person-specific bodies of knowledge. Normative bodies of knowledge are acquired in the context of general socialization events, such as basic cultural skills and educational curricula, and in general are well amenable to psychometric testing (e.g., vocabulary tests, aptitude tests). Person-specific knowledge refers to specialized knowledge systems that branch off from the normative (average) path, with professional expertise being the most prominent example studied so far. Our suggestion is, and this is based on SOC theory, that highest levels of pragmatic skills in the last third of life carry a strong individualized component.

5. The acquisition of expert levels of knowledge during adulthood may lead to an increasing fragmentation of the intellectual system, but it also may offer the opportunity for acquiring bodies of knowledge with a wide range of applicability, generality, and integration. Wisdom-related knowledge, or knowledge about the meaning and conduct of life, is a prototype. The likelihood of acquiring such domain-general bodies of person-specific knowledge depends on a special coalition of experiential, expertise-specific, and person-related factors (Krampe & Baltes, 2003; Sternberg, 1985).

6. Throughout ontogeny, the pragmatics and mechanics of cognition are intertwined. In everyday life, intellectual functioning and intellectual products represent joint effects of both. For instance, the emergence of domains of pragmatic knowledge builds on, and presumably extends and modifies, evolutionarily predisposed core domains. The mechanisms of this pruning of cultural knowledge onto species-specific architecture await further study. Another example of pragmatic/mechanic interdependence concerns the acquisition and use of pragmatic knowledge to compensate for mechanic decline. In close agreement with our general conception of the overall landscape of life span development, this compensatory function of the pragmatics increases in importance but loses in efficiency with advancing age.

7. The study of plasticity (malleability) of intellectual functioning has been a cornerstone of life span research (P. B. Baltes, 1987). Within the limits provided by the mechanics, which remain to be fully explored, intellectual performance is malleable throughout life. Evidence in support of this contention comes both from the study of long-term environmental change and from cognitive intervention studies. With some exceptions (e.g., dementia of the Alzheimer type), there is room for sizeable plasticity at all ages and for all individuals. However, plasticity decreases with advancing age, reflecting losses in the mechanics of cognition. The resulting bounded openness of life span intellectual development is consistent with the biocultural contextualist framework of life span psychology.

8. The joint consideration of different strands of research reveals a striking congruence between three different life span trajectories: Heritability of interindividual differences, relative stability, and level changes in the normative pragmatics (e.g., crystallized intelligence). In all three cases, there is an increase from childhood to middle and late adulthood, coupled with indications of decline in very old age. This life span parallelism between the genetic component of interindividual differences, continuity of interindividual differences, and general knowledge is consistent with the notion of gene-environment correlations in behavioral genetics (Scarr & McCartney, 1983), and the notion of niche picking in ethology (Dawkins, 1982). Whether one likes it or not, this parallelism testifies to the existence of a powerful life span synergism between sociostructural and genetic interindividual differentiation, at least within the range of developmental conditions offered by Western industrialized societies.

SECOND LEVEL 5 EXAMPLE: THE STUDY OF PERSONALITY DEVELOPMENT ACROSS THE LIFE SPAN

In the following, we illustrate what life span theory has to offer in organizing and stimulating the study of personality development. To do so, we first introduce three approaches that in our view need to be taken into account when studying personality development: (1) a trait approach, (2) a self-system approach, and (3) a self-regulation approach.[1] These three approaches are usually treated in different literatures, and cross-links are still rare, especially with regard to life span development. In the following, we consider all three approaches whenever using the term personality or personality system.

The levels-of-analysis approach introduced in the beginning of the chapter is used as an integrating framework for presenting research from the three approaches. Thus, theory and evidence available on personality development across the life span are used to illustrate the biology-culture interface and the notion of differential allocation of resources. Furthermore, three of the life span propositions introduced earlier that bear special relevance for personality development across the life span are discussed in more detail. These three issues are stability and change in personality development across the life span, opportunities and constraints of personality development, and the adaptive potential or reserve capacity of personality.

Three Approaches to the Study of Personality Development

Research and theory building in the study of personality have been quite diverse (e.g., Pervin & John, 1999). Yet, three longstanding and overarching concerns can be identified, that is, structure/content, dynamics, and development of personality (Funder, 2001). Historically, these three concerns have been linked with the three approaches to the study of personality mentioned earlier (Staudinger, in press).

Under the *trait approach* to the study of personality, we subsume efforts to characterize individuals in terms of fundamental attributes and behavioral dispositions, a line of research that originated primarily in the psychometric tradition. Research in this area focuses on the identification of the structure of personality, on interindividual differences, and the extent of longitudinal stability (e.g., Costa & McCrae, 1994; Goldberg, 1993). The emergence, maintenance, and transformation of personality structure, and the conditions of constancy and change in interindividual differences clearly are of importance for a life span perspective on personality (Brim & Kagan, 1980). In addition, however, a life span perspective is aimed at discerning the degree to which these personality attributes and behavioral dispositions evince intraindividual change trajectories and intraindividual plasticity (malleability). Such questions are pursued in the exemplary research programs involving scholars such as Block (e.g., 1995), Helson (e.g., Helson & Kwan, 2000), or John Nesselroade (e.g., 2002).

Content and structure have also been of great interest in a *self-system approach* to the study of personality. But the self-system approach has also been very much interested in understanding the dynamics of personality (Markus & Wurf, 1987). Under the heading of the *self-system approach,* we subsume lines of work that characterize individuals as multifaceted dynamic structures of a relatively stable array of self-conceptions (e.g., Baumeister, 1992; Greenwald & Pratkanis, 1984;

[1] Note that selecting "personality" as the overarching term does not entail that we attribute greater importance to the trait approach. In the 1998 edition of the chapter, we had chosen "self and personality" as a label. This, however, seems impractical and is diverting from the goal to integrate the three approaches. Therefore, we would like to suggest using "personality" or "personality system" as the overarching term to denote the field of study comprising all three approaches. This is also in line with early personality theorists such as Allport or Murray who certainly did not link their usage of the term personality exclusively to the trait approach.

Markus & Wurf, 1987). Self-conceptions are not meant to encompass any self-referent attitude but rather are confined to those beliefs or cognitions that constitute important (fundamental) self-components. Whenever the social meaning of such self-referent attitudes is in the foreground, the notion of "identity" rather than self-concept is used (e.g., Waterman & Archer, 1990). Different situations or contexts activate different subsets of this composite structure of self-conceptions or self-schemata. Markus and Wurf (1987) have called this the working self-concept. This view of the self-system as both stable and dynamic fits life span conceptions that emphasize the potential for continuity as well as change as a characteristic feature of transactional adaptation during development.

In contrast to the trait approach to personality that aims at inferring behavioral dispositions "from the outside," research on self-conceptions is often (but not necessarily) related to what J. L. Singer (1984) has called the study of private experience or private personality, and Ryff (1984) has labeled as the study of personality "from the inside." Operationally, however, at least most of the adult research of both traditions, that is, the trait and the self-system approach, rely on self-report. Besides the classics such as Erikson (e.g., 1959) or Bühler (e.g., 1933), research programs around scholars such as Loevinger (e.g., 1976), D. J. Levinson (e.g., 1986), Ryff (e.g., 1991), Whitbourne (e.g., 1987), Dittmann-Kohli (e.g., Dittmann-Kohli, Bode, & Westerhof, 2001), Diehl (e.g., Diehl, Hastings, & Stanton, 2001), and Herzog and Markus (1999) focus on the life span development of the self-concept and of its adaptive qualities.

Focusing on personality dynamics or the processes underlying microgenetic personality change is yet a third approach, the study of self-regulatory processes (Carver & Scheier, 1998). Under the heading of *self-regulatory processes,* we subsume all efforts that are aimed at characterizing the organized abilities and skills a person brings to bear on monitoring behavior and experience. With regard to life span development, it is the regulatory behaviors of promoting growth as well as those of reaching, maintaining, and regaining psychological equilibrium including in a context of age-related loss—in particular one's sense of coherence, continuity, and purpose under conditions of microgenetic and ontogenetic change—that are of particular interest.

A host of constructs discussed in the literature can be subsumed under this heading, such as self-evaluative processes, goal-related processes, coping, control beliefs and self-efficacy, or emotion-regulation. The focus of such research is on investigating the self-related adaptive potential and the reserve capacities as well as their limits in the course of life span development. Because this field encompasses many different constructs, the group of scholars engaging in this type of endeavor is quite large and still growing. Thus, we can only mention a few laboratories in order to illustrate the type of work we include under the heading of self-regulatory processes from a life span perspective, such as the ones instigated by Brandtstädter (e.g., 1998; Brandtstädter & Rothermund, 2003; Greve & Wentura, 2003), Cantor (e.g., Cantor & Fleeson, 1994), Carstensen (e.g., Carstensen et al., 1999), Filipp (e.g., 1996), Labouvie-Vief, (e.g., Labouvie-Vief et al., 2003), Lachman (e.g., Lachman & Weaver, 1998), and Blanchard-Fields (e.g., 1996). Other examples are the theory of selective optimization with compensation (e.g., P. B. Baltes & Baltes, 1990a; Freund & Baltes, 2002b) and the related endeavor by Heckhausen and Schulz (1995) to construct a life span theory of self-based developmental control.

A number of recent efforts have been made to integrate these rather disconnected fields of research (e.g., Cloninger, 2003; Hooker, 2002; McAdams, 1996; McCrae et al., 2000). The life span focus in these integrative efforts clearly is on relating structure, content and process-related dynamics such that both stability and change characterize personality development during adulthood (e.g., Roberts & Caspi, 2003; Staudinger & Pasupathi, 2000). In the following section, we not only present relevant information, but also attempt to integrate the three approaches to the study of personality within a life span perspective. As we attempt this integration, a necessary by-product is that we may occasionally transform the foci that were at the core of the work of the original proponents.

Key Features of a Life Span Approach to the Study of Personality Development

We define personality to denote *the ways in which human beings behave/act, experience, believe, and feel with regard to themselves, others, and the material world.* With regard to the sources and outcomes of human development, personality has *multiple causes and functions* (cf. principles of multicausality and multifunctionality). First, personality develops, that is, it is the outcome of developmental processes. Different pathways can lead to similar if not the same outcome. Second, personality also operates as an antecedent for developmental processes and co-regulates outcomes. And finally, personality is the correlate of other developmental processes.

Taking a life span view implies (a) that we are concerned with the *commonalities* across individuals in how personality develops. This is reflected in developmental models like the one presented by Erikson (e.g., 1959) but also in theories about the driving forces and the mechanisms of personality development (e.g., Bandura, 1984; R. W. White, 1959). At the same time, as life span developmentalists we are interested in (b) the *interindividual differences* in personality development. For instance, do developmental trajectories become less and less similar as transactions between a given personality make-up and particular environmental conditions accumulate across the life span? Finally, we want to learn about (c) the *intraindividual variability or plasticity* in the ways an individual behaves/acts, experiences, believes, and feels about him/herself, others, and the material world. Is it possible, for example, that an extraverted person under certain circumstances behaves more like an introvert? In extreme cases this plasticity can also result in system lability and lack of coherence. Do these plasticity-related phenomena increase or decrease with age, or do they remain unchanged?

These three questions of commonalities, interindividual differences, and of intraindividual variability (plasticity) can be pursued within a *structural* and a *process-oriented* approach to the study of personality and its development. Under the heading of form or structure, it is primarily the classic personality dispositions and the self-conceptions, schemata, or images that are considered. Under the heading of process research, self-regulatory mechanisms are most prominent. At least five categories can be distinguished within that category: emotion regulation, control beliefs, coping, self-evaluation, and the goal system (goal seeking, goal pursuit, goal restructuring).

Finally, all three facets of structure, process, and function can be approached from a *componential* (multivariate) and a *holistic* (ipsative) view. The componential approach is illustrated by evidence on the Big Five personality factors (e.g., Costa & McCrae, 1994; Goldberg, 1993). Block's ipsative approach to personality assessment (e.g., Block, 1995) is an inspiring example of the holistic approach as is the conceptual and empirical work by Magnusson (e.g., Magnusson & Mahoney, 2003). Taking a typological approach to the study of personality development, for instance, by using cluster analysis can also be subsumed under that rubric (e.g., P. B. Baltes & Smith, 2003). Like Magnusson, John Nesselroade, and others, we suggest that life span work on personality development profits from integrating a componential and a holistic approach.

The Search for General-Purpose Mechanisms in the Area of Personality Development

Throughout this chapter, we have emphasized the significance in life span work of the search for the conditions of successful (adaptive) development. From the field of cognitive psychology, we have taken the idea of general-purpose mechanisms. Thus, we ask whether in the field of personality as well it is possible to articulate *general-purpose mechanisms.* With general-purpose mechanisms, we mean (internal and external) resources and capacities that individuals employ to master developmental challenges in a variety of contexts and at different stages of developmental time. General-purpose mechanisms in the field of personality might help the individual to organize and coordinate the ways in which he or she behaves, experiences, believes, and feels with regard to him/herself, others, and the material world such that the goal of maximizing gains and of minimizing losses is approached. In our own work, the theory of selective optimization with compensation (e.g., P. B. Baltes, 1997) is one such general-purpose mechanism; located at a high level of aggregation.

