Empirical Article

Executive Functions and Behavioral Problems in Deaf and Hard-of-Hearing Students at General and Special Schools

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In this study, behavioral problems of deaf and hard-of-hearing (D/HH) school-aged children are discussed in the context of executive functioning and communicative competence. Teachers assessed the executive functions of a sample of 214 D/HH students from general schools and schools for the deaf, using a German version of the Behavior Rating Inventory of Executive Functions (BRIEF-D). This was complemented by a questionnaire that measured communicative competence and behavioral problems (German version of the Strengths and Difficulties Questionnaire; SDQ-D). The results in nearly all the scales show a significantly higher problem rate for executive functions in the group of D/HH students compared with a normative sample of hearing children. In the D/HH group, students at general schools had better scores on most scales than students at schools for the deaf. Regression analysis reveals the importance of executive functions and communicative competence for behavioral problems. The relevance of the findings for pedagogical work is discussed. A specific focus on competencies such as self-efficacy or self-control in educational concepts for D/HH students seems to be necessary in addition to extending language competencies.

Numerous studies show that the development of deaf and hard-of-hearing (D/HH) students is faced with special challenges. Findings from cognitive science (see Marschark & Wauters, 2011, for review), literacy (see Trezek, Wang, & Paul, 2011, for review), and socioemotional development (see Calderon & Greenberg, 2011, for review) reveal that reduced auditory perception and/or its correlates influence a great many processes that are significant for effective and interactive world disclosure, and that special allowances must be made for this when bringing up and educating these children. Calderon and Greenberg (2011) note that “across all developmental periods, competent functioning is associated with the ability to coordinate affect, cognition, communication, and behavior” (p. 189). We know, however, that many D/HH students make experiences during their development that make this integration of language, cognition, and affect difficult (Greenberg & Kusché, 1998).

This present study deals with the issue of the role that executive functions play in the development of D/HH students at general schools and at schools for the deaf in this context. It also examines what correlations there might be between executive functions, communicative competence, and behavioral problems. Executive functions have become increasingly important in recent years in the neurosciences, cognitive psychology, and education, and it is significant for both theory and educational practice to carefully examine the role executive functions have for the development of D/HH students (see Hauser, Lukomski, & Hillman, 2008, for review).

Executive Functions

This is a collective term for regulatory and controlling mechanisms that are essential if people are to perform goal-oriented and situation-oriented actions (Esslinger, Biddle, & Grattan, 1997; Konrad, 2007). They are mental processes of a higher order that are important when actions are planned or goals and intentions are being followed and monitored over many stages with
regard to how successful they are. These skills are particularly relevant when people are faced with new or unexpected situations and therefore required to use new reaction patterns. These days, most investigators suggest that executive functions are various independent processes that can malfunction selectively (Drechsler, 2007; Klenberg, Korkman, & Lahti-Nuuttila, 2001). They include the ability to initiate problem-solving processes, inhibit the effect of stimuli or actions that distract the attention, select relevant goals for specific actions, organize complex problem-solving processes and adjust problem-solving strategies as needed, in addition to being able to constantly monitor one’s own course of action and assess its success. Also working memory, where information is actively kept available for use in multi-step problem-solving processes is classified as a component of executive function.

Executive Functions in D/HH Students

One way of exploring executive functions is the experimental approach. This involves compiling tasks that present children or adults with new problems that do not normally crop up in everyday life and therefore cannot be solved by automatic processes. These include interference tasks (e.g., the Stroop test), where children are instructed to label visual stimuli according to a certain rule that contradicts the initial sensory impression. The other approach to determining executive functions is to compile behavior inventories by asking parents and teachers, or the children themselves, for the relevant information (e.g., about working memory, emotional control, problem-solving capabilities). This can be done using the BRIEF rating scales (Behavior Rating Inventory of Executive Functions: Gioia, Isquith, Guy, & Kenworthy, 2000). These are available for different age groups (preschool children: BRIEF-P; school children: BRIEF; adults: BRIEF-A).

Some studies that have used experimental tasks to assess executive functions argue that there are systematic differences between D/HH and hearing students. For example, Marschark and Everhart (1999) found significant differences in how D/HH and hearing school children performed in a 20-question task, whereas Luckner and McNeill (1994) obtained similar results with a Tower of Hanoi puzzle. In both cases, the D/HH students had considerably greater difficulties in solving the problem. Mitchell and Quittner (1996) found that D/HH school-aged students had significantly poorer scores than the control group of hearing students when it came to memory tasks requiring attention control. A review by Dye, Hauser, and Bavelier (2008) shows that behavioral characteristics in problem-solving tasks such as impulsiveness, distractibility, and so on, which are frequently attributed to D/HH students, have to do with the stronger visual orientation of the deaf (and perhaps of sign-language users as well), a factor that is often inadequately provided during testing.

