SUMMARY

Advances in brain and cognitive sciences have yielded new insights about learning and brain development during adolescence. These insights not only improve our understanding of learning and development, but are also believed to have potential to improve educational practices and learning outcomes. This has led to the emergence of a new research field, called *educational neuroscience*, which is dedicated to both fundamental and applied aspects of the brain-behavior relationships which are pertinent to education and to the elaboration on their implications for educational practice. A general introduction to this new research field can be found in Chapter 1. Currently, there is a strong need for scientific validation of the practical applications of brain science to educational settings. A close connection between research and practice in education is considered crucial to proceed towards evidence-based education. Therefore, this thesis was dedicated to translational research in the field of brain, learning and education. The primary focus was on young adolescents (10-14 years), because this period is marked by large developmental and educational changes. The main aims were 1) to examine individual differences in factors underlying school performance and 2) to evaluate ‘Brain & Learning’ interventions based on principles from the emerging discipline of educational neuropsychology in school settings.

Chapter 2, 3 and 4 focused on individual differences in school performance during adolescence. The study described in Chapter 2 examined age and sex differences in goal orientation during adolescence. Participants included 910 adolescents aged 10-19 years. They read vignettes of students reflecting four goal orientations and indicated which student they resembled most. Boys and girls from two age-groups (10-14 versus 14-19 years old) were compared. Results showed that girls were more likely than boys to endorse mastery goals (48% vs 39%) or performance-avoidant goals (20% vs 14%). Boys more often endorsed work-avoidant or performance-approach goals. At age 14-19 years, work-avoidance was more than twice as common for boys as girls (27% vs 12%). With age, mastery goals decreased (from 52% to 36%), whereas work-avoidant goals increased...
These age and sex differences in goal orientations may be a possible explanation for boys’ lower academic achievement compared to girls’ and show a need for early intervention.

Chapter 3 elaborated on these findings and investigated whether goal orientations were predictive of academic achievement. It additionally addressed the role of metacognitive self-regulation. The sample included 735 adolescents between 10 and 19 years of age. Results showed that students with mastery and performance-approach goals obtained higher grades than students characterized by learning-avoidant goals. Students with mastery goals showed the best metacognitive self-regulation skills of all students. The relation between goals and achievement was mediated by metacognitive self-regulation. This research suggests that mastery goals and metacognitive self-regulation skills should ideally be supported in the classroom.

Chapter 4 focuses on another possible determinant of school performance, namely processing speed. The study investigated differences between boys and girls regarding efficiency of information processing during early adolescence. A coding task based on over-learned symbols was performed by 306 adolescents in grade 7 and 9 (aged 13 and 15 respectively). Results showed that adolescents in grade 9 outperformed adolescents in grade 7. Irrespective of age, girls performed better than boys. The 25% best-performing students comprised twice as many girls as boys. The opposite pattern was found for the worst performing 25%. In addition, a main effect was found for educational track in favour of the highest track. School grades did not explain additional variance in processing speed. This indicates that real-life school performance cannot be predicted by performance on one cognitive task only. Student characteristics like age, sex and education level were more important for efficiency of information processing than school performance. The findings imply that even after age 13, efficiency of information processing is still developing and that girls outperform boys in this respect.

Neuropsychological insights may provide practical implications that have potential to improve educational practices. To take the first step towards translational research in the field of Brain, Learning and Education, Chapter 5 and 6 investigated teachers’ knowledge about ‘Brain & Learning’. Chapter 5 examined the prevalence and predictors of misconceptions about the brain, so called neuromyths, among teachers in the United Kingdom and the Netherlands. A large observational survey design was used to assess neuromyths as well as general knowledge of the brain. The sample comprised 242 primary and secondary school teachers who were interested in the neuroscience of learning. Participants completed an online survey containing 32 statements about the brain and its influence on learning, of which 15 were neuromyths. Results showed that on average, teachers believed 49% of the neuromyths, particularly myths related to commercialized
educational programmes. Around 70% of the general knowledge statements were answered correctly. Teachers who read popular science magazines achieved higher scores on general knowledge questions. More general knowledge also predicted an increased belief in neuromyths. These findings suggest that teachers who are enthusiastic about the possible application of neuroscience findings in the classroom find it difficult to distinguish pseudoscience from scientific facts. Possessing greater general knowledge about the brain does not appear to protect teachers from believing in neuromyths. This demonstrates the need for enhanced interdisciplinary communication to reduce such misunderstandings in the future and establish a successful collaboration between neuroscience and education.

Chapter 6 examined high school biology teachers’ knowledge of ‘Brain & Learning’. Additionally, it evaluated the effects of a ‘Brain & Learning’ teaching module on both teachers’ knowledge and students’ beliefs about learning potential. The module comprised 3 lessons about brain development, plasticity and learning. Participants were 40 biology teachers who were interested in ‘Brain & Learning’ and 1241 students (grade 8-9). Data were obtained in a controlled intervention which was executed according to a waiting-list control group design. Online questionnaires were completed to examine teachers’ knowledge and students’ beliefs. Results indicated that before intervention, teachers were less familiar with brain functions and brain development than with basic neuroscience (47% vs 76% of the questions correct). Teachers’ knowledge of brain functions and development was significantly higher after implementation of the module (64% correct). After the intervention, students in the intervention group more often believed in the malleability of intelligence than students in the control group (29% versus 21%). This suggests that the teaching module enhanced teachers’ knowledge and promoted effective student beliefs about intelligence. Together with positive teacher and student evaluations, these results emphasize the value of the teaching module for current high school biology curricula.

The second part of the thesis, Chapter 7 to 12, is dedicated to the development, implementation and evaluation of a neuropsychological intervention in a school setting. This new neuropsychological intervention called Brain Lessons focused on improving self-regulation skills in young adolescent boys. The main components of the intervention are 1) psychoeducation about the brain, attention, planning, impulsivity and memory, 2) goal management training to stimulate goal-directed actions, and 3) group discussions to exchange experiences and improve self-evaluation skills. Intervention groups consisted of maximum 8 boys, guided by two trained teachers. The intervention was developed stepwise in close collaboration with four Dutch secondary schools. The research included 80 boys from grade 7-8 with poor self-regulation skills. Participants were randomly assigned to the neuropsychological or control intervention (standard homework support).
Performance evaluations took place before, directly after and three months after intervention. A qualitative evaluation took place in a subset of the sample after intervention completion. Results showed no significant group differences on neuropsychological tests (attention, memory, speed) or cognition questionnaires (teacher, parent, self). Yet, more practice with the strategies may be needed before the changes in performance can be objectified. The qualitative evaluation revealed different experiences in both groups. Knowledge, skills and metacognitive awareness had improved more in the neuropsychological intervention group than in the group which received the conventional homework support. Therefore, more long term benefits may be expected from participation in *Brain Lessons*. This research is a first step towards the development of an evidence-based intervention for educational settings, and underscores the feasibility of a scientific approach to educational methods.

Finally, the main conclusions of this thesis together with suggestions for future research are presented in Chapter 13. It was emphasized that age and sex are important sources of variability in school performance during early adolescence. Furthermore, it was concluded that neuropsychological insights can be translated into viable interventions for school settings. Future efforts should focus on enhancing professional learning of teachers, intervention development and the development of valid outcome measures for this type of research. The present thesis highlights the importance of interdisciplinary communication in order to proceed in the field of Brain, Learning and Education. Empirical evidence should always be used in conjunction with teachers’ practical knowledge and experiences in order to decide upon the best practices for education. In this way, schools may gradually be transformed into dynamic learning environments that stimulate both student and teacher learning.