1 Introduction

1.1 Theoretical and Practical Relevance

Intellectual abilities have always fascinated people. Whole branches of industry deal with the question of which talents and gifts a person has and how they can be used effectively. Despite the variety of suggested ability constructs, research has concentrated on classical academic intelligence, namely reasoning, memory, speed and creativity measured visually with verbal, numerical and figural-spatial material. Although academic intelligence is an important predictor of educational and professional success, it is limited in predicting successful functioning in everyday life (Brody, 1992; Stankov, 1999). In order to cover the spectrum of human cognitive abilities more broadly, several authors began to integrate other intelligences and abilities in their models and tests (see Dulewicz & Higgs, 2000). Gardner (1983) added to classical academic intelligence by including musical-, kinesthetic-, and intra- and interpersonal intelligence. Guilford (1967) integrated social intelligence as well as auditory abilities in his Structure-of-Intellect Model (SOI model). Further approaches widening the intelligence construct include practical intelligence (Sternberg & Wagner, 1986); emotional intelligence (Goleman, 1995); success intelligence (Sternberg, 1997a, 2005); operative intelligence (Dörner, 1986); learning ability (Guthke, 1972); cultural intelligence (Early & Ang, 2003; Sternberg & Grigorenko, 2006); and, recently, sexual intelligence, psychosomatic intelligence, spiritual intelligence, network intelligence and intuitive intelligence (see e.g. Furnham, 2005). According to Weber and Westmeyer (2001), the many new intelligence constructs proposed in the last few years may make the construct of intelligence non-functional. The authors point to the important fact that in differential and diagnostic psychology there is a relative carelessness concerning the introduction of new constructs that lack empirical evidence. However, there is still no consensus about the conditions that have to be met in order to propose a valid construct. Construct validity (CV) concerns the extent to which a measure reflects accurately the variability among objects as they are arrayed along the underlying (latent) continuum to which the construct refers (Sechrest, 2005). Since an underlying variable cannot be directly observed, there are no hard and absolute criteria telling us that CV is established. Nevertheless, indications for construct validity do exist, for example when a potential audience believes that the construct has been defined in a satisfactory way, that the measure captures what is implied by the definition and that scores on the measure are related to broader phenomena implied by the idea of the construct (see Cronbach & Meehl, 1955; Sechrest, 2005). Many of the just mentioned attempts to widen the intelligence construct neither make use of the just specified and additional (see chapter 1.2) indications that indicate CV nor do they examine them and proved their fulfillment. However, there are theoretical as well as practical reasons not to extend the general criticism of the so-called “inflation of intelligences” to constructs like social and auditory intelligence. In this book I will use a framework to examine the CV of both constructs.

According to Cronbach and Meehl (1955), to be judged as valid, a construct has to demonstrate its place in the nomological net of related and empirically established constructs. In order to consider a domain of intelligence as truly separate from general intelligence there must be theoretical justification and empirical support. I will argue that social intelligence and auditory intelligence meet these criteria. Social intelligence (SI) can be understood via many sensory avenues, including auditory functions among others (e.g., vision). Auditory intelligence (AuI) can be understood as a sensory avenue that can be expressed via other intelligences, including social intelligence (e.g., also general intelligence). See Figure 1-1 for a visual conceptualization of social intelligence, auditory intelligence, and how they fit within the broader context of general intelligence.

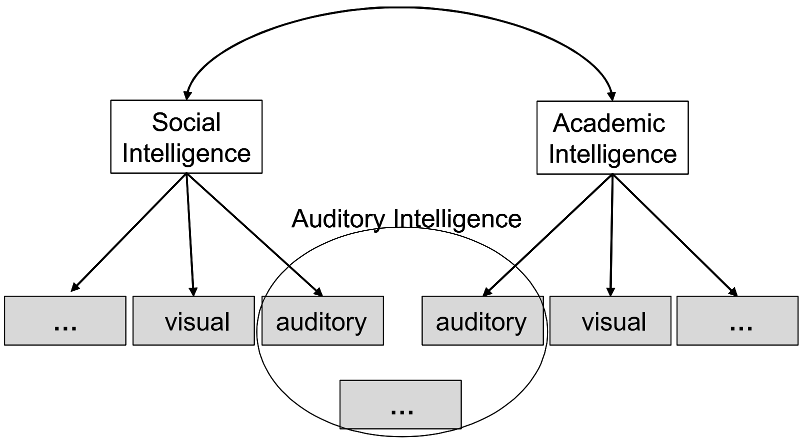

Figure 1-1: Conceptualization of Intelligence

In contrast to other new constructs (e.g., emotional intelligence), social intelligence has quite a long research tradition since it was first introduced by Dewey (1909, cited in Landy, 2006), not long after research in academic intelligence began. Recognition of the importance of social abilities has increased enormously during the last few years and they are now identified as among the most success-relevant characteristics in different jobs (e.g., Bundesinstitut für Berufsbildung, 1998; Frey & Balzer, 2003; Huffcutt, Conway, & Roth, 2001; Nigsch, 1999; Porath & Bateman, 2006; Rosenstiel, 2001; Schmidt, 2002; Schuler & Funke, 1995; Seyfried, 1995), as well as in private life (e.g. Kanning, 2002). Because of increasingly complex tasks and their higher demands, modern jobs often require more certifications, greater responsibilities and more teamwork skills in the context of globalisation. According to a study carried out by the German Institute of Job Education (Bundesinstitut für Berufsbildung, BIBB), social competences were rated as highly important in about three quarters of 4000 job offers (BIBB, 1998). Social competences are required in nearly every situation that concerns interactions with other people. Such situations include introducing new people to a group, educating children, and avoiding misconceptions during email reading or talking to people on the phone. Both basic and complex social abilities are important. Remembering what another person said in a conversation about a friend's problems is an example of a basic social ability. Asserting one's own position while respecting others' opinions is an example of a complex social ability. Both basic and complex social abilities require cognitive abilities. Such cognitive abilities include perception (e.g. perceiving a certain mood when meeting new people), memory (e.g. remembering the faces of school children in a class), understanding (e.g. understanding the feelings, thoughts and relationships of a certain person) and creativity (thinking about possible ways to resolve a socially difficult problem, e.g. an inheritance dispute). The diversity of social abilities and their applications indicates that social intelligence is likely to be a multidimensional construct consisting of dimensions such as perception, memory, understanding, and creativity. In addition, both vision and audition appear to be important for the expression and reception of social intelligence.