There seems to be a foundation of research on which to build when exploring the notion of general-purpose mechanisms. Empirical evidence, especially when focusing on longitudinal studies that search for predictors of adaptive developmental outcomes, has identified a number of candidate concepts. Impulse control or ego control, perceived control, delay of gratification and ego resilience/flexibility, for instance, suggest to us that they might possess the characteristics of such general-purpose mechanisms in the personality domain (e.g., Bandura, 1993; Block, 1993; Caspi, 1998; Masten, 2001; Mischel, Shoda, & Rodriguez, 1989; Rutter & Rutter, 1993; E. E. Werner, 1995). As is true in cognitive psychology, such general-purpose mechanisms will not function by themselves. Rather, they are part of a system of personality characteristics and self-regulatory mechanisms that are functional or adaptive only under specific circumstances.

One reason why we chose to explore the power of the notion of general-purpose mechanisms is the relative openness of human development (Maciel, Heckhausen, & Baltes, 1994). From a life span point of view, there is no single endpoint of development of any facet of self and personality. The challenge is to coordinate resources under varying conditions. Thus, there seems to be theoretical and empirical grounds for the assumption that personality functioning is efficacious if (a) many different ways of being are available (e.g., being internally as well as externally controlled, being optimistic as well as pessimistic, being introverted as well as extraverted) and if (b) adaptive algorithms that monitor the dialectic between such supposedly antagonistic states are accessible (e.g., Blanchard-Fields & Norris, 1994; Colvin & Block, 1994; Staudinger, 1999b). By means of such algorithms the most functional personality characteristic for a given time, place, and circumstance is exhibited. This restates in different terms what has been characterized as a wise person (e.g., Staudinger, 1999a; Sternberg, 1998). The approach is also similar to the notion of fluid intelligence in the domain of intellectual functioning (see previous discussion). It is a special characteristic of that category of the intellect that in the sense of a general-purpose mechanism it can be applied to (invested into) a large variety of cognition problems (Cattell, 1971).

The Executive Function of Personality

Life span theory further suggests a *systemic view* on psychological phenomena. This systemic view has at least two consequences for the way we think about personality (Staudinger, 1999b). First, we believe that the different components of personality, introduced earlier, *together* form the personality system. Dynamic systems theory postulates that, by means of recursive interactions, such components form the basis of self-organization as well as the emergence and stabilization of new forms (e.g., Ford & Lerner, 1992; Thelen & Smith, 1998). Second, the systemic view directs our attention also to the cross-linkages between personality and other subsystems of the developing individual, such as physiological and cognitive functioning (e.g., Mischel, 2004; Pervin, 2001). As mentioned already, it seems that personality has something like an *orchestrating or executive function* with regard to these other systems and the developmental changes occurring in these systems (e.g., Erikson, 1959; Waterman & Archer, 1990). Besides the (dynamics) systems approach to the study of personality, the psychology of action has been suggested as a unifying framework for the microgenetic study of the interplay of cognition, emotion, and motivation (Gollwitzer & Bargh, 1996). The extension of action psychology to issues of life span development has begun to be explored (e.g., Brandtstädter, 1998; Brandtstädter & Rothermund, 2003). There is first evidence accruing that the developmental model of selective optimization with compensation, introduced previously, also holds promise in this respect (e.g., Freund & Baltes, 2002b).

Third, and finally, personality develops to serve a self-reflective function. Personality reflects and evaluates developmental changes in the other subsystems and tries to integrate them. This integrative and adaptive function of personality is also mirrored in the fact that subjective measures of adaptation such as subjective well-being or happiness are even used as measures of self (e.g., Bengtson, Reedy, & Gordon, 1985). Self-reflection is pivotal with regard to evaluating one's standing in the developmental matrix of possible life goals and outcomes (e.g., Staudinger, 2001).

Providing Links from Infancy to Old Age

A further issue with regard to a life span perspective on the study of personality development concerns encompassing the ontogenetic course from *infancy* to *old age*. Empirically and theoretically, this distance may often still appear as a gap. Infancy and childhood research on the one hand and adulthood and old-age research on the other typically proceed independently from each other with little overlap in concepts, methodology, and consequently empirical data basis. Although much progress has been made, especially by longitudinal researchers whose participants have grown into adulthood (Pulkkinen & Caspi, 2002), the caveats expressed in the past continue to exist: For example: Which measures are age-invariant? How to capture explanatory continuity when combined with descriptive discontinuity?

Bridging this gap and establishing connections indeed is not easy (e.g., Brim & Kagan, 1980). It seems necessary to identify constructs that have been used to describe personality development across the life span or have at least shown predictive relationships. This concerns the question of homotypic and heterotypic continuity, a terminology introduced by Kagan and Moss (1962), or of Block's notion of temporal coherence (e.g., Block, 1993). The notion of heterotypic continuity implies that the phenotypic behavior might change between childhood and adulthood, but that specific behaviors in childhood might still be conceptually consistent with adult behaviors. Phenotypically different but conceptually related responses might be derivatives of earlier behavior (e.g., Moss & Sussman, 1980). R. G. Ryder (1967), for example, found that childhood task persistence was related to adult achievement orientation.

There are a number of interesting candidates that serve as examples of constructs that span a lifetime, such as attachment style, control beliefs, the self-concept, or temperament. For temperamental features, for instance, extensive longitudinal evidence is available that has demonstrated quite strong predictive links between temperament in early infancy and personality in adulthood and even old age. In this work, five temperamental features are distinguished, activity level, positive affect, negative affect, avoidance/approach, persistence. Longitudinal relations show that, for instance, activity level is related to extraversion and lower levels of conscientiousness or negative affectivity predicts neuroticism and lower levels of agreeableness (e.g., Caspi, 1998; Friedman et al., 1995; Kagan & Snidman, 1991; J. V. Lerner & Lerner, 1983). These kinds of predictive relationships, however, should not be interpreted as a deterministic argument. Rather, work by Chess and Thomas (1984) and J. V. Lerner and Lerner (1983) demonstrated that depending on the "goodness-of-fit" between the child's temperament and expectations of the environment, temperamental constellations can be aggravated or alleviated.

Recently, there has been notable progress in identifying some of the mechanisms that might link infant temperament and adult personality and that might enable a joint organization of concepts of temperament and personality (e.g., Strelau & Angleitner, 1991; Zuckerman, 1995). Zuckerman (1995), for example, has proposed what he calls the turtle model of personality. In this model, personality traits at the top are linked to genetics at the bottom through (from top down) social behavior, conditioning, physiology, biochemistry, and finally neurology. This model is not meant to be reductionistic; it is necessary to study each level of analysis with its own intellectual agenda to gain a complete understanding. As Zuckerman (1995, p. 331) puts it, "We do not inherit temperamental patterns as such. What is inherited are chemical templates that produce and regulate proteins involved in building the structure of nervous systems and the neurotransmitters, enzymes, and hormones that regulate them. We are born with differences in reactivities of brain structure and differences in regulators." Very much in line with our systemic emphasis, it is included in this multiple levels of analysis model of Zuckerman that the type of temperamental pattern, which initially may have a strong genetic component, attains features of contextually based self-organization. Thus, the temperamental pattern is transformed by context and experience in ways that it becomes an outcome of a multicausal and self-organizing process.

In sum, in this first section we have attempted to engage the reader in an integrative view on research on the development of personality, self-concepts, and self-regulatory processes. In order to gain an understanding of the life span development of self and personality, it seems useful to consider structure and processes, as well as functions (Mischel & Shoda, 1999). A dynamic systems approach to development provides a useful theoretical framework for the integration of the different components of personality discussed in the literature. In addition, interest of a life span perspective centers on features—such as temperament—that allow to study continuity and discontinuity across the whole life span and also demonstrate predictive power from childhood into adulthood. Based on this conceptualization, we will now apply the level of analysis approach, introduced in the beginning of this chapter, to the field of self and personality.

Illustrations of the Role of Biology and Culture in Personality Development

How does Figure 11.1 apply to the field of personality? Working from the assumption that the genome and its expressions, by means of evolution, are not optimized with regard to old age, and that genetic programs potentially are less orderly and integrated for late than for young adulthood (e.g., Kirkwood, 2003), what are the implications for personality functioning across the life span? Recently, there has been growing interest in explicating the evolutionary base of personality, both in terms of biological and cultural-social forces in the sense of co-evolution (e.g., Barkow, Cosmides, & Tooby, 1992; Klix, 1993). This trend, however, is only beginning to reach the second half of life (e.g., Plomin & Caspi, 1999).

As selection primarily operates through fertility and parenting behavior, most of the evolutionary work in the field of personality (in the widest sense) has focused on gender differences in altruism, cooperative behaviors, sexual competition, or jealousy (e.g., DeKay & Buss, 1992; Hammerstein, 1996). In addition, however, arguments have been raised that the ability for self-deception might have been favored by evolution because it seems to increase the ability to deceive others and thereby gain a survival advantage (e.g., Gigerenzer, 1996; Trivers, 1985). The evolutionary importance of the ability to deceive others in turn is related to the crucial role of reciprocal relationships for reproductive fitness (e.g., Axelrod, 1984). We would like to suggest that this ability "to deceive oneself," or one could also say "redefine reality," indeed serves an important adaptive function across the life span and probably increasingly so in old age.

Thus, the fact that the evolutionary base has been less "optimized" for the postreproductive phases of life than for younger ages may not be as detrimental for the ontogenesis of self and personality as for biological and cognitive functioning. Perhaps what is relevant here is that the "mechanics of the mind" which evince definite aging losses (see earlier discussion), either carry little implication for personality functioning, or that evolutionary selection in humans provided a better basis for personality than for intellectual functioning.

This interpretation of findings from evolutionary psychology, that personality is less at a disadvantage than cognition and biological functioning, is supported by findings on the genetic component of interindividual differences in personality functioning as advanced by behavior-genetic research. Evidence from the cross-sectional as well longitudinal analyses of the genotype and the phenotype of personality characteristics indicate that none of the personality traits is without a 40% to 50% genetic variance component. There are still too few data sets, however, that would allow disentangling methods effects. Mostly twin and adoption studies have used self-report data to assess personality. When comparing genetic variance components as derived from self-report with those based on peer ratings clear differences emerge that suggest that observational assessment and/or test-based assessment of personality may still yield other results. Based on the few data sets that allow for multimethod testing it seems that genetic factors largely account for what is in common across assessment methods (Plomin & Caspi, 1999). Across the life span, genetic variance components seem to follow a different pattern than the one just reported for the domain of intellectual functioning. During the life course, stability or even slight *de*creases in heritability coefficients have been found (e.g., Pedersen & Reynolds, 2002).

This very general summary statement needs qualification and differentiation. So far, only few behavior-genetic studies of personality based on longitudinal data with extensive age intervals are available, let alone using multiple assessment techniques. Highly complex statistical methods that allow modeling of the genetic architecture of development (Pedersen, 1991) by simultaneously taking into account mean levels and growth curves (e.g., McArdle & Bell, 1999; J. R. Nesselroade & Ghisletta, 2003) have become available. However, due to the lack of appropriate data sets and to the recency of their availability, they have not been widely applied yet. Therefore, authors in the field of behavioral genetics consider the available evidence as preliminary (e.g., Pedersen & Reynolds, 2002).

Taking such limitations into account, the following preliminary insights into the developmental behavioral genetics of personality seem to find consensus among behavioral geneticists (e.g., Pedersen & Reynolds, 2002). First, results of behavior-genetic analyses of personality assessments are difficult to compare with the equivalent analyses of intelligence assessments because the latter are based on behavioral performance measures, whereas personality measures typically refer to self-reports. Thus, strictly speaking, personality-related analyses refer to the heritability and its life span changes in how people report about themselves. Second, the extent to which genetic influences account for phenotypic variability in personality measures is smaller than for measures of intelligence, with heritability coefficients between .4 and .6 depending on the personality trait and the age of assessment. Third, the importance of genetic influences on interindividual differences in personality seems to decrease slightly with increasing age (e.g., McGue, Bacon, & Lykken, 1993; Pedersen & Reynolds, 2002). And fourth, there is initial evidence for a quite high overlap in the genetic effects (i.e., stability) operating on personality expression at different ages, although at each point in time they account for not more than half of the variance (e.g., McGue, Bacon, et al., 1993; Pedersen & Reynolds, 2002).

One of the more recent and exciting directions for genetic research on personality involves the use of molecular genetic techniques to identify some of the specific genes responsible for genetic influences on personality (Hamer & Copeland, 1998). It is too early to be certain, but it is possible that ultimately this molecular genetic analysis will become more and more prominent. That it will shift our attention away from focusing on quantifying genetic influences to a focus on the causal mechanisms from cells to social systems that will elucidate how genes affect and are affected by personality development. Currently, progress is being made with regard to the molecular analysis of temperamental features such as approach/avoidance or positive/negative emotional tone (see the following discussion). In the long run, such molecular genetic analysis may help to answer questions of heterotypic continuity much more clearly than currently is the case when referring to behavioral measures (Plomin & Caspi, 1999).