Studies with questionnaires have also revealed differences between hearing and D/HH children, youth, and adults. Rhine (2002) compared school-aged D/HH and hearing students and found significant differences between the two groups on some scales in the BRIEF questionnaire (inhibition, shift, working memory), with the D/HH students scoring below hearing peers. In a further study, Rhine-Kahlbeck (2004) also investigated the correlation between executive functions, language, and social skills in a group of D/HH students aged 6–14. Among other things, she found that language development was a significant predictor of executive functions and that the scores on the BRIEF scales correlated with the social competence of the children. Pisoni, Conway, Kronenberger, Henning, and Anaya (2010) conducted a study on a group of 19 five- to ten-year-old children with cochlear implants and 30 five- to eight-year-old hearing children that also revealed significant differences in five out of the eight BRIEF scales, yielding worse scores for the cochlear implanted children. Hartshorne, Nicholas, Grialou, and Russ (2007) documented deficits in executive functions on the same scales for children with CHARGE syndrome, a group of children suffering from hearing and visual impairment. In a study by Oberg (2007), the D/HH students with D/HH parents achieved better BRIEF scores than the group of D/HH students with hearing parents, although it remains unclear whether the children’s language skills were responsible for this or the fact that more children in the group of D/HH students with hearing parents suffered from hearing loss due to other causes (unknown, perinatal, or postnatal; cf. Rehkemper, 2004).
Although the above-referenced studies used different methods to assess executive function, they all point to potential correlations between the hearing ability, the language competencies, and the development of executive functions. The data are consistent with the hypothesis that internal language plays a significant role in self-regulation. In the tradition of the cultural-historical school (Vygotsky, Luria, and Leontiev), internal language is considered the most important means for a child to appropriate the world through its own actions. It develops from the language directed at the child by outside parties and as the child gets older becomes the central tool that controls actions and opens up the world. We can therefore assume that if the development of language or communicative competence is impaired due to hearing loss, the development of executive functions will be similarly affected. Data are beginning to emerge that directly support this hypothesis, although most of the available data are currently still correlational. Figueras, Edwards, and Langdon (2008) showed that the differences in the performance of hearing and D/HH students in different tasks aimed at assessing executive functions with standardized test items from the NEPSY test (Developmental NEuroPSYchological Assessment, Korkman, Kirk, & Fellman, 1998) were mainly due to differences in the language skills of the children examined (as assessed using the Reynell Language Development Scales). Remine, Care, and Brown (2008) obtained similar results with a 20-item task and a Tower of Hanoi puzzle. A study by Barker et al. (2009) used path analysis to investigate 116 D/HH infants and toddlers ranging in age from 1.6 to 5 years. This revealed significant correlations between the children’s language skills, their attentional and action control abilities, and their social–emotional behavior. Language performance had a direct effect on the children’s behavioral problems and an indirect effect on attentional and action control. This study using path analysis provides even more direct support for the hypothesis that language influences executive functioning.

Deficits in executive functions can also be associated with the processes of social cognition. In this context, we see executive functions in D/HH students also being discussed in connection with the development of theory of mind (ToM). ToM refers to children’s understanding that they and others have mental states that are not directly observable (beliefs, intentions, desires, knowledge); in particular, it describes the ability to understand that other people have mental states that are different from one’s own (Kain & Perner, 2007). Simply put, ToM is the ability to put oneself into another person’s shoes and realize that one’s own perspective might not be the same as other people’s. The development of this ability is associated with the quality of verbal communicative exchange between the child and the people in its environment. In her current review of available studies on ToM in D/HH students, Spencer (2010) confirms the view that D/HH students usually have problems adopting such perspectives if differentiated access to language is made difficult for them at an early stage. Studies dealing with executive functions and ToM in D/HH students have so far failed to produce consistent results. Meristo and Hjelmquist (2009) examined four groups of D/HH children with different linguistic backgrounds (bilingually educated native signers, verbally educated native signers, and two groups of bilingually educated late signers). The bilingually educated native signers had significantly better scores in the various ToM tasks, but this was not reflected in the scores of the scales for executive functions. A Chinese study by Yiyuan, Ruiming, Xingwang, Hong, and Zelazo (2006) compared executive functions in 76 D/HH and 78 hearing students finding no differences among the groups of 3-year-old children. The hearing children developed executive functions very quickly between the age of 4 and 4.6 years, whereas similar results were only seen after the age of 6 in the D/HH children. Therefore, although executive functions and ToM are both dependent on language performance, there are differences in how development progresses in both domains that still need further clarification.

Behavior Disorders in D/HH Students

It seems obvious to assume that the development of executive functions also directly affects the ability to control behavior in social situations. Numerous empirical studies are available on the prevalence of behavior disorders in D/HH students. Most current studies on D/HH students show significantly higher rates for behavior disorders in nearly all important domains compared with hearing students. Studies undertaken in different countries (Dammeyer, 2010; Fellinger, Holzinger, Sattel, & Laucht, 2008;
Executive Functions of D/HH Students

Hintermair, 2007; van Eldik, Treffers, Veerman, & Verhulst, 2004; van Gent, Goedhart, Hindley, Treffers, & Philip, 2007) that compare the total scores for problems in the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997) or in the Child Behavior Check List (Achenbach, 1991) are relatively in agreement on their findings for schools for the deaf, showing a 2.6-fold increase in the rate of disorders for D/HH students. Dammeyer reports a 3.7-fold increase in prevalence in a sample of 334 Danish school children suffering from peripheral hearing loss, with the group of D/HH students who had additional handicaps clearly being particularly affected. Meijstad, Heiling, and Svedin (2008, 2009) were unable to determine any increase in values in their study and connect this with Sweden’s policy of consistently implementing bilingual education for D/HH students there (cf. Sinkkonen, 1994). Studies that also included D/HH students at general schools show lower prevalence values overall (Berger, Danzeisen, Hintermair, Luik & Ulrich, 2011; Fellinger et al., 2008; van Eldik, 2005; van Gent et al., 2007).

A possible connection between executive functioning and behavioral problems in D/HH students is reflected in the results of a German pilot study using BRIEF-P. The study examined 46 preschool D/HH children, 38 of whom were attending a kindergarten for the D/HH, whereas the remaining eight were enrolled at an integrative kindergarten (Piskora, Sarimski, & Hintermair, 2010). Comparison of the D/HH sample with the U.S. normative sample revealed far more D/HH children with significant problem scores on all five of the BRIEF-P scales, as well as significant correlations more or less throughout the executive and SDQ-D scales: Children who had problems with their executive functions had more conduct problems, a greater degree of hyperactivity, more problems with peers, and also displayed less prosocial behavior. Children who had difficulty with affect control and adjusting quickly to new situations, as well as problems with working memory, registered more emotional problems on the SDQ.

Integrated and Separate Settings for D/HH Students

Looking at executive functions in D/HH students, it is appropriate to focus separately on the development of D/HH children at general schools and at special schools. In Germany, there are about 80 special schools for the D/HH; As current data from the Statistisches Bundesamt (Federal Statistical Office, 2010) and the KMK (Conference of the German Ministers for Education, 2010a, 2010b) show, about 75% of the D/HH students in Germany attend a school for the deaf, whereas about 25% attend a general school. Most of the students at general schools are integrated and are in most of the cases the only D/HH child in their class. There are a few other schooling options such as co-enrollment models with four to six D/HH students together with hearing students in a general school class taught by two teachers or inverse integration models where hearing students learn together with D/HH students at a school for the deaf. Additionally, it has to be stated that the German educational system for D/HH students has a long oral tradition, so currently there are nearly no systematic bilingual programs available.