The most direct and obvious means of communication between people is spoken language. People impart social information not only through the content but also in the way things are said. The voice helps to reveal if someone is lying or telling the truth, if speakers feel sympathy or antipathy for each other, and if the implicit message corresponds to its content (e.g. Giles, Mulac, Bradac, & Johnson, 1987; Kramer, 1963; Shintel, Nusbaum, & Ok, 2006). Effective interpersonal relationships and social performance require that individuals accurately decode nonverbal expressions of emotions in other people. However, the ability to decode prosodic emotional cues in voices has not received much attention in literature when compared to the investigation of emotion recognition in faces (Baum & Nowicki, 1998; Scherer, 1986). Auditory communication has major importance for work settings like telephone counselling and other situations in which the interaction concentrates on the auditory channel and the person's emotional state has to be recognized (Wallbott, 2003). Auditory abilities play an important role in basic tasks (discrimination, memory and reasoning), for example, within conversations (especially on the phone) or while listening to the radio. The existence of a performance bottleneck, e.g., while driving an emergency vehicle or piloting a plane, places additional demands on the auditory channel (see Kallinen & Ravaja, 2004). Auditory abilities are also especially relevant for the acquisition of foreign languages. Better auditory discrimination and memory abilities should lead to a better pronunciation (minimization of accent), ensure a quicker and more accurate acquisition, and enable a person to adjust quickly in a foreign country (Albrecht, 2005; Bundesministerium für Bildung und Forschung, 2006). Besides their practical relevance, auditory abilities have a rather long research tradition, particularly within the domain of musical abilities (see Carroll, 1993). It is therefore surprising that existing ability and intelligence tests present stimulus material almost exclusively visually (Carroll, 1993; Horn & Stankov, 1982; Shuter-Dyson & Gabriel, 1981).

Despite their apparent importance, the question of whether social and auditory intelligence are useful constructs remains unanswered. Attempts to separate social intelligence from academic intelligence, especially from verbal academic intelligence, have been problematic and mainly unsuccessful (e.g. Brown & Anthony, 1990; Ford & Tisak, 1983; Hoepfner & O'Sullivan, 1986; Keating, 1978; Probst, 1975; Tenopyr, 1967; Thorndike & Stein, 1937; Walker & Foley, 1973). As early as 1958, Wechsler called into question whether social intelligence differs from "general intelligence applied to social situations" (p. 57). The domain of auditory intellectual abilities is even less developed than the domain of social intelligence. Clear definitions of auditory abilities and of how these can be separated from general intellectual abilities (e.g., verbal comprehension) are hard to find in the academic intelligence literature. Carroll (1993), who based his conceptions on studies implemented by Stankov and Horn (1980; Horn & Stankov, 1982), and research in music psychology (see chapter 2.5.4) are an exception.

For several reasons, reliable results and convincing evidence for both constructs are still missing. Social intelligence instruments were often developed without being based on a theoretical model, methods were often inappropriate (e.g. performance subconstructs were examined with questionnaires), tasks were oriented mainly towards classical academic intelligence tasks (see Asendorpf, 1996), and the social context of the situation was neglected. Instruments that attempt to cover the whole spectrum of the purportedly multidimensional SI construct are rare and outdated (e.g. Moss, Hunt, Omwake, & Woodward, 1955; O'Sullivan & Guilford, 1966, 1976). Using realistic material for test development was difficult because it was expensive and there was a lack of appropriate technique. But although today reasearchers do not have to deal with technique and quality problems any more, the very commendable studies assessing SI with Multi-Trait Multi-Method (MTMM) designs (e.g. Wong, Day, Maxwell, & Meara, 1995) still rely on the aforementioned test batteries. Auditory intelligence research has been sparse, and a broad and at the same time thorough measure of the construct does not exist. Test batteries are only available for limited domains, e.g. auditory perception (Surprenant & Watson, 2001; Watson, Johnson, Lehman, Kelly, & Jensen, 1982) or have not been fully developed and published (Horn & Stankov, 1982; Stankov & Horn, 1980). An exception is the Woodcock-

Johnson III battery (Woodcock, McGrew, & Mather, 2001), which also includes a plethora of auditory tests. What they actually measure and how they can be classified theoretically needs further research (see also chapter 2.5.2). Results obtained in musical psychology have rarely been integrated into academic auditory intelligence research (for exceptions see chapter 2.5). One of the primary factors limiting previous work on intelligence constructs was the expense and limitations of early computer software. The early software could not handle the extensive calculations and statistical models necessary to address complex causal models adequately.

Redressing these shortcomings in research on social and auditory intellectual abilities will be the next important step to advance the field of research on intelligence. These can be overcome with (1) a clear construct definition of social and auditory intelligence, (2) an underlying theoretical model, (3) a suitable design, (4) a representative selection and development of tasks, and (5) the use of modern techniques for media presentation. The current set of studies addresses all five areas.

1.2 Purpose of This Book

This book has three primary objectives. The first objective is to examine aspects of validity in auditory and social intelligence. The second objective is to contribute to the clarification of the position of auditory and social intelligence within the nomological network of human intellectual abilities. With the third objective, the relationship between social auditory and general auditory intellectual abilities should be clarified.

According to Süß (1996, 2001), several conditions must be met in order to argue for an ability construct. These conditions are:

1) an empirical foundation with test data (T-data; Cattell, 1957),
2) the construct should be measured by performance-based tasks,
3) the ability should require only basic knowledge,
4) the ability should have a high degree of generality (that is, can be operationalized across different tasks),
5) the construct should demonstrate construct validity that is evident through partial autonomy in the nomological network of established models and constructs,
6) the construct should be stable across time, and, finally,
7) the construct should show evidence of incremental criterion validity when compared to established constructs.

In this book, this framework will be used to investigate whether social and auditory intelligence are coherent and useful constructs (see 5). In order to examine the validity of measures of both constructs, an empirical foundation is laid using test data (see 1). Performance-based tests (see 2) are developed requiring only basic knowledge (see 3). The measures include different types of tasks and assess different groups of people (see 4). The domains of the purportedly multidimensional SI construct should emerge regardless of the kind of material (e.g. auditory or visual) used in a test. Similarly, following the facets of academic intelligence, auditory abilities are hypothesized to split into discriminative, memory and reasoning abilities and make up at least two content domains: a tonal (nonverbal) domain and a speech (verbal) domain. Subsequent steps examine the separability of social intelligence and auditory intelligence from academic intelligence. Shortcomings of past investigations (lack of theory-based studies, unsystematic method application, ignoring social context) are addressed. The final steps include combining the social and auditory constructs and examining the overlap and distinctiveness of social auditory intelligence and general auditory intelligence, controlling for the variance of academic Intelligence. It is important to mention that construct validation depends on the measure we use as an indicator for the construct and on the conditions of the use of the measure (see Sechrest, 2005; Süß, 2006). Therefore, instruments have to be developed carefully and the investigations should be planned and implemented with as little disturbing influences as possible. Conditions 6) and 7) are not addressed in this book but should be examined in subsequent studies.