The Allocation of Resources in Personality Functioning

In an earlier section, we emphasized the life span developmental script of a reallocation of resources, from a predominant allocation into growth to an increase in relative allocation into maintenance, repair, and management of losses (see also Staudinger et al., 1995). In contrast to the domain of cognitive functioning where resources in old age are depleted to maintain a certain level of functioning, the resource situation for life span growth in self and personality might present itself more favorably. Taking a system's view on psychological functioning, we can assume therefore that personality by virtue of being the self-reflective head of the living system "human being" (a quality emerging during childhood) might be able to continue to deliver its orchestrating or executive function with regard to managing the gains and losses across various domains of functioning until at least the third age (cf. Staudinger et al., 1995).

It is less and less certain, however, whether, on average, personality-related resources are available in old age to promote further development of the personality-system itself. In other words, as life reaches old age, it becomes more and more necessary for available personality-related resources to be invested in managing cognitive, physical, and social declines and losses. Possibly only under very favorable developmental conditions would personality-related resources be sufficient to invest in further development of personality itself. Although, in principle, life span changes in personality could include advances, we do not expect them to occur in everyone. Under very favorable conditions, however, personality growth might even involve such high goals as wisdom (cf. Erikson, 1959; see also P. B. Baltes, Smith, & Staudinger, 1992).

Further, we assume that the personality-system also manages and organizes the extension of internal resources (e.g., cognitive capacity, physical strength, personality characteristics) by referring to others and the physical and institutional context as resources (for overview see Staudinger et al., 1995). Others can help to do things that one's own health or time or ability does not allow. External memory aids can help to compensate for the loss in memory performance. Given this line of thought, one can also conceive of a situation that allows personality to optimize the use of external resources such that enough internal resources are left for further personality development, for example, toward wisdom. An extreme case for such personality-based orchestrating of resources aimed at selective optimization is the loss of independent functioning. There the task is to accept dependency in such domains as household management in order to free up resources for other purposes (M. M. Baltes, 1996).

The notion that personality performs an orchestrating or executive function with regard to the management and identification of resources raises the following question: Is it possible to distinguish the mechanisms and characteristics that support the overarching orchestrating or executive functions from those that constitute one of the three domains of psychological functioning, that is intelligence and cognition, self and personality, and social relations, or are both inextricably intertwined? This question is discussed in research on *resilience* (Staudinger et al., 1995). By taking such a research perspective on the origins, maintenance, and consequences of personality—ideally in a longitudinal manner—it becomes possible to identify, for instance, whether, or how, personality manages itself while at the same time having to manage extraordinary challenges such as losses in cognitive functioning or losses of significant others due to death, or to challenges of one's own finitude. Each process and each characteristic constituting personality can thus be identified as a phenomenon in itself but also in its executive and orchestrating function.

We next discuss in more detail three issues of personality development across the life span. The first is the question of stability and change across the life span. Aside from questions of stability in individual rank order, this issue can also be phrased as investigating the gains, maintenance, and losses in mean levels in personality functioning. The second issue relates to the opportunities and constraints of personality development. And finally, the third issue will illustrate the adaptive personality-related potential across the life span, which arguably might present the most comprehensive general-purpose mechanism involved in life span development.

Personality Development as Lifelong Transactional Adaptation: Continuity and Change

Before we explore further the question of continuity and change (gains, losses) in personality development, it seems useful to consider the question what it means to speak about gains and losses in the context of personality functioning. Using the notions of growth and decline or gain and loss with regard to personality characteristics makes the criterion problem of what is a gain and what a loss even more obvious and pressing than it is with regard to intellectual functioning. In cognitive research, it seems obvious that the more words one can remember, the better; the faster we can complete a problem-solving task, the higher the level of performance. But even with regard to intellectual functioning such criteria of adaptive fitness, of what is a gain and what a loss, are subject to contextual conditions. When it comes to personality, we are presented with the problem of determining a "best" direction of personality development. What is the desirable end state of personality development? Is there one, or are there many potentially incompatible ends depending on the outcome criteria we examine? To what degree do subjective and objective criteria converge?

For example, let us take extraversion and assume that being extraverted is set as an aspired goal of personality development. We can think of occasions, however, when, on the contrary, introversion turns out to be the more adaptive personality feature. Similarly, it is very important to strike a balance between affiliation and solitude or between autonomy and dependence. Such considerations remind us of the argument presented previously about general-purpose mechanisms. We argued there that it is the flexibility and the availability of a monitoring algorithm that is "best" with regard to self and personality functioning, rather than one or the other personality characteristic (e.g., Aspinwall & Staudinger, 2003; Staudinger, 1999b). Similar views can be applied to coping research. There, high domain-specificity with regard to the functionality of coping behaviors has been identified. Furthermore, coping behaviors that are adaptive as immediate responses need not be adaptive in the long run. Thus, even with regard to coping, implications for everyday functioning are not fully known (Filipp & Klauer, 1991).

One approach to deal with the question of functionality is to invoke subjective assessments, for instance, about the perceived desirability or undesirability of a given self-related attribute. In a series of studies on beliefs and expectations about development, Heckhausen and Baltes found that people have quite clear conceptions about what they consider to be a desirable and what an undesirable developmental outcome and also when it is supposed to occur. For example, only two desirable personality characteristics were reported to continue to grow in old age, that is wisdom and dignity, whereas many other positive characteristics were mentioned as emerging for the periods of young and middle adulthood (Heckhausen, Dixon, & Baltes, 1989). It was also found in these studies that people of different ages and socioeconomic backgrounds agree about how personality develops and about what is a desirable and what an undesirable personality development, that is, what is a gain or a loss.

In the following, as we characterize gains and losses in life span development of self and personality, we use two approaches (see also Staudinger & Kunzmann, 2005). A first is based on evaluating developmental changes with regard to the adaptivity and functionality of the outcome for the individual, be it from a subjective (e.g., subjective well-being) or an objective perspective (e.g., longevity). The second refers to theoretical growth models of personality (e.g., ego maturity, integrity, generativity) when making a judgment about gains and losses. We alert the reader to the problem that these categorizations are preliminary and by no means absolute.

Be it gains or losses, it is the core assumption of a life span perspective that personality does not simply passively unfold as a consequence of the prewired maturational programs or the mechanistic reaction to environmental stimuli. Personality develops out of a constant and active process of the individual's transactions with changing internal and external influences, including biological changes and changes in historical conditions of society. "Transactional adaptation" (e.g., R. M. Lerner, 1984, 2002) or person-environment interaction (e.g., Magnusson, 1990; Magnusson & Stattin, Chapter 8, this *Handbook,* this volume) are considered the central developmental processes. In this process of transactional adaptation of personality, systemic principles of self-organization are key ingredients. This basic life span premise about personality development is further elaborated by the differentiation between the mechanics and pragmatics of life and how it pertains to our understanding of personality development.

The Mechanics and Pragmatics of Life as Relevant to Personality Functioning

As described earlier the contribution of the mechanics and pragmatics as well as their dynamic interaction is quite well understood with regard to cognitive development (see also P. B. Baltes et al., 2006; Cabeza, 2002). With regard to personality, however, we are still at the beginning of understanding the interaction between mechanic and pragmatic elements in producing developmental trajectories. The developmental trajectories of the cognitive mechanics and pragmatics are well established at least in terms of the behavioral level. We also know that with increasing age the cognitive pragmatics help to compensate functional deficits in the mechanics (e.g., Salthouse, 1984; see also P. B. Baltes et al., 1998; Staudinger et al., 1995). Do we expect to see similar developmental trends when investigating the mechanics and pragmatics as relevant to personality functioning?

It may be useful to extend the notion of cognitive mechanics and pragmatics to encompass personality functioning. Thus, instead of speaking of cognitive mechanics and pragmatics one may consider to use the more general notion of mechanics and pragmatics of life (see also Staudinger & Pasupathi, 2000). Clearly, this model is of a heuristic nature; that is, we do not assume that any phenomenon in the area of personality can be assigned to *only* representing the mechanics or the pragmatics. Rather, we assume that it may be useful to categorize aspects of personality functioning according to their relative position on the continuum between the mechanics and pragmatics of life. In the following, these more general notions of mechanics and pragmatics are explicated with regard to their relevance for personality functioning and development.

The Mechanics of Life as Relevant to Personality Functioning. The life mechanics relevant to personality functioning refer to a unique configuration of elements that contribute to interindividual differences in self-concept, self-regulation, or trait personality such as basic emotional and motivational tendencies as they are studied in temperament research (positive/negative emotional tone, approach/avoidance, novelty seeking; Schindler & Staudinger, 2005a; Staudinger & Pasupathi, 2000). This configuration entails basic emotional and motivational tendencies, as well as cognitive processes that can be observed on the behavioral as well as on the neurophysiological level.

The mechanics of life encompass complex interactions between the cellular, neural, endocrine, and immunological system, which in turn provide the basis for basic behavioral indicators of cognition, emotion, motivation, and behavior/action. On the behavioral level basic temperamental features such as emotional, motor and attentional reactivity as well as their regulation are considered (e.g., Rothbart, 2001). On the level of physiological indicators, it is impossible to clearly separate from each other aspects of the mechanics that underlie either cognition, or emotion, or motivation. For instance, changes in heart rate such as acceleration can be observed during negative affective episodes, but also during mental arithmetic (cf. Baltissen, 2005; Levenson, 2000). With regard to neuroanatomy, there is evidence for specialized brain areas (e.g., the amygdala, prefrontal cortex) that contribute to the formation of both basic emotions and basic motivational tendencies but not to higher cognitive functioning (e.g., Davidson, Jackson, & Kalin, 2000). A further differentiation between emotion and motivation, however, so far seems not possible. The emotion of fear, for instance, is inextricably linked to avoidance motivation. Temperamental dimensions also tend to show substantial interrelations, reflecting an underlying affective-motivational system rather than separate qualities (cf. Rothbart & Bates, 1998).

The Pragmatics of Life as Relevant to Personality Functioning. The pragmatics of life as they are relevant to personality functioning represent the power of experiences and contextual influences. They encompass self-related knowledge as well as self-regulatory competencies (Staudinger & Pasupathi, 2000). Knowledge about the self pertains to trait conceptions of personality as well as to the self-concept. It includes all that we know about our behavior, past experiences, anticipated and idealized futures, needs and wishes, abilities, or weaknesses that characterize our selves. The concept of who we are and what we are like is closely related to how we pursue goals, evaluate our selves or adjust our self-views or goals under threat. Thus, self-regulation constitutes the procedural part of our self-knowledge.

The Dynamic Interaction of the Mechanics and Pragmatics of Life as Relevant to Personality Functioning. The mechanics and pragmatics of life mutually influence each other. As mentioned previously, we follow Cattell's (e.g., 1971) investment theory and consider the life mechanics as the building blocks promoting developmental progress in the life pragmatics (Staudinger & Pasupathi, 2000). At first sight, it seems that the mechanics constrain the pragmatics, and to a certain degree that is true. But most genetic as well as recent brain research has demonstrated that, for instance, the richness or poverty of the (factual and procedural) knowledge we accumulate feeds back into the life mechanics and indeed may even change them (genetic expression, brain structures; Kirkwood, 2003; W. Singer, 2003; see also S.-C. Li, 2003). Extremely inhibited children, for instance, are able to gain control of their fearful behavior, changing not only their psychological state but also the underlying reactive sympathetic nervous system (Kagan, 1998). This reciprocal interaction of mechanics and pragmatics highlights the limits of the hardware-software metaphor introduced earlier (at least as our current understanding of hardware is concerned).

The life span conception of ontogenesis (e.g., P. B. Baltes et al., 1998; Brandtstädter, 1998) as a product of the interaction between biology (i.e., life mechanics), culture, and automated as well as purposeful attempts at regulating one's development (i.e., life pragmatics) implies that it is impossible to clearly separate the mechanics from the pragmatics of life. Starting at conception, biology, culture, and the developing "person" interact. We just showed that, for instance, basic temperamental dimensions (i.e., mechanics) and personality characteristics (i.e., pragmatics) show predictive relations across the life span (e.g., Caspi & Silva, 1995). But we do not know yet how exactly the underlying mechanics play out in the development of traits. For instance, do changes in the life mechanics result in the age-related decrease in openness to experience (e.g., decay in the physiological basis of the approach system, or reduced biological resources "demand" parsimonious; i.e., habituated, rather than novel functioning) or is it rather the result of years of experience (e.g., losing interest because I have seen it all before), that is, the life pragmatics? Or is it both? Despite the seemingly inextricable interaction, it may nevertheless be useful for heuristic purposes to distinguish between the life mechanics and pragmatics of personality and use this distinction to better understand personality development across the life span. We start by reviewing some first and still scarce evidence on the life span development of the mechanics followed by results with regard to the life pragmatics of personality.