The general trend in recent years has been for more and more D/HH children to be educated in integrative settings (Office of Special Education Programs, 2008), and this trend will increase in the future also in Germany. The reasons for this are the programs for newborn hearing screening (National Center for Hearing Assessment and Management, 2008), the much-improved options of hearing aid fitting and cochlear implantation, and in particular, the increasingly intensified inclusion efforts all over the world (Freire, 2009; World Health Organization, 2008). The last point alone may lead to more students who previously attended a school for the deaf going to general schools in future. Whether this will work is not clear at the moment. But for the purposes of this discussion, it must be stated that across nations, the students at schools for the deaf differ in many aspects from D/HH students at general schools (so, e.g., at the schools for the deaf, there are more students with a higher degree of hearing loss, with more additional handicaps, less-favored parental educational setting; there are often also more students with a migration background and more students with less-communicative competences; and so on.; cf. Mitchell & Karchmer, 2011). This may also be true for the development of their executive functions (and for their success while attending a general school). Stinson and Kluwin (2011) point out that the considerable
differences currently existing among students at these
types of school are not due to the school type itself but
to the individual differences among the students in
terms of intelligence and language skills, for example,
or even social background and additional handicaps
(see above). They show that estimates of the impact
of placement can only declare 1% of the total variance
of students’ achievement, whereas a priori students
differences account for between a fifth and a quarter of
the total variance (additionally, it has to be stated that
there remains about 75% unexplained variance). So, it
is important for research to compare the differences
between these two groups if we are to be prepared for
inclusive challenges in the future.

Aim of the Study
This study aims to verify the significance of execu-
tive functions for the development of D/HH children
using a sample of school-aged German students. This
seems to be important for several reasons. Although
some studies have accentuated the relationship of exec-
utive functions and social–emotional behavior (Barker
et al., 2009; Rhine-Kahlbeck, 2004) there exists no
empirical study that explicitly links executive functions
with behavior problems and communicative compe-
tence of D/HH students. Next, it is relevant to col-
clect data on a German sample because nothing has as
yet been published on executive functions in German-
speaking countries. As mentioned above, the German
educational system for the D/HH has a long oral tradi-
tion with very few bilingual programs. So, it may be
of interest to look on executive functions that seem
strongly to be associated with language competencies.

The following issues are of interest:
First, it will be investigated whether D/HH
students at general schools differ in their executive
functions from D/HH students at schools for the deaf
and to determine the differences between the results of
the D/HH students and those of a normative sample
of hearing children. With reference to the conclusion
of Stinson and Kluwin (2011) regarding the role of
individual differences for different school placements,
we hypothesize that D/HH students at general schools
have better executive functions than D/HH students
at schools for the deaf. Further, it is predicted on the
basis of what is known about the effects of hearing loss
(Calderon & Greenberg, 2011; Greenberg & Kusché,
1998) that D/HH students from both educational
settings have more problems developing age-
appropriate regulation and control functions to plan
their actions compared with hearing students.

Second, it is of interest if there are any correlations
between executive functions, communicative compe-
tence, and behavioral problems. Because we assume that
the executive functions are less well developed in D/
HH students, it is predicted that this is associated with
a higher rate of behavioral problems, which includes all
domains covered (emotional problems, conduct prob-
lems, hyperactivity, peer problems, prosocial behavior).
Executive functions especially regarding behavior reg-
ulation are expected to be more important predicting
behavior problems than metacognitive executive func-
tions. Equally, it is predicted that these correlations are
influenced by the children’s level of communicative
competence in that children with higher communica-
tive competences perform better executive functioning
and show fewer behavioral problems.

Method
Participants
Table 1 shows the distribution of demographic vari-
ables. All information is taken from data based on
the teachers’ knowledge and evaluations. The sample
comprised more girls than boys. The mean age of the
children was 12.4 (SD = 3.2). The children taking part
in the survey were mainly German citizens, although
nearly one third of them had migration backgrounds
(50% of the immigrants were Turkish). We have no
information whether the students with a migration
background were born and raised in Germany or
whether they came to Germany later in their lives. The
distribution regarding the degree of hearing loss shows
children (with different number) from all groups.

The cause of deafness was unknown for 50% of
the sample. For nearly a quarter of the children, the
cause was either genetic or acquired. About 25% of the
children had a cochlear implant. As expected, nearly
all these children were in the group that had profound
hearing losses. Additional handicaps are only given for
14% of the children: 35% of them have cognitive delays
and roughly 20% had been diagnosed with attention deficit-hyperactivity disorder (ADHD). About 18% of the sample has parents who are deaf (10%) or HH (7%) themselves. Parent educational status is distributed more or less equally. The data for the preferred mode of communication of the child at school showed that the children in this sample are largely geared toward spoken language (90%), and only 10% use spoken and sign languages according to their teachers’ reports. Two-thirds of the students attend a school for the deaf, with the remaining third being mainstreamed at a general school. If we compare the sociodemographic variables of the students in both school settings, there are several differences: At the schools for the deaf, we find more children aged 14–18 years ($\chi^2 = 8.28, df = 3, p < .04$) but fewer children with an acquired hearing loss ($\chi^2 = 24.6, df = 3, p < .001$) and more children with a higher degree of hearing loss ($\chi^2 = 40.3, df = 2, p < .001$). There are also more students with a cochlear implant ($\chi^2 = 7.01, df = 1, p < .008$), as well as more students using spoken and sign languages ($\chi^2 = 9.18, df = 1, p < .002$) at the schools for the deaf. The majority of D/HH students at general schools live in families where the parents have a higher educational status ($\chi^2 = 14.82, df = 2, p < .001$). No significant differences were found between the two groups regarding additional handicaps or migration background. The specifications regarding additional handicaps show that students with cognitive impairment or ADHD were only in the group of students attending the schools for the deaf. We also asked for the student's