This book was carried out within the broader context of the goals and aims of a collaborative research group. Conceptual development and implementation of tests of social intelligence were carried out by Susanne Weis, Heinz-Martin Süß and me. The auditory intelligence work was carried out together with Jenny Papenbrock and Heinz-Martin Süß. Therefore, I use the first person plural to present our common views and ideas.

1.3 About Terms and Concepts

Literature on intelligence research differentiates among terms and concepts related to intelligence, ability, aptitude, or skill, and these terms are often used interchangeably. Spearman (1927) states: “In truth, intelligence has become a mere vocal sound, a word with so many meanings that finally has none” (p. 14). This overall confusion highlights the importance of bringing order into the chaos of terms and concepts within intelligence research. However, it is not within the scope of this work to address the totality of definition problems in intelligence research. Therefore, I pick up the thread of Snow who did a great deal of work in defining “aptitude” and related terms, and beginning with his definitions, describe how I will use terms within the context of this book.

Snow (1996) regards intelligence as an organization of aptitudes for learning and problem solving. Intelligence is required in situations with novel or complex information that is also meaningful information, particularly when the information available in a situation is partial or incomplete. Cognitive abilities, in his view, are more specialized than intelligence. Intelligence and abilities are subsets of the category labeled “aptitudes.“ The original meaning of aptitude was aptness, appropriateness, and suitability for performance in a (learning) situation. Snow (1986) relates aptitude to any measurable person characteristic that is needed as preparation for future achievement. In his view, aptitude is not limited to intelligence but includes personality and motivational differences, styles, attitudes, and beliefs. Though stable, aptitude can be modified by education and learning.

There has been an aversive reaction within the academic community toward the term "intelligence” in the last few years (see Schmidt, 2002). Predetermined abilities are not very popular in a world in which self-actualisation, self-control, and self-influence gain increasing importance. Therefore, the idea that an intelligence may determine success in training, profession, and life in general is not welcome. In the United States, and with industrial/organizational (I/O) psychologists in general, it is more acceptable to speak of cognitive abilities, general cognitive ability (GCA) or general mental ability (GMA) rather than using the term “intelligence” (Schmidt, 2002). With this controversy comes the even more controversial view that there are group differences in intelligence (see VanRooy & Viswesvaran, 2004). Jensen (2000) describes the possibility of introducing group norms. However, group norms predominating over individual rights does not solve the problem and would not necessarily diminish the adverse impact of psychological intelligence testing. A change of wording (e.g., intelligence versus cognitive ability) does not change the problem, which was also recognized by Horn (2006) writing about Spearman who changed the label of the term “intelligence” to “g” to avoid the problematic connotations. However, the g-labeling did not free Spearman from the definitional and conceptual difficulties associated with “general intelligence”. Is there one (academic) intelligence or should the concept of intelligence be extended beyond the scope of academic intelligence? Is intelligence mainly predetermined or do we consider intelligence open to modifications? As soon as we take a clear perspective on our view of that what we mean by “intelligence”, it does not really matter whether we call it general mental ability or academic intelligence. In this book, I will use the term “intelligence” as specified below.

Another distinction concerns the differentiation between the terms “competence” and intelligence. The following conceptual distinctions are mainly based on a detailed literature review (Süß, Weis, & Seidel, 2005). We regard “competence” as the potential to show the required behavior in a specified situation. Competence is seen as domain- and situation-specific and can be modified through learning processes. The term “competence“ can cover a spectrum of features varying in broadness, subsuming only one variable (e.g. conflict management) or several interacting variables in highly specific social situations (dealing with a low-self-esteem leader whose company merges with another one and who is involved in a family conflict) (see Süß et al., 2005). On the contrary, intelligence can be seen as a precondition to acquire competences and describes cognitive abilities that can be used to deal with very different tasks and problems (Carroll, 1993). Compared to competence, we see intelligence as more stable and genetically determined to a higher degree (see Süß et al., 2005).

Similarly, the terms “skills” and “abilities” often are not used systematically and sometimes are even used as synonyms. As outlined above, abilities are less open to modifications and learning processes and comparatively more predetermined. Skills concern the concrete practice of complex behavior sequences and the acquisition of cognitive operations for concrete problems. Cognitive and behavioral skills are situation specific and are almost entirely automatic. Skills are acquired in several steps. Within this process they are automated successively, requiring high cognitive resources and being associated with more faults and less speed in the first cognitive stage and growing quicker and less faulty in the course of proceduralization (Ackerman, 1987).

For the purposes of this book, I take the position that intelligence has its genetic predispositions, is rather stable, and is restricted to the cognitive domain. This position corresponds to the results we observed in the literature review (see e.g., Ackerman, 1987; Carroll, 1993; Greif, 1987; Schneider, Roberts & Heggestad, 2002). In addition to genetic influences on intelligence, there are proxies for environmental enrichment influencing its expression (e.g., parents’ education and family background). I conceptualize intelligence as narrower than the concept of aptitudes because aptitudes include noncognitive abilities like attitudes and motivation. Second, I consider intelligence to be different from the concept of (general) abilities that may also include arts, sports, music, teaching, and leadership. Abilities can be specific and tailored whereas intelligence is a more basic and general concept. However, intelligence in my view can subsume several explicitly *cognitive* abilities also treated as intelligence subconstructs. Many more specific cognitive abilities (or intelligence subconstructs) -but fewer broad and general intelligences- seem to exist. See Figure 1-2 for the relationship between aptitude, intelligence and cognitive abilities.