The Development of Neurophysiological Indicators of Life Mechanics of Personality

When we consider the mechanics of life it is not trivial to identify indicators that have a clear emphasis on the mechanic side and that at the same time can be used to assess participants across the whole life span. Especially on the behavioral level, such as basic behavioral indicators of temperament are usually not applied throughout the life span but are substituted by personality trait measures when adults are assessed. In our terminology, however, trait measures of personality are the result of many cumulative interactions between the biological basis of personality, context and individual choices. Thus, they are much closer to the pragmatic than the mechanic end of the continuum.

Behavioral operationalizations of basic temperament dimensions clearly are closer to the mechanic end of the continuum even though we need to be aware that the pragmatic component gains importance whenever self-report is involved (cf. P. B. Baltes et al., 1998; Kagan, 1998). Nevertheless, with regard to affective tone it is possible to consult basic behavioral findings from life span emotion research. Also, there is some scarce behavioral evidence on the approach/avoidance system stemming from research on the goal system.

In addition, one can have a look at neurophysiological indicators of personality functioning in order to learn about the development of the mechanics of life. Two neurophysiological indicators have been—reliably and across different laboratories—identified as biological indicators of basic dimensions of affectivity and motivation: (1) autonomic reactivity and (2) cerebral asymmetry (see also Schindler & Staudinger, 2005a). Those two indicators seem to be rather "pure" reflections of the life mechanics given presently available measurement paradigms and they have received most of the empirical attention.[2] In the following, we will first present developmental evidence for the two neurophysiological indicators. Subsequently, progressing from the mechanics a little further toward the pragmatics end of the dimension, we present developmental evidence on the behavioral data about emotional tone and about the approach/avoidance tendency.

Autonomic reactivity (heart rate, heart rate variability). The parasympathetic and sympathetic branches of the autonomic nervous system influence the activity of the heart. Both higher sympathetic reactivity (e.g., Kagan, 1998) and a weaker influence of the parasympathetic nervous system (e.g., Porges & Doussard-Roosevelt, 1997) have been linked to behavioral inhibition (i.e., withdrawal/avoidance). Our focus is on the relationship

[2] These two indicators only present a subset of the physiological indicators of temperament and additional indicators that may be discussed in this context are excitability levels of the amygdala, asymmetric activation of the amygdala, norepinephrine, cortisol, or dopamine levels (e.g., Davidson et al., 2000; Depue & Collins, 1999; Kagan, 1998; Rothbart & Baltes, 1998).

between heart rate and heart rate variability on the one and basic dispositions such as approach/avoidance or positive/negative emotional tone on the other hand.

On the one hand, a low and variable resting heart rate is generally related to approach behavior and positive affect, but also to regulatory disorders and angry irritable affect (e.g., Porges & Doussard-Roosevelt, 1997; Rothbart & Bates, 1998). These two findings seem contradictory, but match the special nature of anger. Albeit considered a negative affective state, anger is associated with a motivation to approach rather than to avoid or withdraw (e.g., Davidson et al., 2000; Harmon-Jones & Allen, 1998). On the other hand, higher resting heart rate combined with lower variability and high reactivity shows relations to inhibitory or avoidance behaviors (e.g., Kagan, 1998). These findings highlight the necessity to consider the regulation of the heart rate in response to stimulation in addition to the resting heart rate. Indeed, it is the physiological regulation of cardiac activity that has been suggested as "an antecedent substrate for emotional, cognitive, and behavioral regulation" (Doussard-Roosevelt, McClenny, & Porges, 2001, p. 58). Infants who have a low and variable resting heart rate *and* demonstrate appropriate heart rate modulation tend to show more optimal developmental outcomes (at age 3) such as fewer depressive and aggressive behaviors and more socially competent behaviors (e.g., Porges & Doussard-Roosevelt, 1997).

During childhood stability of resting and stress-tested heart rate as well as its variability reach close to perfect levels (Porges, Doussard-Roosevelt, Portales, & Suess, 1994). Mean-level decreases in resting heart rate and increased levels of variability have been observed between 9 months and 3 years of age (Porges et al., 1994). Unfortunately, no studies investigating mean-level stability of heart rate and its variability from childhood into adulthood and old age are yet available. But there is evidence that the resting heart rates of older adults hardly differ from those of young adults, while maximum heart rate is considerably reduced with increasing age (Folkow & Svanborg, 1993). Heart rate reactivity is also attenuated in older adults (e.g., Levenson, Carstensen, Friesen, & Ekman, 1991; see Baltissen, 2005, for an overview). In addition, once the ANS is activated, there is at least some first indication from emotion research that the activation tends to persist for longer time periods in old compared with younger adults (Levenson et al., 1991). To date, however, no data exist about possible changes of the relation between autonomic reactivity and behavioral indicators of approach/avoidance or other personality indicators across the life span.

Cerebral Asymmetry. Over the last 15 years different laboratories have developed theories and accumulated empirical evidence concerning the idea that approach (Gray, 1981), activation (Cloninger, 1987), and engagement (Depue, Krauss, & Spoont, 1987) motivation on the one hand, and avoidance, withdrawal (Davidson, 1984), and inhibition (Cloninger, 1987; Gray, 1981) motivation on the other hand are related to different neural substrates, different basic emotions, and have distinct influences on action. The approach/engagement system facilitates appetitive behavior, generates particular types of approach-related positive affect, and is related to relative increases in left-sided prefrontal activation. There is some evidence that dopaminergic pathways play a central role in that system (e.g., Depue & Collins, 1999). The withdrawal/inhibition system, in contrast, responds to threats or signals of punishment. Its engagement inhibits ongoing behavior (Gray, 1981) or supports withdrawal behavior (Davidson, 1984) and involves negative affective states such as anxiety, disgust, and heightened vigilance. The activation of the inhibition/withdrawal system is associated with relatively stronger activation of the right prefrontal cortex.

Interindividual differences in baseline prefrontal activation asymmetry are related to differences in dispositional affect, inhibition, and differential reactivity to negative stimulation (Davidson et al., 2000). For instance, infants with higher relative right anterior cortical activation at baseline are more likely to cry in response to being separated from their mothers compared to infants that do not show that asymmetrical activation pattern. Children with asymmetric right-sided anterior activation show a tendency toward inhibited behavior. During adulthood, greater relative activation of the right anterior cortex at rest has been related to higher levels of general negative affect, higher self-reported behavioral inhibition, stronger negative affect in response to unpleasant film clips, and slower recovery following a negative affective stimulus (for an overview see Davidson et al., 2000).

Although there is evidence of internal consistency and test-retest reliability of measures of prefrontal asymmetry (Tomarken, Davidson, Wheeler, & Kinney, 1992), our knowledge about the intraindividual development of cerebral asymmetry especially over longer time spans is still very limited. Rank-order stability of baseline prefrontal asymmetries seems to be very low over an 8-year period during childhood (Davidson & Rickman, 1999), but stability is assumed to increase after puberty when the prefrontal cortex has stopped to undergo developmental change (Davidson et al., 2000).

Again, there is no study yet that compares the relative magnitude of prefrontal asymmetry between infants, children, and adults. Cerebral asymmetry has been demonstrated during the 1st year of life (cf. Davidson et al., 2000), but it is unclear whether these interindividual differences in brain activity stay stable during further development. It has been speculated that the later development of left-brain abilities might be accompanied by a maturational shift toward better emotion-regulation (see Rothbart & Bates, 1998). Similar to research on heart rate and its variability, there seems to be hardly any evidence on the mean-level stability of prefrontal asymmetry in old age. We only found one study of odor perception in older adults that showed that left frontal brain activation in response to pleasant stimuli was uncompromised. However, brain activity in response to unpleasant stimuli did not differ from that to neutral stimuli (Kline, Blackhart, Woodward, Williams, & Schwartz, 2000). This may imply that the right prefrontal cortex area undergoes stronger age-related losses in functioning than the left prefrontal area. We will see in the next section that on a behavioral level of assessment there is evidence accruing for differentially reduced frequency of negative emotions as well as reduced reactivity to negative stimuli.

Some Conclusions about the Development of Neurophysiological Indicators of the Mechanics of Personality Functioning. To date, there are few studies on either mean-level or rank-order stability of the selected physiological indicators of the life mechanics of personality and the majority of extant findings come from studies on infancy and childhood. Thus, we can only draw some very preliminary conclusions about life span development. Substantial stability coefficients are attained past adolescence. Thus, these physiological indicators may possibly contribute to continuity on the behavioral level. The mechanics underlying basic motivational and emotional tendencies show smaller mean-level changes than the cognitive mechanics across the life span. But there are some decreases such as the declining physiological reactivity of the ANS in old age and the possibly reduced asymmetry in prefrontal brain activation. Please, note that these changes in the mechanics by no means have to play out as losses on the behavioral level but rather—as discussed next—the opposite may be the case.

Overall, our understanding of life span changes in the life mechanics of personality as well as their relation with behavioral indicators is still limited. We need studies linking differential age-related change in physiological indicators to differential intraindividual change in personality. For instance, what happens to inhibited individuals who have a tendency to show strong heart rate acceleration in response to challenge when they reach old age? We know that heart rate acceleration probably declines with increasing age due to reduced reactivity of the ANS. But is there any age-related change in behavioral inhibition as a result of declined heart rate reactivity? Or what happens to emotion-regulation in old age given the changes in brain activity discussed previously? Is there a mechanic basis to the age-related changes found in emotion-regulation (e.g., Labouvie-Vief, Lumley, Jain, & Heinze, 2003)? These and related questions are especially relevant when we describe and explain the findings about the development of behavioral indicators of emotional tone and approach/avoidance that are much closer to the pragmatics of personality next.

The Development of Behavioral Indicators of Life Mechanics of Personality

Emotional Tone and Reactivity. The physiological patterns are maintained, however the magnitude of physiological responses seems to be reduced (e.g., Levenson et al., 1991). Studies assessing emotion via self-reported positive and negative affect, that is indicators much closer to the pragmatic side of emotion-regulation, supported the view of a gain in affective functioning in old age. Overall the subjective salience of emotion seems to increase with age (e.g., Carstensen et al., 1999). Negative affect has been shown to either stay stable or decline in old age. Positive affect was found to be rather stable or even increasing with age depending on the study and the age range under investigation (e.g., Charles, Reynolds, & Gatz, 2001; Diener & Suh, 1998; Kunzmann, Little, & Smith, 2000). Increased affective complexity (i.e., more factors underlying emotional experience, plus higher potential for the co-occurrence of positive and negative affect) and improved reported emotional control were also linked to increasing age (e.g., Gross et al., 1997). A common interpretation of those findings is an age-related emotional maturation as a result of accumulated experience and knowledge about emotions as well as a changing time horizon (e.g., Carstensen et al., 1999), that is, changes in the life pragmatics of personality. Based on the findings about neurophysiological indicators of the mechanics of personality presented earlier, we would like to offer some speculations about how those changes may contribute to these changes in emotional tone and emotion-regulation observed on the behavioral level.

First, as noted, there is indication that ANS activity (particularly the cardiovascular system) in reaction to elicited emotions is smaller and refraction times are longer in older adults in comparison with younger adults. Further, an age-related reduction of the asymmetry of prefrontal brain activity seems to occur. These changes (and we have only looked at a small selection of possible mechanic indicators) may contribute to the changes observed in emotional tone and emotion-regulation. For instance, lower ANS reactivity may make it easier to deal with upsetting emotional experiences. Decreased asymmetry in prefrontal brain activation during emotional experiences may contribute to differences in the relative frequency of specific emotional experiences and may predispose toward the processing of a particular kind of emotional quality.

Second, with regard to emotional control there is indication that in contrast to self-report assessment, behavioral measures of emotional control actually find no age-related increases but rather that older adults seem to overestimate their own ability to regulate their emotions as measured by physiological indicators (Kunzmann, Kupperbusch, & Levenson, 2005). And there is first indication that when using highly age-relevant emotional stimuli (loss of a loved one) older people actually report to experience *stronger* negative reactions (sadness) than younger ones (Kunzmann & Grühn, in press). Thus, it may be the case that certain constellations of emotional reaction are practiced more often than others and thus by pragmatics means (i.e., exercise) developmental trends based on the life mechanics of personality are "compensated." In sum, we suggest that the interplay between mechanic and pragmatics components of personality development is far from being understood but that the heuristic distinction between the mechanics and pragmatics of life may be quite helpful in order to increase our understanding of emotional functioning across the life span.

