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## **Neuro-Auditory Profile of Children with Attention Deficit Disorder**

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AD(H)D is one of the most common behavioral disorders in children and adolescents, with a worldwide prevalence of about 5%. A substantial percentage of children remain affected into adulthood. While hyperactivity may decrease with time, inattention and impulsivity often persist. AD(H)D is characterized by the key symptoms of hyperactivity, impulsivity, and/or inattention. Therapies often consist of medication (especially stimulant medication), such as methylphenidate, and/or behavior modification therapy, among other things. Currently, AD(H)D is diagnosed merely on the basis of patterns of observable behavior, which can lead to diagnostic variability among different informants, cultures, and countries. Currently, no commonly accepted brain-based test exists that could contribute to a more objective diagnosis. AD(H)D can be diagnosed with the DSM or the ICD. The diagnostic criteria and the validity of AD(H)D subtypes/presentations have undergone changes with every publication of a new edition of the DSM and ICD in past decades and, to date, remain a matter of debate. The newest edition of the DSM-5 distinguishes three presentations, namely the ADHD-combined presentation, the ADHD-predominantly inattentive presentation, and the ADHD-predominantly hyperactive-impulsive presentation. In contrast, the ICD-10 emphasizes mainly one (sub-)type of this disorder, which is defined by the existence of symptoms of all three behavioral categories (hyperactivity, impulsivity, and attention deficit). However, "attention deficit disorder without hyperactivity" can be found under F 98.8. As of yet, little is known about the influence of musical experience on the anatomical and functional maturation of the auditory brain in children with developmental disorders such as AD(H)D. In the current doctoral thesis, the neuroanatomical and neurofunctional profiles of the AC as well as the auditory performance were investigated in a cross-sectional design in 36 children with ADD (ICD 10)/ADHD/IA (DSM-5) compared with healthy controls in relation to the intensity of instrumental practice, musical aptitude, and musical performance. It was hypothesized that subjects with ADD would exhibit a characteristic and distinguishable auditory profile on a neuroanatomical, neurofunctional, and auditory performance-related level. In one study (AMseL I), AD(H)D exhibited decreased volumes of HG, lower HG/PT ratios, and enlarged volumes of the PT, which were associated with a bilateral P1 asynchrony. No distinction between the AD(H)D subtypes/presentations was carried out in the AMseL I study. Hence, it was assumed that subjects with ADD would show similar but still specifiable neuroanatomical patterns with enlarged PTs and smaller HGs and HG/PT ratios. Performance on auditory tests was hypothesized to differ significantly between the ADD and the control group. It was further hypothesized that musically trained children with ADD should have larger HG gray matter volumes, smaller PT gray matter volumes, and a higher HG/PT ratio when compared with musically untrained and untalented children. DISYPS-based DCL-HKS scores could be lower as a sign of decreased symptom severity. Moreover, musically trained children with ADD should achieve better results on the performed auditory tests. The results reveal that subjects with ADD exhibit a characteristic AC morphology with an enlarged left PT and a decreased left HG when compared with their nondisordered peers, resulting in a smaller left HG/PT ratio. Furthermore, subjects with ADD show a clear bilateral asynchrony of the P1 answer and a tendency for a delayed P1 answer in the left hemisphere. The comparison between ADD HPs and ADD NPs/LPs reveals a smaller right PT and an increased right HG/PT ratio for the ADD HP group. Moreover, the ADD HPs outperformed

the ADD NPs/LPs on the IMMA tonal score, the Dinosaur Frequency Subtest, the Metric Test, and the Performance Test. Compared with the ADHD group, children/adolescents with ADD show a smaller right PT and an increased right HG/PT. Moreover, the ADD group achieved higher scores on the Metric Test, the IMMA total test, and the IMMA tonal test. Compared with boys with ADD, girls with ADD show bilateral albeit right-accentuated smaller PTs and bilateral increased HG/PT ratios. Subjects with ADD and comorbidity are characterized by an increased left PT compared with the ADD group without comorbidity. Handedness and medication have no effect on the results. Neuroanatomical and neurofunctional parameters of the AC are correlated with AD(H)D behavioral characteristics. Taken together, the results of this study show that the bilateral P1 asynchrony seen in the MEG data is able to distinguish between children and adolescents with an ADD or ADHD (Christine Groß's doctoral thesis) pathology and healthy controls. Furthermore, the size and ratio of the AC allows first for a categorization of disordered subjects and healthy controls and second for a differential diagnosis between ADD and ADHD. While the right AC was similar in size and ratio between ADD and non-disordered controls, the left AC distinguishes different groups. In contrast, the right AC distinguishes the ADHD subjects from the ADD subjects. ADD HPs demonstrate a smaller right PT and an enlarged right HG/PT ratio than the ADD NP/LP group. Interestingly, the right HG/PT ratio is negatively correlated with the FBB-HKS inattention index, the FBB-HKS hyperactivity index, and the FBB-HKS impulsivity index, while right PT volumes are positively correlated with the FBB-HKS inattention index and the FBB-HKS hyperactivity index, pointing out the possibility for musical expertise and musical training to counteract AD(H)D-typical behavior. In conclusion, these results and findings could help to completely change the method of diagnosing developmental disorders such as AD(H)D. Neuroanatomical and neurofunctional parameters of the auditory cortex could contribute to and provide valuable markers for a future brain-based objective diagnostic procedure for auditory-related developmental disorders in general and differential diagnoses between ADHD and ADD in particular. Moreover, musical expertise and musical training seem to be able to counteract AD(H)D-typical behavior. Hence, further detailed studies are warranted in order to develop a music-based therapy for children with ADD or ADHD that could improve and complement therapies for subjects with AD(H)D.