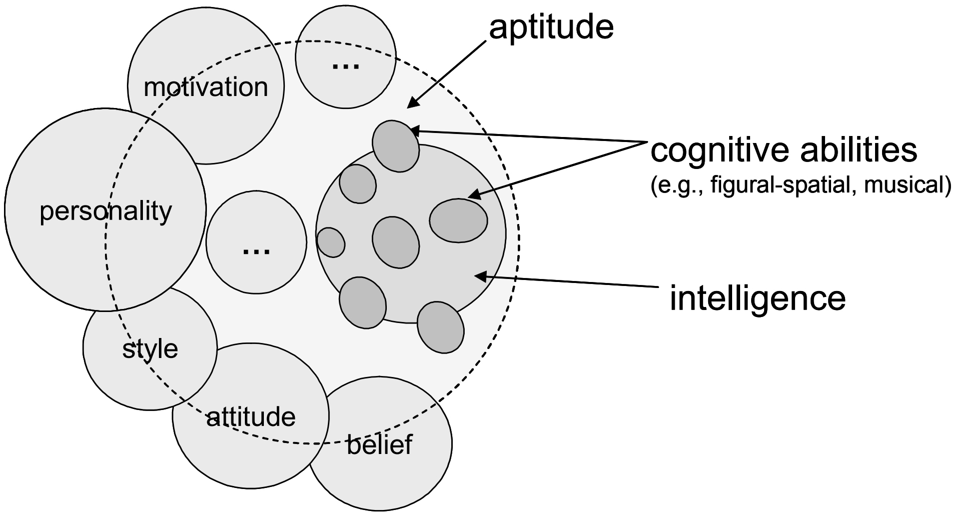

Figure 1-2: Relationship between Aptitude, Intelligence and Cognitive Abilities

The third major position I take is that social and auditory intelligence are located at the most fundamental level of understanding. These intelligences can be seen as preconditions for developing more specific social and auditory competences that are open for modifications. In addition, I regard social and auditory intelligences as generalizable across different situations that require cognitive effort and, therefore, these intelligences have to be distinguished from cognitive and behavioral skills. In spite of these rather clear distinctions, it is obvious that transitions are imprecise and sometimes it will be not as easy to differentiate amongst intelligence, abilities etc.

Some notes are necessary regarding the position I take on incremental validity in the context of condition for valid constructs (see chapter 1.2). In comparison to the already mentioned problems we have in establishing construct validity, there is not a single criterion validity. The data produced by a specified academic intelligence test that was applied to a certain group of subjects may predict success in academic studies but does not have to be related to dealing with patients in a hospital. A measure that is taken to predict "success," the definition of which is also important, in a specified proficiency should always be related to the demands that are placed on that proficiency. In other words, the predictor and the criterion must be symmetrical (see Wittmann, 1988). I acknowledge the empirical results that although leaving a large portion of 75% variance unexplained, found academic intelligence to be unmatched in predicting training and proficiency success (see e.g. Schmidt & Hunter, 1998; Schmidt, Ones & Hunter, 1992; Jensen, 1986; Olea & Ree, 1994; Van Rooy, Dilchert, Viswesvaran & Ones, 2006). However, there may be further predictors that will be even more successful in predicting other (or more specific) criteria (e.g. a social intelligence test predicting social behavior in dealing with patients) with different methods (e.g. different from supervisory ratings that have been widely applied, see Schmidt, 2002). Therefore, additional instruments introduced in this book should not be regarded as in competition with academic intelligence tests and their already well-established results but rather as complementary in providing possibilities to cover an intelligence domain in order to make predictions for criteria that differ from those summarized and analyzed by the just mentioned authors. In the same way, I regard social and auditory intelligence as complementary, not competitive, constructs to academic intelligence. However, both constructs have to show incremental validity against academic intelligence in predicting adequate symmetric criteria. Social and auditory intelligence will be defined in further detail in chapter 2.2 and 2.5.

2 Theoretical Background

This chapter starts with a short insight into the already established academic intelligence construct. It continues with a literature review including the theoretical conceptions, the empirical findings, and the relationships to other constructs for both social intelligence and auditory intelligence, and their combination (social/emotional auditory abilities). I present my own perspective at the end of each section. The chapter concludes with objectives for the development of measures for social intelligence and auditory intelligence I derive from the conclusions of past research.

2.1 Academic Intelligence

Intelligence has long been defined in several ways. The following definitions reflect the variability: mentally effective coping with changing environments (Anastasi, 1986); dealing with actual situations (Binet & Simon, 1905, cited in Amelang, 1996); mental self-government (Sternberg, 1986); an ensemble of abilities that is common to successful people in one culture (Wechsler, 1964); compound ability to act wisely, to think sensible and to deal effectively with the environment (Hofstätter, 1957); adaption to new tasks (Stern, 1911) or situations (Rohracher, 1965); and thinking in an abstract or concrete way within language, numerical, or figural-spatial relations (Groffmann, 1964). Differences in the definitions of intelligence are based on models or theories that differ according to the number of dimensions/factors they distinguish and according to the levels of hierarchy they include in their models. Carroll (1993) remarks that “the long-discussed problem of defining intelligence is transformed into one of defining the various factorial constructs that underlie it and specifying their structure,” (p. 627).

2.1.1 Overview of Intelligence Approaches

There are several possibilities for classifying conceptualizations of intelligence into different kinds of approaches (e.g., Amelang, 1996; Davidson & Downing, 2000; Kail & Pellegrino, 1988). I chose the classification of Davidson and Downing (2000), who distinguish between four different approaches, namely biological, psychometric, contextual, and complex system approaches. The biological approach is based on the neural efficiency hypothesis and assumes that intelligent people have brains that operate more quickly and accurately than those of people who are less intelligent (e.g. Hendrickson, 1982; Deary & Stough, 1996; Haier, Siegel, Nuechterlein, Hazlet, Wu, Paek, Browning & Buchsbaum, 1988; Reed &

Jensen, 1991). Representatives of this approach use evoked potentials, inspection time tasks, cerebral glucose metabolic rates and nerve conduction velocity in their work. This view is also known under the label “mental speed hypothesis” (e.g., Vernon, 1983; Kail & Salthouse, 1994; Neubauer & Bucik, 1996). In contextual approaches, it is assumed that the meanings and instantiations of intelligence are culture and context dependent (e.g. Berry & Irvine, 1986; Berry, Irvine & Hunt, 1987; Ceci & Roazzi, 1994; Das, 1994). Representatives argue that intelligent behavior in one culture is sometimes rather idiotic in another culture and that different conclusions about the nature of intelligence are drawn depending on the context intelligence is assessed in. According to psychometric approaches, the structure of intelligence can be discovered by analyzing the interrelationship of ability test scores (e.g. Carroll, 1993; Cattell, 1943; Spearman, 1927; Thurstone, 1938). This approach makes use of statistical techniques (e.g. factor analysis) applied to data from a large number of people. Complex system approaches assume intelligence to be dynamic and changeable depending on the predominant conditions (Sternberg, 1985, 1997b; Gardner, 1983, 1998; Ceci, 1996). These approaches combine the biological, psychometric and contextual approaches and lead to a broader view that is more successful in reflecting the complexity of intelligence and enlarging it beyond a static and narrow conception (Davidson & Downing, 2000). As an example, Gardner (1983) extends the conception of conventional academic intelligence and includes musical, bodily-kinesthetic, intra- and interpersonal and naturalist intelligence in his model (see also chapter 2.2.2 and 2.5.2). Gardner also attaches great importance to the context in which intelligence is measured. It can be viewed as positive that he includes tasks that are performed in real-world settings and avoids paper-pencil measures; however, Gardner’s work is not confirmed through empirical findings. Empirical foundation is a general problem with contemporary approaches since it is not yet clear how they can be validated completely. Until now, only parts have been tested empirically.