Approach and Avoidance Goals. Corresponding to the age-related declines in the mechanics of life, goal-focus is expected to shift with increasing age from growth, that is, trying to reach higher levels of functioning, toward maintenance, that is, preserving levels of functioning in the face of challenge, and regulation of loss, that is, organizing functioning at lower levels (Staudinger et al., 1995). Inspecting findings from research on the goal system (e.g., Emmons, 1996) that distinguishes goals focusing on gains, that is, approach goals, and goals focusing on the avoidance of loss, that is, avoidance goals, can be used to test this hypothesized developmental trend. And indeed in line with the assumption, it has been demonstrated that growth (approach) goals were more frequent in adolescence, while maintenance (avoidance of loss) goals increased in frequency during middle adulthood and into old age (Ebner & Freund, 2003; Freund, 2002; Heckhausen, 1997; Ogilvie, Rose, & Heppen, 2001). Further, maintenance goals still increase in frequency during very old age (J. Smith & Freund, 2002). Nevertheless, in spite of middle-aged and old people becoming more invested in maintenance and loss management, approach goals persist throughout life (Ogilvie et al., 2001). When asked about their future selves, even a majority among the very old consistently reported to pursue improvement goals across two measurement points (J. Smith & Freund, 2002). And elective selection is the component of the SOC theory that is maintained into old age (Freund & Baltes, 2002b). This pattern of findings is replicated across different methodological approaches, such as coding of goals by raters, self-rating of goals, and goal-selection behavior. Further, with regard to a systems view on goals it was demonstrated that one goal could receive ratings on the approach as well the avoidance dimensions (Ebner & Freund, 2003). Relating these behavioral and self-report findings on approach and avoidance to the evidence based on neurophysiological indicators it is striking that it is the right anterior cortex, which is related to avoidance behavior that seems to undergo stronger age-related declines in functioning suggesting that the goal-related approach/avoidance findings are more closely linked with the life pragmatics rather than the life mechanics of personality.

Evidence on the Development of the Life Pragmatics of Personality

In this last part of reviewing evidence on personality development, we turn to constructs that on our mechanic-pragmatic continuum are much closer to the pragmatic end such as personality traits, the self-concept but also self-regulatory processes. A frequent distinction drawn in reviews of personality and aging (Kogan, 1990) is the one between trait and growth models of personality development.

Radical trait theorists equate personality with personality traits, that is, dispositional behaviors and attributes. Some even argue that personality is "set like plaster" after age 30 (Costa & McCrae, 1994). *Trait models of personality* approach the question of continuity and discontinuity and stability and instability from the continuity side. Trait-oriented researchers are interested in exploring and possibly arriving at a structure of personality characteristics that captures an individual's experiences and behaviors in a way that is as comprehensive and continuous as possible.

Among a large number of trait personality researchers there is consensus that personality can be reasonably well described by the so-called "Big Five." The Big Five have been identified by means of factor analysis across different instruments and different samples, though labels vary somewhat among authors. We have chosen Costa and McCrae's factor names to convey the information: Extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience.

Growth models of personality, in contrast, like the most influential one by Erik Erikson (e.g., 1959), contend that we continuously adapt to changing internal and external requirements and thereby grow. If all requirements are successfully met, at the end of an ideal trajectory, Erikson envisions a person full of hope, will power, purpose in life, competence, fidelity, love, care, and wisdom. Clearly, this outcome is not the rule but rather the exception.

More and more empirical evidence based on either of the two models, however, has demonstrated that *both* stability *and* change (i.e., gains and losses) characterize personality development in adulthood and old age. Thus, the focus of this overview will be on presenting this evidence and suggesting ways to better understand the dialectic between stability and change in personality development.

Development of Trait Personality. When asking about stability or change of personality traits, this implies three questions rather than one, that is, stability or change of (1) mean levels within a group of individuals, (2) inter-individual differences between individuals (variance), and (3) of the structural interrelationships of dimensions of personality (covariances). To start, a meaningful comparison between different age groups is solely possible if personality dimensions measure the same characteristics at different ages. For the Big Five factorial model of personality cross-sectional as well longitudinal information on structural invariance is available (Costa & McCrae, 1994; Small, Hertzog, Hultsch, & Dixon, 2003). Such studies have demonstrated high structural invariance during adulthood and into old age.

According to a recent meta-analysis (Roberts & DelVecchio, 2000), the rank-order stability of the Big Five increases almost linearly across the life span with stability levels in the .40 to .50 range during adolescence and a peak in stability at over .75 in middle adulthood (50 to 59 years). This peak of personality consistency at age 50 to 60 contradicts earlier arguments that the consistency of personality traits should plateau after age 30 (Costa & McCrae, 1994). Comparison among the five dimensions showed that extraversion and agreeableness had slightly higher stabilities than the other three dimensions (see also Vaidya Gray, Haig, & Watson, 2002). In this meta-analysis (Roberts & DelVecchio, 2000), stability estimates did neither vary by assessment method (i.e., self-report, other-report, projective test) nor by gender. Finally, controlling for sample attrition did not alter the results. The findings from this meta-analysis are confirmed with regard to old and very old age by recent publications from two longitudinal aging studies (Mroczek & Spiro, 2003; Small et al., 2003). In both studies, consistencies across 12 and 6 years, respectively, were around .7. No evidence has been found for cohort differences in consistency. Please note that even though a consistency of .75 at age 50 and 60 is high, on the assumption of higher reliability than stability, it leaves room for individual change. In this vein, recent studies using latent growth modeling found that with increasing age individual differences in personality change also increase (Pedersen & Reynolds, 2002; Small et al., 2003). As no age-graded increase but rather a decrease in the relative importance of genetic effects on personality development has been found, this increasing interindividual variability of change most likely is related to interindividual differences in life circumstances (Pedersen & Reynolds, 2002). Alternatively, it may also be the case that overall system robustness is reduced with age and thus greater intraindividual variability emerges (S.-C. Li, Aggen, Nesselroade, & Baltes, 2001; J. R. Nesselroade, 2002).

Finally, what happens with the mean levels of personality traits? Do we become less extravert and less open, but also less neurotic, as we move through adulthood and old age? Taking into account cross-sectional and longitudinal evidence, it seems that neuroticism decreases across adulthood (Mroczek & Spiro, 2003) and may show some increase again very late in life (Small et al., 2003). Some decrease is also found for openness to experience and extraversion (e.g., Costa, Herbst, McCrae, & Siegler, 2000). In contrast, agreeableness and conscientiousness increase to some degree (Helson & Kwan, 2000).

This mean-level decrease in neuroticism, increase in agreeableness and conscientiousness across adulthood and into old age can be described as an increase in social adaptation, in the sense of becoming emotionally less volatile and more attuned to social demands (Helson & Wink, 1987; Staudinger, 2005; Whitbourne & Waterman, 1979). The decrease in openness to experience, in contrast fits a different developmental pattern that is discussed next.

McCrae and others (e.g., 2000) lately offered an interesting proxy of a longitudinal study. Comparing samples between age 14 and 83 years from Korea, Portugal, Italy, Germany, Czech Republic, Turkey, they found cross-country consistency with regard to the pattern of mean-level changes just described. The authors argue that the observed similarity across cultures makes it unlikely—given the very different historical and cultural circumstances in these different countries—that such age differences are indeed cohort differences. Instead the authors suggest that this developmental pattern may reflect changes in genetic expression selected for by evolution (McCrae et al., 2000). Thus, using the terminology introduced in this chapter, McCrae and others view those results as reflecting changes in the life mechanics underlying personality functioning.

Knowing the many different ways that genes and environment interact in order to produce stability (cf. Plomin, DeFries, & Loehlin, 1977; Roberts & Caspi, 2003) and also how important specific life experiences are in personality development (e.g., Magnus, Diener, Fujita, & Pavot, 1993), we are somewhat reluctant in accepting this explanation as the only valid alternative. For example, the transition to partnership during early adulthood is accompanied by decreases in neuroticism and shyness and increases in conscientiousness (Neyer & Asendorpf, 2001). Thus, personality changes can also be attributed to normative, in the sense of culturally shared, life events. For instance, a recent cross-sequential study found that two cohorts differed in their development of neuroticism between the ages of 70 and 75 (Mroczek & Spiro, 2003). The older cohort (1897 to 1919) showed stability whereas the younger cohort (1920 to 1929) showed decline in neuroticism pointing to the fact that aging might express itself differently in different cohorts.

In sum, when we return to our heuristic dual-component model of the mechanics and pragmatics of life, we question the degree to which the Big Five are prototypical elements of the life mechanics, as McCrae and others (2000) suggest. In our view, the Big Five are prototypical elements of the life pragmatics. They are the result of an endless number of interactions between biology, culture, and the person. Thus, aside from stable genetic components, their relative high degree of stability can also be located in the physical and social environments in which individuals live and which, as sociological theories of human development and social differentiation suggest (Settersten, 2005), evince systematic and stable interindividual differences. Therefore, in our view personality traits likely are much less of an exclusively biological nature than is assumed to be the case for the more fundamental elements of the personality system such as basic emotional tone and basic motivational tendency.

Using a psychometric approach to the study of *growth-aspects of personality* replicates and extends the finding of increased social adaptation just described for the Big Five. Measuring dimensions such as "environmental mastery," "autonomy," or "personal growth" and "purpose in life," Ryff and Keyes (1995) find that the first two dimensions increase with age during adulthood and old age and the latter two level off after midlife. The increases in environmental mastery and autonomy can be described as being highly functional and adaptive for mastering adult life.

Personal growth and purpose in life, however, level off in midlife. This developmental trend fits well with the decline observed in openness to new experiences in old age. It has been argued (Staudinger, 2005), that these observed declines in self-reported openness, personal growth and purpose in life, may indicate that in contrast to social adaptation, personal maturity is less likely to come with age for most people. And indeed studies of wisdom (e.g., Staudinger, 1999b) and of ego development (e.g., Labouvie-Vief et al., 1987) find no normative increase with age during adulthood.

Self-Concept Development. When studying the self-concept both content and structure need to be considered (e.g., Filipp & Mayer, 2005; Staudinger & Pasupathi, 2000). Therefore, developmental trajectories of both will be covered next.

The *content* of the self-concept refers to the beliefs we hold about ourselves and to the domains we employ when describing ourselves. Answers to questions like "Who am I?" (e.g., Freund & Smith, 1999) are indicators of the content of the self-concept. The content of spontaneous self-descriptions shows change, but also stability (Filipp & Klauer, 1986). There is, for instance, substantial stability in the content of self-definitions across different age groups when it comes to central domains of life (e.g., health, social relations; Filipp & Klauer, 1986). But there is also change that can be attributed to the influence of a succession of developmental tasks, critical life events, and also changes in the life mechanics. During childhood the academic self-concept and school achievement assume a central role, in adolescence we are very much concerned about our physical appearance (for an overview cf. Filipp & Mayer, 2005). With increasing age, however, people define themselves more and more in terms of health and physical functioning, life experiences, and hobbies (Dittmann-Kohli, 1991; Freund & Smith, 1999). Another aspect of this adaptation to aging seems to be that activity and agency become important parts of the self-definition in old age, as they are no longer self-evident (Freund & Smith, 1999; Herzog, Franks, Markus, & Holmberg, 1998).

The *structure* of the self-concept refers to the organization of the self-concept. This organization is often investigated in terms of its complexity and integration (cf. Campbell, Assanand, & Di Paula, 2003). One classic definition of complexity (or differentiation) taps the number of nonredundant self-aspects or content categories of the self-definition (Linville, 1987). Integration often is assessed as the correlation of trait ratings across different domains of the self-concept (Donahue, Robins, Roberts, & John, 1993).

Cognitive representations of the self emerge during the 2nd year of life (cf. Harter, 1998) and can be characterized with regard to the degree of differentiation (measured in terms of correlations among different self-concept domains) as early as 4 to 5 years of age (Marsh et al., 2002). During childhood, the average correlation among self-concept domains has been shown to become smaller. This trend of decreasing integration levels off during adolescence, where no further decline in average correlations between preadolescence and late adolescence has been demonstrated (cf. Marsh et al., 2002). In contrast, there is evidence that the self-structure becomes more integrated again and that self-complexity increases between 18 and 22 years of age (Elbogen et al., 2001). For the age range from 20 to 88 years, cross-sectional findings indicate an U-shaped relationship between self-concept integration and age (Diehl et al., 2001). Currently, there is not much evidence on the rank-order stability of self-complexity or differentiation. 1-week test-retest correlations for measures of self-complexity and integration are in the .60 range (Campbell et al., 2003). No knowledge about long-term stability is available.

In sum: It seems that mean levels of integration of the self-concept increase until adolescence, decrease up to midlife and increase again thereafter. In contrast, the trajectory of self-complexity (in the sense of number of relevant self domains mentioned) follows an inverted U-shape function during adulthood. Thus, in contrast to the orthogenetic principle proposed by Heinz Werner (1926), one of the pioneers of developmental psychology, normatively there seems to be no coexistence of complexity and integration. In this vein, recently an effort has been made to develop a measure of self-concept growth, which incorporates this combination of differentiation and integration, and no significant age differences have been found during adulthood (Staudinger, Dörner, & Mickler, 2005).