Table 1  Demographic information about the sample ($N = 214$)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Characteristics</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male (1)</td>
<td>123</td>
<td>57.5</td>
</tr>
<tr>
<td></td>
<td>Female (2)</td>
<td>91</td>
<td>42.5</td>
</tr>
<tr>
<td>Age (median = 12.4, $M = 12.4$, SD = 3.2)</td>
<td>5–6 years (1)</td>
<td>2</td>
<td>0.9</td>
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<td></td>
<td>7–8 years (2)</td>
<td>31</td>
<td>14.5</td>
</tr>
<tr>
<td></td>
<td>9–13 years (3)</td>
<td>103</td>
<td>48.1</td>
</tr>
<tr>
<td></td>
<td>14–18 years (4)</td>
<td>78</td>
<td>36.4</td>
</tr>
<tr>
<td>Citizenship</td>
<td>German (0)</td>
<td>145</td>
<td>67.8</td>
</tr>
<tr>
<td></td>
<td>Other citizenship (1)</td>
<td>68</td>
<td>31.8</td>
</tr>
<tr>
<td></td>
<td>Missing data</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Degree of hearing loss</td>
<td>Unilateral (1)</td>
<td>9</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>10–39 dB (2)</td>
<td>35</td>
<td>16.4</td>
</tr>
<tr>
<td></td>
<td>40–69 dB (3)</td>
<td>70</td>
<td>32.7</td>
</tr>
<tr>
<td></td>
<td>70–89 dB (4)</td>
<td>39</td>
<td>18.2</td>
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<td></td>
<td>90–120 dB (5)</td>
<td>58</td>
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<td>Missing data</td>
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<td>Cause of deafness</td>
<td>Genetic (1)</td>
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<td>26.2</td>
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<td></td>
<td>Illness/accident (2)</td>
<td>48</td>
<td>22.4</td>
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<td></td>
<td>Unknown (3)</td>
<td>108</td>
<td>50.5</td>
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<tr>
<td></td>
<td>Missing data</td>
<td>3</td>
<td>0.9</td>
</tr>
<tr>
<td>Cochlear implant</td>
<td>Yes (1)</td>
<td>52</td>
<td>24.3</td>
</tr>
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<td></td>
<td>No (0)</td>
<td>162</td>
<td>75.7</td>
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<tr>
<td>Additional handicap</td>
<td>Yes (1)</td>
<td>30</td>
<td>14.0</td>
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<td></td>
<td>No (0)</td>
<td>184</td>
<td>86.0</td>
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<td>Parental hearing status</td>
<td>Deaf (1)</td>
<td>24</td>
<td>11.2</td>
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<td>Hard of hearing (2)</td>
<td>15</td>
<td>7.0</td>
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<tr>
<td></td>
<td>Hearing (3)</td>
<td>175</td>
<td>81.8</td>
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<td>Educational setting</td>
<td>Elementary/middle school (1)</td>
<td>46</td>
<td>21.5</td>
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<td></td>
<td>Junior high school (2)</td>
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<td></td>
<td>High school (3)</td>
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<tr>
<td></td>
<td>Missing data</td>
<td>63</td>
<td>29.4</td>
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<tr>
<td>Most preferred language by the child</td>
<td>Spoken language (1)</td>
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<td>89.3</td>
</tr>
<tr>
<td></td>
<td>Spoken and sign language (2)</td>
<td>23</td>
<td>10.7</td>
</tr>
<tr>
<td>Kind of school</td>
<td>School for the deaf and hard of hearing (1)</td>
<td>145</td>
<td>67.8</td>
</tr>
<tr>
<td></td>
<td>General school (2)</td>
<td>69</td>
<td>32.2</td>
</tr>
</tbody>
</table>
IQ scores, but data were only available for 37% of the sample. Because all the IQ data came from the group of D/HH students at schools for the deaf, the IQ data was excluded from further analysis.

Instruments and Measures

Behavior Rating Inventory of Executive Function. The BRIEF (Gioia et al., 2000) was used to assess the executive functions of the children. This is in the form of a questionnaire, and the teacher’s version used for this study comprised 73 items targeted at children and adolescents in the age range 5–18 years. These 73 items are distributed over eight theoretically and empirically based clinical scales, with high scores indicating problems with executive functions.

Inhibit: The child can control impulses and behavior; it holds back or modifies its own behavior at the appropriate time or according to the circumstances (10 items; examples: “Interrupts others,” “Is impulsive”).

Shift: The child moves smoothly from one situation, activity, or problem component to another, depending on the demands of the situation; it masters transitions and has a flexible approach to solving problems (10 items; examples: “Becomes upset with new situations,” “Thinks too much about the same topic”).

Emotional Control: The child can modify its emotional reactions according to the demands of the situation or the circumstances (nine items; examples: “Has explosive, angry outbursts,” “Has outbursts for little reason”).

Initiate: The child is able to independently tackle set tasks or activities and at the same time come up with ideas and problem-solving strategies of its own (seven items; examples: “Is not a self-starter,” “Does not take the initiative”).

Working Memory: The child can keep information available in its memory so as to complete a task or choose a suitable reaction (10 items; examples: “When given three things to do, remembers only the first one,” “Has a short attention span”).

Plan/Organize: The child can anticipate certain future events or consequences; it can direct its behavior at goals or instructions; it develops the appropriate steps needed to complete a task beforehand (10 items; examples: “Has good ideas but cannot get them on paper,” “Gets caught up in details and misses the big picture”).

Organization of Materials: The child is able to keep its work and play areas tidy, including the places where belongings are kept (seven items; examples: “Cannot find clothes, glasses, shoes, toys, books, pencils, etc.,” “Backpack is disorganized”).

Monitor: The child is able to check the effectiveness of its work during and after the activity; it can gauge the effect of its behavior on other people (10 items; examples: “Does not check work for mistakes,” “Makes careless errors”).