This book is based on the empirically testable psychometric approach of intelligence research. However, it extends the psychometric approach in the direction of contemporary models in assuming intelligence components (e.g. social intelligence and auditory abilities) that are only minimally addressed in well-established models of intelligence. An important aim of this book is to include the context in the measurement and to use new media instead of relying only on paper-pencil measures. In the present work, intelligence is seen as a composite of different component abilities, and is regarded as a complex, latent (hypothetical) and open construct that can be differentiated and enlarged.

2.1.2 Intelligence Theories in the Psychometric Tradition

Sternberg and Powell (1982) describe the development of psychometric intelligence theories in an evolutionary model. They suggest that theories of intelligence undergo an evolutionary process that leads to a deeper level of construct understanding. Three stages represent successive degrees of complexity. These stages are (1) monistic vs. pluralistic theories, (2) hierarchical vs. non-hierarchical theories, and (3) integrative theories. The first stage differentiates monistic theories of intelligence from pluralistic theories. In monistic theories (i.e., Spearman, 1914), a single instantiation of the given unit of analysis dominated thinking about intelligence. Spearman (1914) assumes a general factor (g) that permeates performance in all varieties of tests. In pluralistic theories, many independent instantiations of a given unit influence thinking about intelligence. As an example, Thomson (1939) sees general intelligence as a composition of many independent structural bonds including reflexes, habits and learned associations.

The second stage differentiates between hierarchical and non-hierarchical theories. In hierarchical theories, instantiations of successively lower orders are nested within instantiations of successively higher orders. For example, Cattell divides a superordinate “g-factor” into two higher order factors, crystallized and fluid ability, which in turn subsume several lower order factors. Carroll’s (1993) Three-Stratum model is another example of a hierarchical second stage model (see below and chapter 2.5). Thurstone’s (1938) theory of primary mental abilities (PMA) can be classified into the category of nonhierarchical theories. Thurstone regards intelligence as the sum of relatively independent constructs (PMA) extracted by means of factor analysis. He could find and justify seven abilities. Perceptual speed, word fluency, and memory are seen as rather specific abilities whereas verbal, spacial, numeric and reasoning ability are regarded as more general abilities.

In the third stage, the competing views of hierarchical and non-hierarchical theories (stage 2) are merged. Representative of this stage is Guttman’s Radex theory (1954, 1958). In addition, Guilford’s Structure of Intellect model (1967, see section 2.1.4) can be classified within this stage. A radia extension of complexity unites two distinct notions in a single theory, namely different kinds of tests and degrees. Guttman’s radex is the basis for the so-called facet theories. Integrative models that combine facet theoretical and hierarchical approaches into a superordinate theory can be regarded as an advancement of the third stage (e.g. Jäger’s Berlin Intelligence Structure model, BIS, 1982, 1984, see section 2.1.5). This work is based on an integrative theory and makes use of both facet and hierarchical models. Therefore, representative hierarchical and facet models and their backgrounds will be described in the following sections.

2.1.3 Hierarchical Models of Intelligence

About Hierarchical Models

Most current psychometric models propose a hierarchical structure of intelligence since empirical results have not yielded verification for non-hierarchical models (e.g. Thurstone), monistic models (Spearman), or pluralistic (Thomson) models (Davidson & Downing, 2000). Hierarchical models place one or more factors at the top and delegate specific factors to lower hierarchical levels. Higher level (second order) factors are expected to explain the correlations of lower level (first order) factors. The higher a factor is in the hierarchy, the farther it is removed from people's actual performance on psychometric tests (Davidson & Downing, 2000).

Advantages of Hierarchical Models

Hierarchical theories comprehensively depict general as well as more specialized abilities and their interrelationships, and this research has empirical support (see Carroll, 1993; Davidson & Downing, 2000; Sternberg & Powell, 1982). In addition to having stimulated extensive research, hierarchical approaches have, in contrast to other types of models (contemporary and context models, some types of radex models, see Ackerman, 1989 and this chapter), the advantage of being empirically testable. However, the nature of the factors extracted or found in a given study is influenced by the intelligence tests that are applied and by the choice of factor analytic techniques used. This is especially true with regard to a general academic intelligence factor (g), which often lacks comparability across studies.

Applications of Hierarchical Models

The two most widely acknowledged hierarchical models are the Three-stratum theory (Carroll, 1993) and the Theory of crystallized (gc) and fluid (gf) intelligence (e.g. Horn & Cattell, 1966). With respect to the latter, gf is defined as innate reasoning ability using culture reduced material, gc as knowledge due to formal education and acculturation. In the view of Cattell (1971) gf is the precondition to acquire gc, which is also described as invested intelligence. Indicators of gf were mainly figural tasks (considered as culture-independent measures). Gc was assessed with numerical and verbal tasks (culture-dependent measures). On a second hierarchical level, the broad cognitive factors of perception (auditory and visual), memory (short- and long-term), speed, and knowledge were added in an extension of the theory (see e.g. Horn, 1994; Horn & Noll, 1997). The latest empirical findings do not support the gf-gc model but instead argue for three factors: perceptual, verbal, and image rotation (see Johnson & Bouchard, 2005).