Development of Self-Regulatory Processes. Having discussed some of the major evidence on the content and structure of self and personality, we turn next to results about the self-related processes. Self-regulation includes both the agentic (assimilative, primary control, problem-focused coping) and yielding qualities (accommodative, secondary control, emotion-focused coping; P. B. Baltes & Baltes, 1990b; Brandtstädter & Greve, 1994; Brandtstädter & Rothermund, 2003; Heckhausen & Schulz, 1995). Accommodative and yielding qualities have consistently been found to increase with age (e.g., Brandtstädter & Renner, 1990). Most likely this is a pragmatic response to the declines in the mechanics of life. In contrast, theoretical predictions and findings with respect to the development of agentic and assimilative qualities are inconsistent. Different authors speak of declining (Brandtstädter & Renner, 1990), stable (Heckhausen & Schulz, 1995), and even increasing

(Heckhausen, 2000) primary control across adulthood. In line with findings of increase and stability of primary control is evidence that demonstrates that older adults report elective, self-governed selection (within the model of selective optimization with compensation) as their primary action strategy (Freund & Baltes, 2002b).

Human beings are producers of their development (R. M. Lerner & Busch-Rossnagel, 1981), but there are also times when to accept the limits of our agency and to cope with challenges, threats and losses (see P. B. Baltes et al., 1998; P. B. Baltes & Smith, 2004; Brandtstädter, 1998; Staudinger & Lindenberger, 2003). And indeed, it may be that with age self-regulatory behaviors differ markedly in their prioritization. In order for people to maintain active involvement as composers of their lives, it is crucial to believe in one's ability to control and select environments, optimize outcomes, and to have compensatory strategies dealing with emotions in situations of failure and stress (e.g., Freund & Baltes, 2002b). In the following, we are interested in the developmental trajectories of various facets of self-regulation, such as (a) internal and external control beliefs, (b) emotion-regulation, as well (c) goal setting and goal pursuit.

Control and Self Efficacy Beliefs. When considering the development of control beliefs and related beliefs such as self efficacy (Bandura, 1997), one variable in the equation has to be the actual potential for control afforded by current psychological and nonpsychological resources. Based on the overall life span architecture presented earlier (P. B. Baltes, 1997), there is reason to assume that our capacity to influence outcomes in the external world follows an inverted U-shaped trajectory across the life span (primary control potential: Heckhausen & Schulz, 1995). Thus, the rise in objective control potential during childhood and adolescence may be reflected in increasing internal control beliefs, while the declining control potential in old age may be accompanied by declining internal and increasing external control beliefs. However, the ontogenesis of control beliefs is a little more complicated than this assumption would suggest.

If the two dimensions are considered separately, which is the current state of the art in research on control beliefs (E. A. Skinner, 1996), interesting differences between the development of internal and external control beliefs have been found. For instance, children from age 8 to 14 show no systematic *mean-level change* in internal control beliefs, but external control beliefs (powerful others) decline (cf. E. A. Skinner & Connell, 1986). Further, stability and even increases in internal control beliefs with increasing age are observed. In adult samples, no clear-cut changes in perceived internal control and a tendency for older adults to report more external control are found (Brandtstädter & Rothermund, 1994). A global measure of perceived internal control demonstrates increases between young adulthood and old age (up to age 75; Lachman & Weaver, 1998).

Recent findings from the Berlin Aging Study (a sample of old and very old adults) indicate that a high sense of internal control can be maintained into very old age, that is, in spite of losses and functional decline the old adults did not report diminished internal control over desirable outcomes. Simultaneously, however, mean levels of perceived others' control increased (Kunzmann, Little, & Smith, 2002). Thus, there seems to be a consistent pattern of increasing externality in control beliefs with increasing age. Results for internal control beliefs are less clear. We can conclude that beliefs in one's ability to control desirable outcomes are relatively stable during adulthood and might even show some increases with age. In other words, the belief in our agency "survives" actual losses in resources. Age differences in domain-specific control beliefs show that control over children and sex life decreases, while control over work, finances, and marriage increases between young adulthood and old age (Lachman & Weaver, 1998). Control over mental functioning and health declines in very old age (Lachman, 1991).

Selected evidence on the *rank-order stability* of control beliefs points to moderate stability estimates ranging between $r = .45$ and $r = .57$ (Brandtstädter & Rothermund, 1994; Kunzmann et al., 2002; Lachman, 1986b). In sum, findings on the stability of control beliefs suggest increases (external control) or stability (internal control) and moderate stability in interindividual differences across time.

Coping. When we turn to age-comparative research on coping, Folkman, Lazarus, Pimley, and Novacek (1987), for example, found that older respondents were less likely to seek social support or use confrontive coping and were more likely to use distancing and positive reappraisal. In fact, more and more of the recent evidence supports this "growth" view of coping in adulthood and old age (e.g., Aldwin, Sutton, & Lachman, 1996; Costa & McCrae, 1993;

Labouvie-Vief, Hakim-Larson, & Hobart, 1987; Rott & Thomae, 1991) or at least speaks for stability in coping behavior. With respect to the developmental stability of coping behavior during adult life, it has also been observed that individual differences in the endorsement of coping mechanisms are more a function of the type of stressful event than of age (McCrae, 1989).

Furthermore, older adults seem to be more flexible in adapting their coping response to the characteristics of the situation (e.g., controllability) than younger adults (e.g., Aldwin et al., 1996). Such evidence is congruent with findings that, in comparison to younger adults, older adults have been found to demonstrate an accommodative coping style in the face of adversity or failure; that is, older adults were more flexible and better able to adjust their strivings to changed circumstances than were young adults (Brandtstädter & Renner, 1990). Conversely, younger adults were more likely to adhere to their once established goals (i.e., assimilative coping), even if they were no longer realizable. With age, Brandtstädter and Renner (1990) have demonstrated that adults favor *accommodative* (goal flexible) over *assimilative* (goal persistent) coping. In a similar vein, Heckhausen and Schulz (1993) have proposed and presented empirical evidence (Heckhausen, 2000) that an age-related shift from *primary* to *secondary control* strategies takes place in order to master the tasks of aging.

Personal Life Investment (PLI) and the Goal System. Self-regulation is also reflected in goal setting and goal pursuit (cf. Cantor & Blanton, 1996). The *goals* people hold at different points in their life and how they try to achieve these goals in part are reflections of developmental contexts and developmental tasks. For instance, although family related goals are prominent throughout adulthood, young adults frequently mention marriage and family goals, whereas the goals of middle-aged adults relate to the lives of their children (Nurmi, 1992). Another well-established finding is that occupational goals lose priority with increasing age, while health-related pursuits do gain (e.g., Frazier, Hooker, Johnson, & Klaus, 2000). Ryff (1989b) demonstrated that younger people strive for accomplishment and career, whereas older people are more likely to aim at good health and the ability to accept change. In another vein, Riediger, Freund, and Baltes (2005) have suggested that the degree of goal convergence and interference may be considered another kind of relevant age-related change in the goal system.

Thus, whether the goal system shows more change or stability seems to be an issue of perspective. Although change in the goal system is evident, continuity has also been demonstrated (Frazier et al., 2000; Smith & Freund, 2002). For instance, across a 5-year period, people in late adulthood and old age tended to consistently mention the same domains of possible (future) selves at two measurement occasions (Frazier et al., 2000). And even for the old and oldest old more stability than change was reported with regard to the domains of possible selves across a 4-year period (Smith & Freund, 2002). Obviously, as was true for our discussion of the trait literature, evidence suggests that continuity as well as discontinuity play a role in age-related changes of the goal system.

Personal life investment (PLI), one aspect of the goal system, is defined as the amount of energy and effort (in terms of both acting and thinking) that people invest in central life domains (e.g., Staudinger et al., 1999). This broad conception of investment in terms of thought and action allows to capture all aspects of the motivational process, that is, goal selection, planning, and goal pursuit, but also disengagement from blocked goals and restructuring of goal hierarchies. The development of PLI in ten life domains (health, cognitive fitness, independence, well-being of one's family, relationships with friends, sexuality, hobbies, one's occupation or similar activities, thinking about one's life, and one's death and dying) has been studied across the entire adult life span.

Cross-sectional evidence from a sample ranging in age from 14 to 103 years demonstrated that the investment patterns across these ten life domains indeed reflect the developmental tasks of the respective life periods (Staudinger & Schindler, 2005). Certainly, age and its related social and biological demands is only one developmental context influencing investment patterns. In addition, socioeconomic characteristics and personality play an important role in moderating age-related differences in investment patterns. Finally, a distinction between investment related to age-graded societal and biological demands (obligatory) and self-selected investment (optional) turned out to be useful. These two types of investments follow stable and declining trajectories, respectively, as analyses with the longitudinal data from the BASE showed (Schindler & Staudinger, 2005b).

Summary on Stability and Change in Personality across the Life Span

Considering the evidence on the development of personality structure presents only half of the picture. Without the investigation of personality processes, we may be lead to think that personality and aging is about some increases in social adaptation and decreases in personal growth. Taking self-regulation and developmental regulation into account, however, "complicates" the story. Yes, there is stability that can be associated with enduring genetic and contextual influences. And there is a psychological need for coherence and stability that allows us to have a sense of enduring self. Stability, however, should not be completely equated with standstill. Rather, stability is also reflective of resilience. Considerable regulatory processes "produce" that stability. In addition to biological changes, change on the structural level of personality occurs when self-regulation cannot withstand the pressure for modification any longer. In the future, we need to better understand the biological underpinnings of personality functioning and how they change with age and interact with contextual features and individual choices.

Reserve Capacities of Self and Personality Development

As a further life span problematic, we have selected the notion of reserve capacity and resilience for further elaboration. This notion gains special importance for a functional perspective on personality development, that is, for perspectives that aim at an analysis of the orchestration of self and personality as a system of adaptive functioning. The topic of reserve capacity and resilience in the domain of self and personality relates to the allocation of resources introduced earlier but discusses this theme at a more microanalytic level of analysis. What are the self-related mechanisms and characteristics that either show or contribute to reserve capacity?

Traditionally, the central role of reserve capacity, or related concepts such as resilience, is articulated within the province of child development (e.g., Cicchetti & Cohen, 1995). More recently, this view was extended to include adulthood and old age (e.g., Brandtstädter, Wentura, & Rothermund, 1999; Staudinger et al., 1995; Vaillant, 1993). For the present purpose we have chosen aging as a forum of illustration. We make this selection for several reasons. One is the relative novelty of this age period for researchers in child development. Another is because presenting research on aging permits us to elaborate more clearly the theme of gains and losses and the dynamic of differential allocation of resources into growth, maintenance, and management of losses.

We discussed that there is little or no correlation between age and trait-based personality structure. In a similar vein, there is little correlation between age and various self-related indicators of adaptation (e.g., P. B. Baltes, 1993; Brandtstädter, Wentura, & Greve, 1993), including self-esteem (e.g., Bengtson et al., 1985), sense of personal control (e.g., Lachman, 1986b), or happiness and subjective well-being (e.g., Costa et al., 1987; Ryff, 1989a). This also includes 70- to 80-year-olds (J. Smith & Baltes, 1993). Only in advanced old age, do we seem to observe more salient changes toward a lower level of desirable functioning in trait-like dispositions (P. B. Baltes & Smith, 2003; J. Smith & Baltes, 1999). Thus, on the group level, for the larger part of the adult age spectrum, age does not seem to be a "risk" factor for these aspects of the personality system (note, however, that age challenges become larger when comparison with younger ages are requested).

The absence of strong relationships between age and self-related indicators of well-being, despite what we have characterized above as an increase in risks and potential losses with advancing age, but also for certain especially disadvantaged groups, is theoretically and methodologically important. Indeed, the discrepancy between an increasing number of risks on the one hand, and maintenance of adaptive functioning in the self on the other, is perhaps one of the most persuasive indicators of the power of the personality system in dealing with reality (P. B. Baltes & Baltes, 1990b; Greve & Staudinger, in press; Staudinger et al., 1995). It is suggested that the personality system exhibits resilience, or reserve capacity, in the face of age-related risks and primarily health-related losses. In a similar way, it has been argued in childhood research conducted in the field of developmental psychopathology that certain self and environment constellations allow maintenance of adaptive development even in the face of adversity (e.g., Garmezy, 1991).

Multiple arguments can be presented to understand this discrepancy between an age-related increase in risks and stability in self-related indicators of well-being (Staudinger, 2000). First and foremost, the self applies various protective mechanisms to reinterpret or transform reality in the interest of maintaining or regaining levels of well-being (e.g., M. M. Baltes &

Baltes, 1986; Filipp, 1996; Greve & Wentura, 2003). Second, age is only a rough proxy of increasing risks; not everyone of a given age cohort needs to be concerned by them. Therefore, the negative effects need not necessarily show on a group level. Third, as just argued, the self has a strong interest in continuity and growth. Over a given period of time, the self adapts to even adverse circumstances as if nothing or not much has happened. Thus, for researchers interested in the "self at work," it seems crucial at which point in this adaptive process the assessment takes place. Fourth, the changes due to increasing risks may be chronic rather than acute and therefore might not affect the self suddenly, but gradually. It may be difficult, therefore, for the self to recognize them and reflect them in self-report measures.