The subscale values can be summarized in two higher-order scales—the “Behavior Regulation Index (BRI)” (cumulative value of the “Inhibition,” “Shift,” and “Emotional Control” scales) and the “Metacognition Index (MI) “ (cumulative value of the “Initiate,” “Working Memory,” “Plan/Organize,” “Organization of Materials,” and “Monitor” scales). In addition to this, it is possible to derive a “Global Executive Composite (GEC)” cumulated from the results of all eight subscales. Separate norms for hearing boys and girls are available for four age groups. The reliability of the results data for the U.S. normative sample of 720 children was very satisfactory (e.g., Cronbach’s alpha between .90 and .96 for all eight subscales, .97 for the BRI, .98 for the MI, and .98 for the GEC). We ran a reliability check on the results of our study separately for each type of school, which yielded slightly lower scores but was nevertheless very satisfactory overall (Cronbach’s alpha between .84 and .95 for all eight subscales, .94 for the BRI, .97 for the MI, and .97 for the GEC).

Strengths and Difficulties Questionnaire. The D/HH children’s behavioral problems were measured with the German teachers’ version of the SDQ. The questionnaire is therefore a measure of the difficulties as perceived by the teachers (emotional problems, conduct problems, hyperactivity, peer problems, total difficulties score, prosocial behavior; Rothenberger & Woerner, 2004). It contains 25 statements pertaining to the child (e.g., “many worries, often seems worried”; “constantly fidgeting or squirming”; “considerate of
other people’s feelings”; and so on) that teachers have to grade as not true (0), somewhat true (1), or certainly true (2). Thus, the score for any one scale (five items) can range from 0 to 10, and the total difficulties score (20 items) can be anywhere from 0 to 40.

There is no German normative sample for the teachers’ version of the SDQ-D available (Normative SDQ Data), so the British normative sample is used for comparison. Studies using the SDQ-D with hearing and D/HH students show mainly satisfactory scores for reliability (Cronbach’s alpha between .51 and .77 for the subscales with D/HH students, .81 for the total difficulties score; Hintermair, 2007). A reliability check on the data from the present study according to the two groups of D/HH students at schools for the deaf and at general schools was also very satisfactory (Cronbach’s alpha: subscale “emotional symptoms”: .74; subscale “conduct orders”: .69; subscale “hyperactivity/inattention”: .80; subscale “peer relationship problems”: .78; subscale “prosocial behavior”: .79; total difficulties score: .84).

Communicative Competence Scale. To measure the children’s communicative competence, we used a scale that we had devised and that has proven to be reliable in previous studies (Hintermair, 2007; Hintermair, Krieger, & Mayr, 2011). The scale comprises four items with five-step ratings (examples: “My child is able to tell me something about all the things that are on his/her mind”; “My child is able to understand the things I/people want to tell or explain to him/her”). The reliability of the scale regarding the data from this study was very satisfactory (Cronbach’s alpha = .94 for the D/HH students at schools for the deaf, .89 for the D/HH students at general schools). The teachers are requested to judge the student’s competences regarding the preferred language modalities by the child.

Additional data. Additional modifying factors were assessed (see also Table 1). These included sociodemographic variables (sex, age, citizenship, type of school, parent educational status) and certain variables relevant to hearing loss (hearing status, cause of deafness, cochlear implant, additional handicap, parental hearing status, preferred mode of communication by the child at school).

Procedure

The study was conducted with the teachers of students from schools for the deaf and mainstreamed D/HH students at general schools in two German states. About 350 questionnaires were distributed, and 214 of them were sent back with all items completed (rate of return: 61.1%). The rate of return was higher for questionnaires about students at the schools for the deaf than for those at general schools (74.0% versus 44.8%)

All statistical analyses were performed using SPSS version 18.0.

Results

Comparison of Executive Functions in Hearing and D/HH Students

In order to check the differences in executive competencies of hearing and D/HH students at general schools and at schools for the deaf, a univariate analysis of variance (ANOVA) was conducted with the BRIEF data from the American hearing normative sample (cf. Gioia et al., 2000) using cumulative scores for this comparison (lower scores mean elevated executive functioning, higher scores diminished executive functioning). The alpha level was adapted by a Bonferroni correction. The U.S. normative sample comprised a representative group of hearing children from one of the U.S. states. Gender distribution differed in the normative sample and the sample of D/HH students. The normative sample comprised more girls than boys (56%/44%), whereas almost exactly the opposite was true of our sample (42%/58%).

Table 2 gives the results. The results presented show that the group of D/HH students attending a school for the deaf proved to differ significantly from the group of hearing children in all domains of executive functioning. Differences were also obvious between the D/HH students at general schools and their hearing peers, with the exception of the “Inhibit” and “Plan/Organize” subscales. At the same time, there were also significant differences between the D/HH students at general schools and those at schools for the deaf, except in the “Shift” and “Emotional Control” subscales. If we look at the three cumulative scores, however, it can be seen that both groups of D/HH students have far more problems developing executive functions than the hearing
sample and in turn, that the D/HH students at schools for the deaf have even more problems with this than the students at general schools. The effect size of the differences among the three groups (Cohen’s $d$) was medium to high, with the exception of two subscales. Also after the correction of the alpha level by Bonferroni, all indicated single comparisons in Table 2 remain significant at least at $\alpha < .05$. A rerun of the analyses excluding students with additional handicaps or students with migration background led to comparable results.

In support of these findings, Table 3 shows the number of D/HH students with a $T$ score $\geq 65$, which is used as the cut-off score for significant problematic behavior in each of the domains (Gioia et al., 2000, p. 14)$^1$. According to the BRIEF, scores equal to or higher than 65 indicate serious problems with executive functioning, placing a significant part of the D/HH students in that category.

Accordingly, the D/HH students at the schools for the deaf show a rate of executive dysfunction that is 3.6 to 5.1 times higher. If we look at the Index scores and the Global Executive Composite score, we see a 4- to 4.5-fold increase. D/HH students at general schools show a 1.8- to 3.2-fold increase in the rate of executive dysfunctions. The Index scores and the global score rate them as having a 2.4- to 3.6-fold increase.