The Three-Stratum theory of Intelligence (Carroll, 1993) is based on the reanalysis of more than 460 available datasets reported in the psychometric literature applying statistical procedures thoroughly and consistently. Carroll (1993) distinguishes three levels that differ in generality, or stratums (The model is illustrated in the context of auditory intelligence, see Figure 2-9). On the top, the third stratum, Carroll describes a general intelligence factor “g” that underlies all aspects of intellectual abilities. The second stratum is comprised of eight subconstructs, namely (1) fluid and (2) crystallized intelligence, (3) general memory and learning, (4) broad visual perception, (5) broad auditory perception, (6) broad retrieval ability, (7) broad cognitive speediness and (8) processing speed. These subconstructs are listed in descending order according to the degree to which they are influenced by the third stratum g-factor. On the first stratum, altogether 68 primary order factors are further specifications of the secondary order factors on the second stratum and are dominated by the respective second order factor. They represent specialized skills reflecting the acquisition of particular strategies or specific types of knowledge. According to Carroll, the three strata are open for extensions, for example concerning additional (intermediate) strata. The Three-Stratum model is supported by the research of Bickley, Keith, and Wolfe (1995) who performed a hierarchical confirmatory factor analysis on tests scores obtained in a study with more than 6000 participants. Although the Three-Stratum structure was supported, a competitive model with an additional intermediate stratum between the third and the second stratum provided an even better fit. Factors on the intermediate level were interpreted as gf and gc.

The Three-Stratum theory (Carroll, 1993) and the theory of gf and gc (Horn & Cattell, 1966) were recently integrated into a common Cattell-Horn-Carroll (CHC) theory (see McGrew & Evans, 2004). CHC theory maintains Carroll’s Three-Stratum structure with a g-factor at the top (stratum III), broad cognitive abilities (stratum II), and narrow cognitive abilities (stratum I). The broad cognitive abilities include nine second order factors very similar to the Carroll factors: fluid intelligence (Gf) and crystallized intelligence (Gc), visual processing (Gv), auditory processing (Ga), long-term retrieval (Glr), processing speed (Gs), decision/reaction time/speed (Gt), reading and writing (Grw), and quantitative knowledge (Gq). The nine factors subsume about 70 narrow cognitive abilities. They are seen as positively intercorrelated but independent through structural evidence (best-weighted linear combination of any set of the eight factors does not account for the reliable covariance among the elements of the ninth factor). However, Horn and Carroll do not agree with regard to a general “g-factor”. According to Horn (2006), most of the empirical analyses do not support “g-theory” (p. 43). Different curves of development with age confirm this assumption, since gc and Glr increase with age whereas Gf, short-term storage (STM), and Gt decline with age. The CHC theory underlies the Woodcock–Johnson test battery III (WJ-III) as one of the best known tests in the USA, and influenced others, for example the revised Binet-Simon tests and the WAIS-III. In empirical analyses (see Lohman, 2003; McGrew & Murphy, 1995; Woodcock, 1998), selected factors could be confirmed. Instead of studies reporting support of the whole CHC factor structure with one test, confirmatory factor analysis revealed four higher order factors (Woodcock, 1998): STM, stores of knowledge, thinking abilities and automatic processing speed. Thinking abilities are regarded as the core “classical intelligence” applied in novel and difficult tasks and requiring reasoning. I will refer to this theory again in the context of auditory intellectual abilities (see chapter 2.5.2).

2.1.4 Facet Models of Intelligence

About Facet Theory

According to Guttman (cited by Gratch, 1973; see also Borg, 1976), facet theory is a “hypothesis of a correspondence between a definitorial system for a universe of observations and an aspect for the empirical structure of those observations together with a rationale for such a hypothesis.” Facet theory can be regarded as a general research methodology in the social sciences containing instructions for the implementation of studies and a composition of principles often called “metatheory” (Canter, 1985; Holz-Ebeling, 1991). Facet theory assumes that human behavior is a function of situations and person characteristics. The major aim of facet theory is to define the relevant facets that describe a specified research domain completely and economically for a certain field of research. A facet can be described as a set (C) involved in a Cartesian product of a finite number of sets (A and B). C contains the combined elements of A and B (Guttman, 1954, 1958). The combination of different types of facets and their elements are the foundation of a facet design. The design is specified through a “mapping sentence,” which links facets of a definitional domain “person” and ”stimulus” with a complex variable range “reaction” (or result). Qualitative and quantitative categories are distinct and supplement each other in addition to characterizing the facet in further detail. The use of general already existing and commonly accepted ranges is preferred rather than creating new mapping sentences for every kind of study. According to Guttman (1965), among the most important facets are the communication modes. Guttman distinguishes between the five senses sight, sound, touch, smell and taste. Each mode of communication may define a different kind of intelligence. After the specification of a facet into its main characteristics, it should be possible to describe every observation in terms of the basic characteristics. Within such a system, prognostic statements regarding the empirical similarities between the observations are possible (Holz-Ebeling, 1991). With the formalization of the assumptions of a facet design, it is also specified under which conditions it is valid. Any theory could benefit from being enunciated in facet-theoretical terms and tested using the facet approach to data analysis (Canter, 1985).

Advantages of Facet Models

A plethora of advantages and corresponding methodological applications exist concerning the application of facet models. To begin with, facet models allow a systematic description of a field of research that make a transfer into an empirical operationalization easier (Holz-Ebeling, 1991). Facet theory leads to multifactorial measurement designs that have an important impact on the content and construct validity of a measure. With regard to content validity, at the stage of test development, facet theory allows the theoretical understanding of the construct serving as a basis for the item development. A rational for item construction ensures the representativeness and completeness of the item universe for the construct to be measured. If test items correspond to the facets, positive correlations between test items are expected, whereas, if there is no correspondence, there should be no positive manifold. Items that share more similarities concerning their conceptual definitions should be more similar empirically (principle of contiguity) (Brown, 1985). The combination of scores according to the facets leads to a relatively large number of ability measures with a relatively low number of scores and therefore provides efficient tools for psychological assessment (Süß & Beauducel, 2005). Concerning construct validity, the application of facet theory helps to guarantee internal and external validity of the construct. Tests that share two facets require the same cognitive operation and apply the same content. In addition, they are assumed to correlate higher than tests sharing only one facet (e.g. same content but different cognitive operation). The lowest correlation is expected between tests having no facets in common. As a very general approach, facet theory can be related to construct validation (e.g. Ridgway, 1980) similar to the Multi-Trait Multi-Method approach (MTMM, see Campbell & Fiske, 1959). The MTMM approach describes a validational process that makes use of a matrix presenting all of the intercorrelations resulting when each of several traits is measured by each of several methods. Measures of the same trait should correlate higher with each other than they do with measures of different traits involving separate methods. Moreover, these validity values should be higher than the correlations among different traits measured by the same method. However, these criteria are seldom met. The MTMM approach can be regarded as a special form of a facet approach in which the contiguities of the construct facet should be more pronounced than the contiguities of the other facets (methods).