In the following, we will illustrate the reserve capacity of the personality system by citing select findings ordered according to the distinction introduced above between (a) form and structure of the personality system and (b) self-regulatory and self-transformational processes. Except for few studies with objective indicators of adaptivity, such as longevity or professional success, in most of the studies adaptivity is measured by self-report indicators of well-being. First, with regard to form or structure we will highlight information on differences in the adaptive fitness of personality and self profiles. Second, we will select evidence on the adaptive value of self-regulatory processes in three domains for further illustration of life span developmental changes: (1) goal seeking and reorganization; (2) self-evaluative comparison processes; and (3) coping. Finally, note that the protective mechanisms described in the following are an inherent part of theories of successful development such as the theory of selective optimization with compensation (P. B. Baltes & Baltes, 1990b).

Evidence for Reserve Capacity in Indicators of Personality Structure

There is longitudinal and cross-sectional evidence that individual differences in largely stable personality characteristics contribute to level of adaptation and sometimes even advances. From a life span perspective, it is important to note that the adaptive patterns differ somewhat depending on the first time of assessment (i.e., adolescence or adulthood) and thus whether short- or long-term predictions are involved. This applies especially to two traits widely assumed to constitute a risk or a protective factor, that is, neuroticism and optimism or cheerfulness (Friedman et al., 1995; Scheier & Carver, 1987). One possible explanation for the contradictory finding with regard to cheerfulness and optimism might be that cheerfulness in adolescence is linked to certain risk behaviors whereas optimism in adulthood is related to higher levels of positive emotions, which have protective effects in the face of stress (e.g., Fredrickson & Levenson, 1998). As very few life time studies are available, our knowledge about the long-term protective personality profile to date is still limited. Nevertheless, it seems safe to say that across a number of studies, positive expressions of the following personality characteristics have been demonstrated to mostly contribute to positive outcomes, thus, can be called general-purpose mechanisms (cf. Friedman et al., 1995; Helson & Wink, 1987; Manners & Durkin, 2000; Peterson, Seligman, Yurko, Martin, & Friedman, 1998): *Conscientiousness, extraversion, openness to experience, behavioral flexibility, ego resilience, ego level, internal control or agency (efficacy) beliefs, and cognitive investment.*

Another strand of research focuses less on trait-based personality characteristics than on the structure and content of self-conceptions. Evidence is accruing that a positive, multifocal and diversified, yet integrated structure of priorities and self-conceptions, or identity projects, makes transactive adaptation to developmental changes easier (e.g., Diehl et al., 2001; Freund, 1995; Riediger et al., 2005).

It is recent work that has shown that understanding the adaptivity of self-definitions is more complex than first thought. Combining dimensions like quantity, richness, positivity, integration, and importance of self-definitions, as well as differentiating real and potential selves in one theoretical framework will be an important step in capturing the adaptive life span dynamics of self-knowledge. Very important also seems a more explicit recognition of contextual factors including issues of collective self-concepts such as among spouses (M. M. Baltes & Carstensen, 1999; Hermans, 1996).

Evidence for Reserve Capacity in Self-Regulatory Processes: The Goal System and Self Evaluation

Selection of Goals and Life Priorities. Life span theory (P. B. Baltes, 1997) emphasizes the critical importance of selection of domains and life priorities for effective regulation of developmental processes such as advancement, maintenance, recovery and regulation of loss. In this sense, personality traits as well as possible selves act as motivational sources, and are linked to goals that are either strived for or avoided.

The evidence on life span development of life priorities and personal life investment patterns reported above indeed points to selection into individual life contexts and the importance of internal and external contexts in defining salient features of the self across the life span (see also Brandtstädter & Rothermund, 1994; Cantor & Fleeson, 1994; Carstensen, 1995; Staudinger & Schindler, 2005). Socioemotional selectivity theory, for instance, argues for systematic and adaptive life span changes in social goals over the life span (e.g., Carstensen et al., 1999). So, temporal constraints like impending end of life may shift the criteria used for selecting social relationships, requiring a corresponding change in the criteria for judging a particular relationship as adaptive (e.g., Carstensen et al., 1999).

Beyond the social realm, the adaptive value of life priorities in general seems to change. For example, older adults find meaning in life predominantly by searching for "contentment," whereas younger adults report searching for "happiness" (Dittmann-Kohli, 1991). Younger people tend to assess their subjective well-being in terms of accomplishments and careers, whereas older people associate well-being with good health and the ability to accept change (Ryff, 1989a). These changes are highly adaptive and illustrate the importance of flexibility—giving up or reducing investment in those roles and commitments that are no longer available, and investing in commitments which fit current conditions of living (e.g., Brim, 1992; Dittmann-Kohli, 1991; Freund & Baltes, 2002b). Flexibility in goals and investments, or priorities, is of course facilitated by a rich variety of self-defining concepts to select from and prioritize. In this sense, a rich variety of interrelated but well-articulated life goals is part of a person's developmental reserve capacity (cf. Staudinger et al., 1995; Riediger et al., 2005).

In addition to the repertoire and selection of goals, other facets of goal pursuit also relate to adaptation. Achieving a goal is usually adaptive, but the meaningfulness of the goal and the degree of commitment to it may enhance or limit that adaptivity (see also Brunstein, 1993; Emmons, 1996). Further, one must act; one study demonstrated that the relationship between people's goals and well-being was primarily mediated through doing more in the selected domain (Holahan, 1988; see also Harlow & Cantor, 1996). Recent evidence suggests that the pursuit of approach goals (or hoped-for selves) is related to greater well-being, while that of avoidance goals (or feared-for selves) relates to less well-being (e.g., Carver & Scheier, 2003; Elliot, Sheldon, & Church, 1997). Most of this research is done with young adults and much less is known about changes over the life span. Due to reduced resources and increased risks, avoidance goals seem to be more prevalent in later life and lose the dysfunctional effect which they evince in young adulthood (Freund & Ebner, in press). In old age it is the maintenance goals that demonstrate the highest adaptive value.

The adaptiveness of goal investment is also altered by life circumstances. Given highly restrictive life circumstances, such as major health constraints, concentration on a few selected goals rather than many helps to sustain levels of subjective well-being (Staudinger & Fleeson, 1996). This finding has been replicated with longitudinal data from the Berlin Aging Study (Schindler & Staudinger, 2005b). When considering a life span sample, it was found that it is during middle adulthood and into old age that the exact composition of the investment pattern (i.e., the selection pattern) contributes significantly to subjective well-being (Staudinger & Schindler, 2005).

The Adaptive Value of Self-Evaluations. In addition to changes in content, ranking, and valence of self-concepts and goals, self-evaluative processes can be considered protective or risk factors. Three motives of self-evaluation (see Fiske & Taylor, 1991) can serve protective functions—self-verification, self-enhancement (e.g., Taylor & Brown, 1988), and self-improvement (e.g., Taylor, Neter, & Wayment, 1995).

General statements such as "positive illusions are adaptive" are simplistic (cf. Taylor & Brown, 1988; Colvin & Block, 1994; Baumeister, 1989). It's important to know when positive illusions are adaptive (e.g., at which point in the action sequence; see e.g., Schwarz & Bohner, 1996). It may, for instance, be adaptive to have positive illusions before the action is completed to maintain motivation. But it may be dysfunctional to maintain positive illusions during implementation and when interpreting outcomes, because this reduces the likelihood of an adequate response (Oettingen, 1997). Consistent with this reasoning, people think more realistically when setting goals than when implementing them (Taylor & Gollwitzer, 1995). The particular content of the illusions is also important. For example, positive expectations about behavior outcomes contrasted with negative fantasies about the same outcome can result in the best behavioral outcome (Oettingen, 1996). Such unresolved recent issues qualify the existing literature on the adaptivity of self-evaluations, which we address next.

Self-Evaluation: Social Comparisons. Goals shift in any activity during the life span, and those shifts lead to shifts in the selection and weighting of comparative information (Bandura & Cervone, 1983; Frey & Ruble, 1990). Individuals also modify their self-evaluative standards within a given domain in order to adapt to decreases in their behavioral competence or negative changes in their health condition, thus maintaining stability in their self-views (Buunk & Gibbons, 1997; Frey & Ruble, 1990).

Social comparison and other forms of interactive minds (P. B. Baltes & Staudinger, 1996a) are one important mechanism of self-regulation (e.g., Wood, 1996). New reference groups are selected or sometimes even constructed in order to permit a reorganization of personal standards of evaluation (e.g., Buunk, 1994). Downward comparisons, in which individuals compare themselves to people who are worse off in a relevant domain of functioning, may become more important with age, increasing levels of risk, or losses that cannot be remedied through instrumental action (e.g., Filipp & Mayer, 2005; Heckhausen & Krueger, 1993; Heidrich & Ryff, 1993). Of course, little is known about the level of consciousness at which people make such comparisons in everyday life.

The downward comparison story is not as simple as it seems, however (see also Wood, 1996). The operationalization of downward social comparisons varies markedly between studies. Some studies evaluate spontaneous reasons for self-evaluations provided "on-line," which are later coded for comparison standards. Other studies ask in retrospect for the frequency with which social upward, downward, and lateral comparisons are made and relate this to measures of well-being (e.g., Filipp & Buch-Bartos, 1994). Still other studies have participants rate themselves and a generalized other on certain personality dimensions, and then indirectly infer upward or downward comparisons (e.g., Heckhausen & Krueger, 1993). As suggested above, the most critical issue for adaptivity may be the use of the most functional comparison at the appropriate time during the person-situation transaction, something seldom addressed in these studies.

Self-Evaluation: Lifetime Comparisons. Besides social comparisons, comparisons with oneself at different times in the life span constitute an important resource for the self. As noted earlier, evidence on lifetime trajectories of social and lifetime comparisons remains scarce. In one study, higher frequency of future-oriented comparisons by older participants was related to lower well-being (Fillip & Buch-Bartos, 1994). In contrast, drawing on past successes in difficult situations can produce adaptive outcomes (Aldwin, Sutton, Chiara, & Spiro, 1996; see also Staudinger & Fleeson, 1996). Obviously, it is critical to distinguish between upward and downward temporal comparisons, as past and future comparisons can involve standards of better or worse functioning. It is not the temporal comparison per se that is protective or damaging; rather, depending on the characteristic or domain, and on the point in the self-regulatory process, lifetime comparisons can result in an enhanced self-evaluation or a sense of loss and decline. Selectively attending to positive aspects of the self at different points in the lifetime can support a positive sense of self at the present. The endorsement of selective lifetime comparisons may contribute to the lack of age differences in concurrent self-evaluations.

Longitudinal work has demonstrated that self-perceived personality change may be biased by what one might call "time enhancement" (Woodruff & Birren, 1972). Participants perceive improvement as compared to their own past, whereas the actual ratings collected at the two occasions (25 years apart) did not reveal significant change (see also Ross, 1997). Unfortunately, no interactions with age in this tendency to upgrade the past were tested. Other work on self-perceived personality change shows that discrepancies between ratings of past, present, future, and ideal personality are especially pronounced for young adults and hardly existent for older adults (Ryff, 1991; see also Ross & Bühler, 2001). It seems adaptive—and in line with respective developmental tasks—for young adults to strive for improvement and thus perceiving the past and the future to be of a different category (contrast effect; Schwarz & Strack, 1999). While for older adults, with decreasing resources, it seems adaptive to conceive of the future as being close to the present and the past and perceiving them as belonging to one category (assimilation effect; Schwarz & Strack, 1999). In this vein, a recent study found that in old age perceptions of ourselves in the past and the future have a stronger predictive value for our well-being in the present than in young and middle adulthood, which may in fact contribute to perceiving fewer changes (Staudinger, Bluck, & Herzberg, 2003).

Persons' current view of themselves may not be meaningful unless we also understand how they believe they once were and will become. Being moderately extraverted in the present when having been very extraverted in the past has different implications for well-being than being moderately extraverted in the present and introverted in the past. Fleeson and Baltes (1998) showed that past and future ratings of personality predicted well-being above and beyond present ratings. When only current personality is assessed, the absence of information about change may mask relationships between personality perceptions and well-being (see also Fleeson & Heckhausen, 1997). Similar cautions apply to goal assessments. Regrets about past, unattained goals predict lower subjective well-being over and above current goal ratings and general tendencies toward negative affect (Lecci, Okun, & Karoly, 1994).

