The hearing brain in males and females
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Chapter 1
Preface and outline of the thesis

About ten percent of the western population suffers from some type of hearing impairment, hearing loss or deafness. The source of these hearing impairments can be found in the peripheral or central auditory nervous system. Unfortunately, many of the centrally caused hearing deficits are not fully understood and hence lack treatment. This lack in understanding central hearing deficits also reflects our limited knowledge of the normal structure and function of the central auditory system. In the past, animal studies and postmortem human studies revealed the auditory pathways from the cochlea up to the auditory regions in the brain and backwards, although only schematic and not fully mapped. Our knowledge on the function of the central auditory system has increased during the past few decades by the development of functional neuroimaging tools. These techniques are very valuable because they allow investigators to study the human brain function in vivo. They measure changes in brain activity due to changes in behavior or cognition, induced by well-controlled tasks.

Functional neuroimaging tools are based on the concepts of functional segregation and integration. Functional segregation is based on our knowledge that the human brain can be divided in several regions based on a distinct neuronal architecture, or cytoarchitecture, and states that specific brain functions can be attributed to these different regions. Functional integration acknowledges that displaying a specific behavior requires the interaction of various regions, each with its own specific function. Hence functional integration requires anatomical connections between different
brain regions, i.e. functional connectivity requires anatomical connectivity. In the early days of functional neuroimaging, the techniques were mainly used for functional localization, i.e. the locations of certain functions were explored. Over time, new neuroimaging methods were developed, which allowed investigators to study the functional networks of the brain. These developments increased our knowledge on the functional processing in general and also on the central auditory system in particular. Combining this knowledge with current technological know-how has resulted in the development and implementation of several revolutionary treatments for hearing impairments, like cochlear implants and implant devices for tinnitus. The ongoing developments in neuroscience and technology allow us to be optimistic and to envisage further options for treating or even curing hearing impairments. In this evolution, functional neuroimaging research can play an important role in: 1) acquiring the basic knowledge about the central nervous system, like its normal function or changes in the central auditory system caused by hearing deficits, 2) evaluating the impact of treatment on the function of the auditory system and 3) patient selection. Although the first steps towards treatment of centrally located hearing deficits are made, there are still gaps in our basic understanding of the functional localization and integration of the central auditory system.

The present thesis contributes to the assessment of basic knowledge on the central auditory nervous system. We investigated its function in normal hearing subjects using positron emission tomography (PET). We focussed on imaging the primary auditory cortex and investigated how the activation in this region can be influenced by the sex of the volunteers using auditory stimuli alone and visual stimuli that have a strong link with auditory stimuli.

In chapter 2, an overview is presented on the structure and function of the human central auditory system and the application of functional neuroimaging techniques to assess its function in vivo. We discuss the possibilities and limitations of neuroimaging research with a focus on
PET and highlight how these techniques have increased our knowledge on auditory processing.

In the subsequent chapters we describe PET-experiments on hearing related topics. In chapter 3 we investigated how the sex of the volunteers can influence a fairly basic functional imaging experiment on auditory processing. We used auditory stimuli that are well known in neuroimaging research and studied brain activity, with a focus on the primary auditory cortex, in a population of healthy male and female subjects. The results of this study prompted us to investigate also the influence of sexual orientation on auditory processing, which is discussed in chapter 4. In chapter 5 and 6 we further explored the influence of sex on activation patterns by using silent lipreading, i.e. using visual stimuli that have a very strong link with an auditory counterpart. Chapter 5 contributes to the ongoing debate on whether or not the primary auditory cortex is involved in silent lipreading, by showing a relation with the sex of the volunteers. Chapter 6 additionally explores the (dis)similarities between males and females in overall brain activation during silent lipreading. Chapter 7 concludes with a general discussion reviewing the results of the previously described experiments by putting them in a general framework. At the end future perspectives of PET in auditory functional imaging are given.