Facet theory is very flexible, can cope with virtually any content area, and has been applied successfully in a wide context of ability research: in working memory capacity, (Oberauer, Süß, Schulze, Wilhelm, & Wittmann, 2000; Oberauer, Süß, Wilhelm, & Wittmann, 2003; Süß, Oberauer, Wittmann, Wilhelm, & Schulze, 2002), in intelligence (Beauducel, Brocke, & Liepmann, 2001; Guttman & Levy, 1991; Snow, Kyllonen, & Marshalek, 1984), and in a facet approach that integrates working memory, intelligence and knowledge (Kyllonen, 1994). Two applications of facet theory in the domain of intelligence research that are theoretically relevant in the context of this book are described in the following section.

Applications in Academic Intelligence

a) Radex Model (Guttman, 1958)

Guttman (1958) developed hypotheses regarding the correlations between tests according to their common characteristics. He first introduced the “level of complexity” as a facet of tests. This facet is regarded as a continuum: the more components a test includes, the more complex it is. More complex tests, therefore, include the components of simpler tests plus additional components. The more components tests have in common, the higher their correlation should be. The order of correlations is called a simplex. In similarity structure analysis (SSA), correlations are represented as distances between points. Points that are close together indicate high correlations, points that are far from one another indicate low correlations. Tests of similar complexity though should form a circular array, a circumplex, in SSA. Tests of the same content but different in complexity should be located on a straight line array in SSA (simplex). The combination of simplex and circumplex forms a radex –a disc or sphere in two- or three-dimensional SSA– divided into verbal, numerical and figural content areas. In contrast to Guttman, who expected complex tasks to be located at the periphery of the radex, empirical analysis showed that complex tests were located at the center of the radex (Marshalek, Lohman, & Snow, 1983; Schlesinger & Guttman, 1969; Snow et al., 1984). Marshalek et al. (1983) assumed that the shorter the average distance of a test from all other tests in the universe, the closer a test would be located to the center of the radex. Tests measuring rather general abilities thus would be located in the center whereas tests that represent more specific abilities would be more peripheral (see Figure 2-1). As SSA differs from traditional factor analysis, an evaluation of the radex model is rather difficult. Results obtained with SSA could not be compared with structural models of intelligence based on factor analysis. Consequently, the model and its empirical results received only minor criticism but were also not sufficiently integrated in the process of theorizing in intelligence. Adler and Guttman (1982) replicated Guttman’s radex structure of intelligence tests, having 200 school children work on 13 intelligence tests that were defined within a framework containing four facets: rule type (inference, application, practice), modalities of expression (verbal, figural, numerical), language of communication (paper-pencil; manual), and dimensionality of object portrayed (two, three). SSA revealed the hypothesized facets.

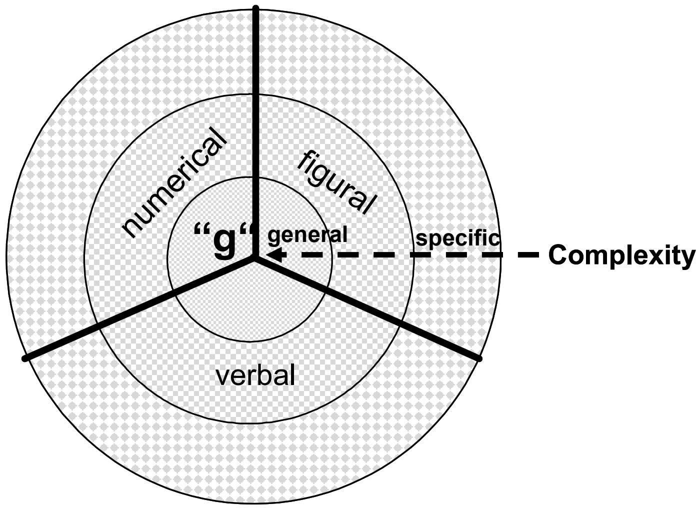

Figure 2-1: Radex Model of Intelligence (Marshalek et al.,1983)

Note. The level of generality is indicated by the resolution of the pattern. High resolution indicates a high level of generality; low resolution indicates a low level of generality.

b) The Structure-of-Intellect Model (Guilford, 1967)

Guilford (1967) postulated an information-processing model that should describe and sort but also explain intellectual functioning. Guilford cross-classified mental abilities into three facets: Operations (mental processes), content (kind of information) and products (form of information). In terms of the information-processing approach, the contents represent stimuli, the operations represent processes and the products represent responses (Süß & Beauducel, 2005). The three facets were arranged in a cube representing the Cartesian product of all elements of all facets, the Structure of Intellect model (SOI model). The operation facet contains the following elements: evaluation, convergent production, divergent production, memory and cognition. The content facet consists of the five elements: visual, auditory, symbolic, semantic and behavioral. The products contain the elements, namely units, classes, relations, systems, transformations and implications. Each of the postulated 150 basic abilities (5 contents x 5 operations x 6 products) is identified by its unique conjunction of one element of each of the three facets. In 1988, Guilford added another 30 abilities to his model when he decided to split up the memory operation into memory recording (immediate recall) and memory retention (recall after a period of time). However, the statistical procedures Guilford used were rather problematic (inadequate factor rotation, no availability of fit indices, use of random hypotheses), hence the empirical status of the model is not clear. Guilford did not expect a general intelligence factor but several second and third order factors emerging according to the facet elements the tests have in common. Even though Guilford claimed to have identified more than half of the 85 second-order abilities, empirical investigation indicated that the identification of the higher order factors, especially the product factors, was problematic. Nevertheless, the SOI model provides a large map of potential factors and stimulated the identification of new factors (e.g. social intelligence, see chapter 2.2) and the development of new tests (Süß & Beauducel, 2005).

2.1.5 Integrative Models of Intelligence

One of the most important integrative theories, especially in the domain of German language, is the Berlin model of Intelligence Structure (BIS; Jäger, 1982). The BIS model combines a facet structure with a hierarchical component and adopts the advantages of both types of models. The purpose of the BIS development was to explain the differences between most of the competing models (Jäger, 1967). Jäger ascribed the differences between these models to different tasks (generality), different subjects (universality), and different techniques of data analysis (Pfister & Beauducel, 1993). Therefore, in a first empirical-inductive stage, Jäger used about 2000 intelligence tasks he found up to the year 1973 in the literature in order to develop his integrative model. 191 tasks that contained marking variables for principal components of competitive structure models of intelligence were selected according to the maintenance of diversity and were then administered to an age homogeneous (16-21 years) German-speaking sample of 545 high school students in Berlin. Data were analyzed and interpreted by means of factor and cluster analysis. Stability was tested with a retest study after four years with 347 of the previously tested high school students. Exploratory factor analysis revealed four unambiguous operational factors: processing capacity (equivalent to reasoning), processing speed, memory, and creativity. Jäger (1984, p. 30) defines the operations as presented in Box 2-1.