Coping and Control Strategies: Further Evidence for Reserve Capacity Related to Self-Regulatory Processes

In contemporary contextual models of coping (e.g., Brandtstädter & Greve, 1994; Filipp, 1999; Heckhausen & Schulz, 1995; Lazarus, 1996; Staudinger et al., 1995) questions of adaptivity are conditioned on the particular situation, including all its inherent constraints and demands. Whether a coping behavior is adaptive depends entirely on who does it, in response to which stressor, and in which situation the behavior occurs. In this vein, increasing evidence highlights the importance of context. For example, depending on a person's level of physical impairment, different coping styles are related to subjective well-being (Aldwin & Revenson, 1987; Staudinger & Fleeson, 1996). What has been labeled "regressive" and thus dysfunctional coping under "normal" living circumstances (e.g., "I like someone to take over," "denial," "I give up") is functional under conditions of physical impairment. Thus, older adults' "regression" in coping styles may be adaptive, given higher incidences of physical constraints (Staudinger et al., 1999). Of course, even "normally" adaptive behaviors are noneffective if not well executed (e.g., Suls & David, 1996).

Beyond the adaptivity of specific coping behaviors, it is important to have multiple coping options to choose from, while retaining some selectivity. Those old individuals who report selective flexibility in coping, that is endorsing some coping styles very strongly and others not at all, also demonstrate high levels of well-being (Staudinger & Fleeson, 1996). Similar findings are reported for coping with depression in old age. Rather than any particular form of coping, better mental health means being able to choose from several different responses (Forster & Gallagher, 1986). In a similar vein, the integrated multiplicity and selectivity (with regard to importance) of self-definitions has protective value, and social relations with multiple functions are a richer resource than other types of relationships (for an overview, see Staudinger et al., 1995). This evidence suggests that access to, and flexible selection from, a repertoire of regulating functions or characteristics (e.g., coping, self-definitions, functions of a relationship, life investments) may be a key resource used by individuals in proactive adaptation.

People obviously show highly adaptive coping behavior well into old age. In contrast to stereotypical views of the elderly as rigid, the evidence based on social-cognitive processes of self-representation, self-regulation, and self-enhancement, points to a substantial capacity for adjustment to and mastery of life's demands. Of course, this capacity for adaptation may find its limits in extreme situations, such as the challenges of advanced old age (P. B. Baltes & Smith, 2003; J. Smith & Baltes, 1999).

Many facets of coping and control processes remain uninvestigated or poorly understood, however, including the microgenesis of coping processes (e.g., Lazarus, 1996). To outline one example—findings suggest that the critical factors in success at quitting cigarette smoking involve being reflective and thoughtful (e.g., emotion/self-focused) at a planning stage and then problem-focused and behavioral during the actual quitting process (Perz, DiClemente, & Carbonari, 1996). As in the case of self-evaluative cognitions, it is also crucial to focus on the timing of coping. We need to consider which coping behavior is exhibited at which point in the coping process (e.g., Suls, David, & Harvey, 1996). For instance, longitudinal studies in the domain of coping with cancer (e.g., Filipp, 1999) and with death of a close person (e.g., Wortman & Silver, 2001) demonstrated that coping strategies such as "minimizing the threat" and "wish for someone to take over" maintained their adaptive power across a period of 9 months after the critical event. In contrast, the strategy "rumination" only showed positive relations during the first 3 months and turned into being maladaptive thereafter.

Summarizing Foci and Facets of Personality Development across the Life Span

In this section, we brought together theory and research from three different areas of research, that is, trait personality, the self-system, and self-regulatory processes. Each of these areas is characterized by their own foci and methodological approaches. We have argued that a life span perspective on personality development, rather than viewing these three approaches as relatively independent from each other or even mutually exclusive, tries to incorporate and integrate theoretical and empirical evidence from these fields. Dynamic systems theory and similar theoretical perspectives such as models of successful development provide useful theoretical guidance for this endeavor.

1. A central feature of personality development is the emergence of structure and of an associated system of self-regulatory mechanisms that mediate successful transactional adaptation. Beginning in childhood, we obtain solid evidence for structure, a sense of coherence, and some stable modes of adaptive behavior (e.g., Caspi & Bem, 1990). Such a view is represented in dynamic-system models of development (Magnusson, 1996), where principles of structural emergence and self-organization are critical for successful ontogenesis. Structural organization and coherence of personality, self, and self-regulatory mechanisms are a necessary precondition (constraint) for adaptive fitness and further growth. In this sense, the ensemble of features described function as general-purpose mechanisms.

2. Theory and research have advanced beyond the traditional trait versus change contrast. Traits themselves are part of the dynamic personality system. Thus, even stability is developmental in the sense that it is the result of surviving continuous challenge. Indeed, we do change during adulthood and old age but to a degree that does not jeopardize our sense of continuity. Personality development is characterized by a dialectic between trait expressions and self-regulation at work.

3. We have started to explore the fertility of extending the distinction between the biologically driven cognitive mechanics and the culturally driven cognitive pragmatics to also cover the field of personality functioning. The result of this endeavor is a heuristic model that distinguishes between the biologically driven mechanics and the culturally driven pragmatics of life. The two neurophysiological indicators selected to represent the mechanics of life, that is, heart rate activity and cerebral asymmetry, seem to evince less steep increases in the beginning and lesser decreases at the end of life; as well as lower longitudinal stability of interindividual differences when compared with the developmental evidence that is available about the life mechanics of cognition. One source of this difference in trajectories may be that for evolutionary reasons children are already further developed with regard to basic emotional and motivational tendencies than in terms of higher cognitive functions. Consequently, we may speculate that following the law of "first in, last out" these basic indicators of emotional and motivational functioning maintain higher levels of functioning until later in life than indicators of the cognitive mechanics. Such an interpretation would make it understandable why many personality mechanisms are well-preserved into older ages and only demonstrate decline when the oldest-old are considered.

4. There has been no systematic work as of yet on the interaction between the life mechanics and pragmatics of personality. Also our knowledge about the links between the neurophysiological and the behavioral level are still at the beginning. Thus, our insight into the functional relations between the life mechanics and pragmatics in that regard is rather limited. Nevertheless, the limited evidence available foreshadows the rich and complex interactions taking place along the continuum between the life mechanics and pragmatics of personality. The picture is further complicated by the special role of the self in the development of the mechanics and pragmatics of life. The self is not merely a developing element in this system, but also has an orchestrating function, coordinating cognitive, emotional, and motivational development. When it comes to life as a whole, the self can be postulated to play a central role in organizing our actions and thoughts, but we need to recognize that at least the consciously agentic self is but part of organizing behaviors.

5. Against this background, we suggest that in the domain of the personality system, developmental increases and stability dynamics extend over longer time spans than is true for the domain of cognition qua cognition. In fact, we have argued that the losses and stressors of adult life may even result in advances regarding the acquisition and refinement of self-regulatory skills. Still, when studying the resilience of the aging self, we also need to take into consideration whether the underlying physiological and neurological systems have a debilitating and/or facilitating influence on self and personality functioning. The less positive evidence on personality functioning in the oldest old supports this conjecture.

6. Personality as a dynamic system composed of various components with different properties holds a domain-general potential for the transactional adaptation of the developing organism. We argued and presented evidence that personality serves an executive or orchestrating function with regard to the management of gains and losses during ontogeny. Personality possesses a great ability to negotiate the opportunities and constraints of development that come with age, historical, and idiosyncratic conditions. What we have called general-purpose mechanisms play a central role in this adaptational process. Besides protective personality structure and content, it is primarily the availability of a rich variety of self-regulatory mechanisms, and of an adaptive algorithm which monitors their application, that contribute to the adaptational power of personality. Table 11.6 summarizes these protective features in more detail. This adaptive potential reaches its limits in very old age when, due to biological processes, the functional losses may for more and more persons reach an overwhelming degree or at earlier ages when other extreme life circumstances result in an imbalance of gains and losses.

TABLE 11.6 Summary of Protective and Optimizing Characteristics of Self and Personality

Self and Personality Components	Protective and Optimizing Characteristics (Examples)
Personality	Conscientiousness, extraversion, openness to experience, behavioral flexibility, ego resilience, advanced ego level, and cognitive investment
Self-concept	Interrelated, well-articulated variety of self-conceptions and life priorities
	Positive agency (efficacy) beliefs
Self-regulatory and life-management mechanisms	
–Self-evaluation	Application of a functional type of comparison (up, down, lateral, temporal) at the appropriate time in the adaptational process
–Goal setting and restructuring	Selection and reorganization of life priorities
–Coping styles	Intraindividual variability and flexibility in coping styles and compensatory strategies
	Flexibility in adapting goals to circumstances
–Systemic processes	Selective optimization with compensation (SOC)

7. The systemic and overall developmental theory of selective optimization with compensation introduced in the first part of this chapter serves as a useful theoretical tool when analyzing the adaptive potential of the self and personality (P. B. Baltes & Baltes, 1990b). When orchestrating the optimization of development by processes such as selection and compensation, the appraisal of resources is of central importance. Questions such as how to evolve a goal structure and the associated goal-relevant means and motivational investment strategies, how to deal with selection-related disengagements from other possible goals, when to accept a loss and reorient one's life, and when to still strive harder because current behavior is not yet employed to its fullest capability become crucial in composing life development. Brim has argued, for example, that one criterion for making this decision could be to consider something like a "performance/capacity ratio" (Brim, 1992). According to this ratio, acceptance of a certain loss becomes necessary when the display of the behavior requires a "dysfunctionally" high amount of reserve capacity.

CONCLUDING COMMENTARY

The purpose of this chapter was to present life span developmental psychology as a theoretical orientation to the study of human development. Because the dominant theoretical approaches in developmental psychology have been formed primarily by research on infants, children, and adolescents, we made special efforts to highlight the uniqueness in developmental theory that emanates from a life span developmental framework. An unfortunate by-product of this strategy of presentation may have been the relative inattention paid to important commonalities between age-specialized developmental theories and theoretical efforts in life span work.

There is a larger (and growing) commonality in theoretical approach between more age-specialized developmental theories and life span developmental theory than might appear to be true based on the arguments presented in this chapter. In part, this is true because there are several new sources (only alluded to in this chapter) from which innovative theoretical efforts in various quarters of developmental psychology have emerged and which contain a structure of arguments similar to those put forward in the short history of life span developmental theory. Work in cultural psychology, dynamic systems theory, and on other forms of self-organization in ontogenesis, are examples of this new theoretical treatment of ontogenesis that is beginning to pervade the developmental field as a whole.

As was true for life span psychology and the benefits it derived from its contact with the biology of aging, these new kinds of theoretical treatments have benefited from transdisciplinary dialogue, especially with modern developmental biologists but also anthropologists. Biologists have perhaps led the way in moving research away from unilinear, organismic, and deterministic models of ontogenesis to a theoretical framework that highlights the contextual, adaptive, probabilistic, and self-organizational dynamic aspects of ontogenesis (P. B. Baltes & Graf, 1996; Magnusson, 1996). Similarly, cultural psychologists and anthropologists (e.g., Cole, 1996; Durham, 1991; Valsiner & Lawrence, 1997) have succeeded equally in convincingly demonstrating that human ontogenesis is not only strongly conditioned by culture, but that the architecture of human development is essentially incomplete as to the culturally engineered pathways and possible endpoints (P. B. Baltes, 1997).

Not the least because of this transdisciplinary dialogue, a new conception has emerged regarding the "nature" (Kagan, 1984) of human development. In the modern context, the nature of human development no longer refers to the fixed-biological (P. B. Baltes, 1991; R. M. Lerner, 1984; Magnusson, 1996). Rather, in modern versions of ontogenesis, its nature is both biological and cultural, and both of these categories are subject to dynamic and interactive changes as well as systemic transformations. Of all developmental specialties, life span development, because of its intimate connection with long-term processes of individual development, cultural evolution, and generational transmission is perhaps the field most dependent on, and committed to, such views (e.g., P. B. Baltes, Reuter-Lorenz, & Rösler, 2006; P. B. Baltes & Smith, 2004; S.-C. Li, 2003). Most recently, the emergence of the concept of biocultural co-constructionsim is another justification of this orientation.

The future of life span developmental theory will depend significantly on the extent to which the metatheoretical perspectives advanced turn out to be useful in the conduct of empirical inquiry. On this score, the 1980s have witnessed impressive growth. In the area of intellectual development (see following), for instance, we now have available a cohort- and age-sequential study that extends over close to 50 years (Schaie, 2005) and demonstrates the varied conditions and outcomes which we can observe when placing adult development into the context of historical change and, in addition, consider processes of individual differentiation. There also have been advances in demonstrating the usefulness of the life span approach for other specialties such as clinical (Staudinger et al., 1995; Vaillant, 1990) and applied psychology (Abraham & Hansson, 1995; B. B. Baltes & Dickson, 2001; Sterns & Dorsett, 1994). In fact, these intersects of the life span approach to the study of human development with other psychological specialties need to be identified and nurtured.

Close to 25 years ago, one of us wrote: "There can be no strong field of life span developmental psychology without a solid foundation in and connection to childhood. By the same token, the study of child development does not exist in a vacuum, but is vitally enriched by considering the aftermath of childhood" (P. B. Baltes, 1979b, p. 1). Since then, there has been much progress in elaborating this reciprocal connection between age-focused developmental specialities and their integration into a life span view of human development, but at the same time, this challenge continues to be with us.

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