Additional univariate variance analyses (ANOVAS) were computed regarding the importance of demographic variables for executive functioning including Bonferroni correction. There were no differences found for gender, child’s degree of hearing loss, cochlear implant, parental hearing status, and child’s preferred language. With respect to citizenship students with a migration background show higher problem scores for “Working Memory” ($F = 9.23, df = 1,211; p < .003$). D/HH students with additional handicaps have more problems regarding the domain “Initiate” ($F = 10.90, df = 1,212; p < .001$). Parents with a lower educational status have children with more problems in the domains “Inhibit” ($F = 5.67, df = 2,148; p < .004$) and “Monitor” ($F = 6.96, df = 2,148; p < .001$). For the cause of deafness, there is a difference regarding the “Working Memory” domain: Students with unknown cause have higher scores than students with a genetic background ($F = 7.13, df = 2,209; p < .001$).

### Table 2  Comparison of BRIEF scores between hearing students, D/HH students at general schools, and D/HH students at schools for the Deaf

<table>
<thead>
<tr>
<th>Scale</th>
<th>Significant difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Hearing students from normative sample ($N = 720$)</td>
<td></td>
</tr>
<tr>
<td>(2) D/HH students at general schools ($N = 69$)</td>
<td></td>
</tr>
<tr>
<td>(3) D/HH students at schools for the Deaf ($N = 145$)</td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Inhibit</td>
<td>12.5</td>
</tr>
<tr>
<td>Shift</td>
<td>11.9</td>
</tr>
<tr>
<td>Emotional control</td>
<td>10.7</td>
</tr>
<tr>
<td>Initiate</td>
<td>9.4</td>
</tr>
<tr>
<td>Working memory</td>
<td>12.9</td>
</tr>
<tr>
<td>Plan/organize</td>
<td>13.1</td>
</tr>
<tr>
<td>Organization of materials</td>
<td>8.5</td>
</tr>
<tr>
<td>Monitor</td>
<td>13.4</td>
</tr>
<tr>
<td>BRI</td>
<td>35.0</td>
</tr>
<tr>
<td>MI</td>
<td>57.4</td>
</tr>
<tr>
<td>GEC (BRI + MI)</td>
<td>92.5</td>
</tr>
</tbody>
</table>

Note. BRIEF, Behavior Rating Inventory of Executive Functions; D/HH, deaf and hard of hearing; BRI, Behavior Regulation Index; MI, Metacognition Index; GEC, Global Executive Composite.

$ES^a = $ effect size (Cohen’s $d$).  
$**p \leq .001$.  

Relations Between Executive Functions, Behavioral Problems, and Communicative Competence

Table 4 shows the correlations between the BRIEF scales for assessing executive functions ($T$ scores), the SDQ-D for assessing behavioral problems (cumulative...
scores), and the Communicative Competence Scale (averaged cumulative scores).

With the exception of one score, significant correlations were observed consistently but with a wide range of magnitude in the direction expected: Increased problems with executive functions are connected with a higher probability of behavioral problems occurring and go hand in hand with a lower level of communicative competence in the students. Communicative competence also correlates with the social–emotional development of D/HH students: The more competent the children the less likelihood of behavioral problems arising.

Additionally, a multiple linear regression analysis was conducted with the independent variables included simultaneously (Table 5). As independent variables on the one hand, demographic and handicap-specific characteristics were used as presented in Table 1 to control their importance for behavioral problems of the sample. On the other hand, the communicative competence data, as well as both of the Index scores of the BRIEF questionnaire, were included as potential psychosocial relevant factors explaining behavior problems of D/HH students. The SDQ total problem score was used as criterion for the regression equation.

Table 3  Frequency of executive problems in D/HH students at schools for the Deaf and at general schools (T score in BRIEF scales ≥ 65)

<table>
<thead>
<tr>
<th>Scale</th>
<th>D/HH students at schools for the Deaf (N = 145)</th>
<th>D/HH students at general schools (N = 69)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Inhibit</td>
<td>38</td>
<td>26.2 (3.6)</td>
</tr>
<tr>
<td>Shift</td>
<td>48</td>
<td>33.1 (4.3)</td>
</tr>
<tr>
<td>Emotional control</td>
<td>41</td>
<td>28.3 (3.9)</td>
</tr>
<tr>
<td>Initiate</td>
<td>47</td>
<td>32.4 (4.4)</td>
</tr>
<tr>
<td>Working memory</td>
<td>54</td>
<td>37.2 (5.1)</td>
</tr>
<tr>
<td>Plan/organize</td>
<td>42</td>
<td>29.0 (4.0)</td>
</tr>
<tr>
<td>Organization of materials</td>
<td>45</td>
<td>31.0 (4.2)</td>
</tr>
<tr>
<td>Monitor</td>
<td>46</td>
<td>31.7 (4.3)</td>
</tr>
<tr>
<td>BRI</td>
<td>44</td>
<td>30.3 (4.1)</td>
</tr>
<tr>
<td>MI</td>
<td>47</td>
<td>32.4 (4.4)</td>
</tr>
<tr>
<td>GEC (BRI + MI)</td>
<td>48</td>
<td>33.1 (4.5)</td>
</tr>
</tbody>
</table>

Note: D/HH, deaf and hard of hearing; BRI, Behavior Regulation Index; MI, Metacognition Index; GEC, Global Executive Composite.