Box 2-1: Operations of Academic Intelligence According to the BIS (Jäger, 1984)

PROCESSING SPEED (S)
Processing speed refers to the ability to perform simple tasks quickly and accurately.

MEMORY (M)
Memory refers to the ability to recognize and recall lists and configurations of items a few minutes after learning them.

CREATIVITY (C)
Creativity refers to the ability to produce fluently many different ideas.

PROCESSING CAPACITY (= REASONING, R)
Processing capacity corresponds to reasoning factors in other models. It refers to the ability to process complex information including inductive and deductive reasoning, construction, judging and planning.

Jäger and colleagues predicted that there would be seven primary order factors. However, when they ran the initial model, they did not find the typical content factors -verbal, numerical and spatial-figural- as originally predicted. Jäger and his colleagues assumed that they were hidden by the operation factors because the highly educated sample could have overlearnt the use of words and numbers. In a second quasi-experimental stage, Jäger and his colleagues used a special aggregation technique (Jäger, 1982, 1984). Following a suggestion of Humphreys (1962), tests heterogeneous with respect to operations but homogeneous concerning their content were aggregated to so-called parcels. Verbal, numerical and figural parcels were formed. Only those 48 tasks that were pure with regard to their content were used for further analysis. Four tasks were available for each of the 12 cells (4 operations x 3 contents) and consequently four parcels could be formed for each content domain. The facet model was replicated very clearly. The hypothesis that the content variance was masked by the operation variance could be confirmed. Jäger (1984, p. 31) defines the content domains as follows (see Box 2-2).

Box 2-2: Contents of Academic Intelligence According to the BIS (Jäger, 1984)

VERBAL (V): Ability to deal with language.

NUMERICAL (N): Ability to deal with numbers.

SPATIAL-FIGURAL (F): Ability to deal with figures and space.

Parceling technique was also applied in order to reveal a general intelligence factor (academic intelligence, AcI). Parcels heterogeneous with regard to their content as well as their operation were formed and analyzed. AcI was identified which explains the correlations between content and operation factors. One should note that empirical investigations have shown that parceling did not produce a result where there is no empirical basis in the correlation matrix (Jäger & Tesch-Römer, 1988; Süß & Beauducel, 2005) and therefore the data was not conducive to manipulation. Figure 2-2 represents the structure of the BIS model.

To summarize, the BIS has a hierachical structure with a general intelligence factor on the top. It can also be described as a facet model with seven principal components at the same level arranged in two facets, contents and operations. The twelve cells should be regarded as multifactorial conditioned performances rather than as primary ability factors as in Guilfords SOI model. The facets and classes of the BIS model do not have to be independent from one another (Jäger, 1982, 1984). Until now, only two facets have been specified but the model is open to the integration of new facets (Jäger, Süß, & Beauducel, 1997). The completion of the model can concern additional operations and contents, facets and performances. The BIS has been replicated several times and with different methods (e.g. Beauducel & Kersting, 2002; Bucik & Neubauer, 1996; Jäger et al., 1997; Jäger & Tesch-Römer, 1988; Süß et al., 2002).

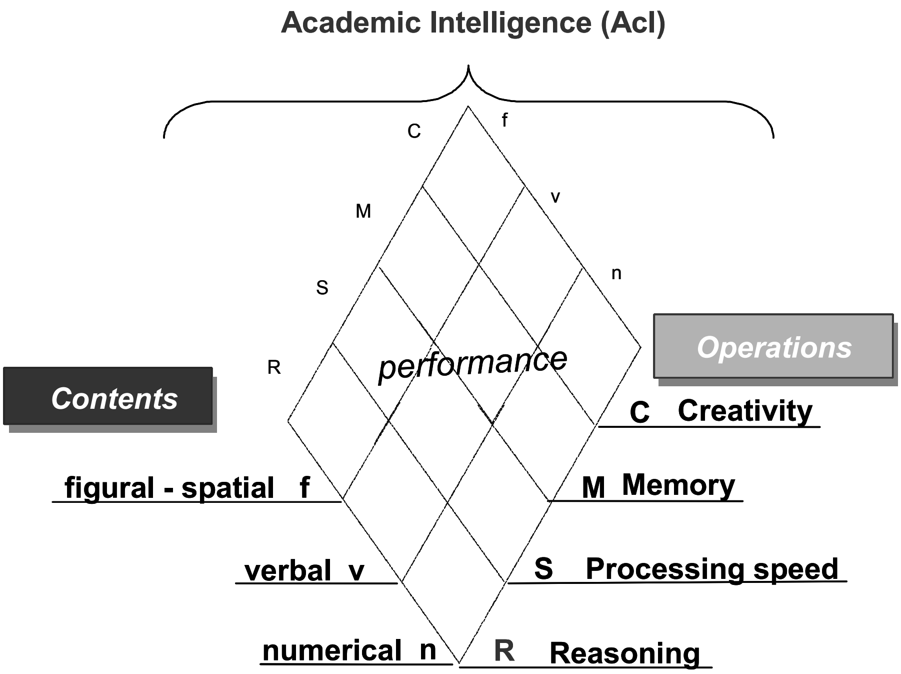

Figure 2-2: Berlin Model of Intelligence Structure (Jäger, 1984)
Note. The model is adapted according to Jäger (1984, p. 26)

2.1.6 Conclusions from Academic Intelligence Research

Integrative models combining the advantages of both hierarchical and facet models are expected to be empirically most valid. They provide an approach that can be empirically validated. Therefore, the BIS model is chosen within this book as a foundation and reference model in order to contrast academic, social and auditory intelligence. The BIS model has been validated extensively and is well-established in theoretical context and practical application. However, neither social nor auditory intellectual abilities, which are included in some widely accepted intelligence models (e.g. Carroll, 1993, broad auditory perception; Guilford, 1967, social intelligence), are taken into account within the BIS model. Attempts (see Jäger et al., 1997) to add a social content domain were never implemented. In the following chapters, research with regard to definitions, conceptions, models and measurement of social and auditory intelligence is reviewed. Both constructs are related to constructs within their nomological network with a focus on academic intelligence.