Table 4  Correlations (Pearson) between BRIEF scores, SDQ scores, and communicative competence score (N = 214)

<table>
<thead>
<tr>
<th>Scales</th>
<th>Total difficulties score</th>
<th>Emotional symptoms</th>
<th>Conduct problems</th>
<th>Hyperactivity/ inattention</th>
<th>Peer relationship</th>
<th>Prosocial behavior</th>
<th>Communicative competence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhibit</td>
<td>.68***</td>
<td>.25***</td>
<td>.66***</td>
<td>.67***</td>
<td>.30***</td>
<td>−.53***</td>
<td>−.29***</td>
</tr>
<tr>
<td>Shift</td>
<td>.51***</td>
<td>.56***</td>
<td>.26***</td>
<td>.26***</td>
<td>.36***</td>
<td>−.28***</td>
<td>−.25***</td>
</tr>
<tr>
<td>Emotional control</td>
<td>.61***</td>
<td>.46***</td>
<td>.54***</td>
<td>.33***</td>
<td>.40***</td>
<td>−.40***</td>
<td>−.21***</td>
</tr>
<tr>
<td>Initiate</td>
<td>.51***</td>
<td>.35***</td>
<td>.29***</td>
<td>.49***</td>
<td>.26***</td>
<td>−.28***</td>
<td>−.40***</td>
</tr>
<tr>
<td>Working memory</td>
<td>.64***</td>
<td>.33***</td>
<td>.37***</td>
<td>.70***</td>
<td>.32***</td>
<td>−.30***</td>
<td>−.37***</td>
</tr>
<tr>
<td>Plan/organize</td>
<td>.56***</td>
<td>.31***</td>
<td>.35***</td>
<td>.59***</td>
<td>.29***</td>
<td>−.30***</td>
<td>−.27***</td>
</tr>
<tr>
<td>Organization of materials</td>
<td>.38***</td>
<td>.14*</td>
<td>.29***</td>
<td>.42***</td>
<td>.16*</td>
<td>−.26***</td>
<td>−.11</td>
</tr>
<tr>
<td>Monitor</td>
<td>.63***</td>
<td>.25***</td>
<td>.50***</td>
<td>.61***</td>
<td>.36***</td>
<td>−.45***</td>
<td>−.32***</td>
</tr>
<tr>
<td>BRI</td>
<td>.67***</td>
<td>.48***</td>
<td>.54***</td>
<td>.47***</td>
<td>.39***</td>
<td>−.45***</td>
<td>−.28***</td>
</tr>
<tr>
<td>MI</td>
<td>.60***</td>
<td>.29**</td>
<td>.40***</td>
<td>.62***</td>
<td>.31**</td>
<td>−.36***</td>
<td>−.33***</td>
</tr>
<tr>
<td>GEC (BRI + MI)</td>
<td>.71***</td>
<td>.41***</td>
<td>.51***</td>
<td>.64***</td>
<td>.39***</td>
<td>−.44***</td>
<td>−.34***</td>
</tr>
</tbody>
</table>

Note: BRIEF, Behavior Rating Inventory of Executive Functions; SDQ, Strengths and Difficulties Questionnaire; BRI, Behavior Regulation Index; MI, Metacognition Index; GEC, Global Executive Composite.

*p ≤ .05; **p ≤ .01; ***p ≤ .001.
The results indicate that 60% of the variance in the total problem score could be explained by the variables that were included in the analysis (Table 5). Apart from gender and age, the children’s executive functions and communicative competence were significant contributing factors here. As expected, the BRI had a particularly strong effect.

Additional regression analyses were conducted to specify the results in Table 5 and to verify the importance of the BRIEF indices, communicative competence, and gender and age for the different domains of behavior problems assessed with the SDQ. Table 6 shows the results presenting the standardized regression coefficients that even for the significant relations have a rather small size.

The BRI correlates mainly with the emotional problems scale, behavior disorders scale, and prosocial behavior scale, whereas the MI only shows a correlation to the hyperactive behavior scale. Communicative competence turns out to be particularly relevant for shaping peer relations. With regard to gender, the correlations we know from the literature reappear—boys are more prone to conduct problems and hyperactive behavior than girls, whereas the latter show more prosocial behavior than boys (Hölling, Erhart, Ravens-Sieberer, & Schlack, 2007; Lahey, Miller, Gordon, & Riley, 1999). The age of the children plays a role in the hyperactive behavior scale; here too, it is known that symptoms of hyperactive behavior frequently diminish with age.
Discussion

This study examines the frequency of executive function disorders in D/HH students in Germany and compares them to those of hearing students. It also investigates the correlation between executive functions, communicative competence, and behavioral problems. To obtain the relevant data, we surveyed a sample of 214 D/HH students attending either a school for the deaf or a general school by distributing the BRIEF questionnaire (Gioia et al., 2000) to their teachers.

The comparison of the executive functions of the D/HH students with the data from the U.S. normative sample of hearing students revealed highly significant differences in all domains of executive functioning for the students from the schools for the deaf, with a 3.5- to 5-fold increase in the rate of dysfunctions in these children. In all but two subscales, there were also clear differences in the scores for D/HH students at general schools and the hearing sample. The differences in this case were not so great, however, corresponding to a 1.8- to 3.2-fold increase in the rate of executive dysfunction in this group. Similar results—albeit with a different number of affected domains and differing degrees of differences—can also be found in the studies by Rhine (2002) and Pisoni et al. (2010). What is important here, however, is the overall perspective, which reveals that both groups of D/HH students have considerably more problems with their executive functions, but also that there are considerable differences between the two groups themselves, in that the D/HH students at general schools have better executive functions. Our data fail to give sufficient indication of the reasons for this, but this study also shows that the two groups differ in a range of relevant characteristics, with the group of mainstreamed students containing more children who have better hearing status, parents with a higher educational status, and less significant additional handicaps (cognitive impairment, ADHD). This finding would confirm the position of Stinson and Kluwin (2011), after which the differences between both types of school are in a moderate way related to the individual differences among the students.

Hence, knowing about executive functions and their characteristics is important for deaf education, and this seems particularly true in the case of D/HH students from schools for the deaf, whose executive functions are especially vulnerable. As language seems to play a crucial role for the development of executive functions, the success of a long oral tradition of deaf education in Germany must be questioned. Although we have no data available from D/HH students in bilingual programs to compare, all the participants of this study come from oral programs and their data are the basis for the discussion in this article. It would be of importance for further studies to include D/HH students from the few bilingual programs in Germany to test the role of language.

On the other hand, knowing about executive functions is also very important if we are to be prepared for the challenges of inclusion that will undoubtedly occur increasingly in the future. Because deafness is a low-incidence disability, there are comparatively few professionals who are sufficiently specialized to work effectively with D/HH students and their families. If more and more D/HH students leave special schools for the deaf to attend general schools, it cannot be guaranteed that each D/HH child will have access to an educator or teacher on site at the general school with the special knowledge and competencies to adequately support the class teacher of that D/HH child. The results of this study—one of many published studies with interesting findings about D/HH students—provide the reader with a variety of information on executive functioning. They also indicate the challenges of executive functions for deaf education with regard to specific behavior regulation issues and metacognition problems that will need increased attention in the following years to ensure social and academic success, especially in the context of inclusion. If there is not enough expertise available on what it means to be D/HH, the needs of D/HH students involved in the inclusion process are at risk of not being met.

The results also show significant correlations between almost all of the domains of behavioral problems investigated and the executive functions assessed, as well as significant correlations between communicative competence and executive functioning. The D/HH students with executive dysfunctions have more behavior problems and show less-communicative competences. Multiple regression analysis was used to investigate the
significance of executive functions and communicative competence for the development of behavioral problems from the perspective of the children’s sociodemographic and handicap-specific characteristics and showed that 60% of the variance in behavioral problems could be explained by the variables included in the model. This indicated that in addition to the important role played by the children’s communicative competence and metacognitive abilities, the executive aspect of behavior regulation is particularly significant here as assumed.

Our present findings accord with the results of a German study on D/HH preschoolers, which used the BRIEF-P questionnaire to survey the teachers. The correlations were almost identical (Piskora et al., 2010). Similarly, the results of the study by Barker et al. (2009) show significant correlations between the attention control difficulties—a subcomponent of executive functions, measured while observing children at play—as well as the language status of the children and the degree of behavior disorders. The results of the study by Rhine-Kahlbeck (2004) also make a good case for a significant correlation between executive functions and social competencies. Accordingly, deficits in self-regulation skills and limited metacognitive competence are highly significant for the development of social-emotional behavior in D/HH students. These findings on D/HH students fit with those of several other studies on children without sensory handicaps. For example, Raaijmakers et al. (2008) used neuropsychological tests to investigate pronounced aggressive behavior in school children and found significant deficits in inhibition and adjustment processes, as well as in working memory. Similar results are documented in a study on children with language disorders and children with special learning needs conducted by Korella, Spanofsky, & Sarimski (2011). If one summarizes the core message of all these studies, including the present one, it would appear to confirm that difficulties in verbal expression and processing are closely associated with problems in executive functioning (cf. Crick & Dodge, 1994), and this in turn seems to have serious consequences for psychosocial development issues in D/HH children.

In addition to the data of this study results from other studies on ToM in D/HH children that go in the same direction (Spencer, 2010) confirm the crucial role of language for all developmental processes of this group.

Limitations

With regard to method and data sources, one should note that the information on executive functions did not come directly from observing or surveying the executive functions of the children themselves but from questioning the teachers of these children. It therefore follows that any surveys in further studies should also include data from the BRIEF-SR questionnaire completed by the children involved, as already available in a study on adolescents with specific language impairment (Hughes, Turkstra, & Wulfeck, 2009). Furthermore, there may be problems with the two D/HH samples and the normative sample used for comparison: Barely half of the teachers of mainstreamed D/HH students who were in principle available for this study decided to participate, whereas nearly three quarters of the teachers with D/HH students at schools for the deaf did take part. It could well be that this group of nonparticipants from general schools contained more children with problems related to their executive functioning, meaning that the data for the mainstreamed D/HH students might be too favorable compared with the data on D/HH students at the schools for the deaf. Finally, we compared data on German D/HH students with data on a hearing normative sample from the USA because currently there are no German normative data available.

Educational Conclusions

Overall, the results reveal that there is a greater need for action on the part of educators. The results reveal a range of basic functions that have proven to be significant for the development of social-emotional behavior, and yet these functions are not present to a sufficient extent in a great many D/HH students. Reinforcing students’ executive functions should feature much more in educational endeavors. Although currently there may not be intervention studies available to prove that this has relevance for the broader domains of social or academic functioning in D/HH students, it is evident that having such competencies available is definitely of advantage to D/HH learners. In this context, it should be noted that we have well-evaluated prevention programs such as the PATHS program (Greenberg & Kusché, 1998) that promote...
the social–emotional development of D/HH students. Also other programs that start in the sense of the theory of Lev Vygotsky, very early to promote executive functions in communicative settings, should be considered to adapt them to the situation of D/HH children. One of these programs (Bodrova & Leong, 2007) has proven to be successful in hearing children with respect to the promotion and development of executive functions (Diamond, Barnett, Thomas, & Munro, 2007). Studies on working memory training (Conway, Jarrold, Kane, Miyake, & Towse, 2007) have to be examined from the perspective of their significance for D/HH children and for cochlear implanted children in particular, where this competence is critical, especially for their success with spoken language.

Essentially, the basic concept behind these programs is to strengthen the competencies that are attributed to the executive functions (impulse control, emotional understanding, acquisition of problem-solving strategies). It is essential that concepts for educational support programs take executive functions into account early enough because data from other studies show that the correlations between executive functions and social–emotional development in D/HH students shown here appear very early on in life (Piskora et al., 2010).

Greater care must be taken at the schools for the deaf in particular, but also at the general schools, to ensure that the development of D/HH students is discussed in the wider context of developmental psychology so that besides the supposed “main job” of meeting special language needs, we also enable these students to acquire competencies that contribute to improved self-efficacy and self-control. Given the totally inclusive schooling of children with special education needs that many countries are striving to introduce, the results of the D/HH students in this study corroborate the fact that the challenges we face in Germany and elsewhere are huge, but must be met if we are to do justice to the development needs of D/HH students (Marschark & Hauser, 2012).

Note

1. T scores are commonly used for neuropsychological normative data. A T score is a special type of standard score. T scores result from a transformation of raw scores to standard scores (M = 50, SD = 10).

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