Summary

A cochlear implant (CI) is a medical device that improves the hearing of patients with severe-to-profound hearing loss. The standard clinical care pathway for CI users in the Netherlands is intense with numerous visits to the clinic in the first year after implantation and regular follow up visits thereafter. During these visits, speech recognition is assessed and the sound processor is fitted or fine-tuned. This thesis describes studies which aim to improve different aspects of the clinical care pathway of new and experienced CI users.

Chapter 1 provides a brief overview of the history of cochlear implantation, changes in candidacy criteria over time, the clinical care pathway of new and experienced CI users, and the use of telehealth in the clinical care pathway. Finally, the outline of this thesis is presented.

Chapter 2 addresses the technical challenges that were encountered in the development of self-administered speech recognition tests for experienced adult CI users at home. It was demonstrated that speech recognition in noise is not influenced by the use of continuous steady-state masking noise (i.e., noise that is presented continuously throughout the test) instead of the standard discontinuous noise (i.e., noise that starts and stops after each stimulus) for both normal-hearing individuals and CI users. The study also showed that the direct coupling between the sound processor and tablet computer by means of an audio cable can be used as an alternative to a loudspeaker and sound booth for speech recognition testing, and that calibrated stimuli can be presented at predefined levels.

In Chapter 3, home self-administered speech recognition in quiet and in noise tests were compared to the standard tests in the clinic for a group of experienced CI users. Potential effects of stimuli presentation mode (loudspeaker or audio cable) and assessment (clinician in the clinic or self-assessment at home) on speech recognition scores were investigated. For the recognition of speech in quiet, no significant differences were observed between any of the conditions. In noise, speech recognition scores were significantly better with the audio cable than with the loudspeaker. Home self-assessment of speech recognition had no effect on speech recognition scores. The results demonstrated that it is feasible for experienced CI users to perform speech recognition tests in the home environment.

Chapter 4 presents a study that evaluated the use and feasibility of the self-administered test functionality as part of a telehealth application, the MyHearingApp, with newly-implanted CI users during the first three months of rehabilitation. The frequent assessment of speech recognition provided fine-grained progress details and revealed that speech recognition in quiet and in noise improved steadily during the first few weeks of rehabilitation, after which it stabilized. The fine-grained information enables clinicians to monitor their CI user’s speech recognition ability over time without the need for the CI user to visit the clinic.
The home tests provide a good alternative for tests in the clinic for newly-implanted CI users who are able to use the technology required.

In Chapter 5, the self-administered speech recognition test setup was used to assess speech recognition in noise with the Australian English digits-in-noise test in bimodal and bilateral CI users. Monaural and binaural speech recognition in noise was assessed via direct audio input in different conditions to determine the binaural benefit, to investigate the presence of binaural unmasking, and to assess the fluctuating masker benefit. For both bilateral and bimodal CI users, no binaural benefit was demonstrated when comparing monaural to binaural speech recognition in noise. There was no binaural unmasking present in both bilateral and bimodal CI users when speech recognition in noise was compared for diotic (i.e., identical signals in the left and right ear) and dichotic (i.e., with an inter-aural phase difference in the speech signal) listening conditions. Both bilateral and bimodal CI users benefit from interruptions in the masking noise, which yielded a large fluctuating masker benefit when speech recognition assessed with steady-state masking noise was compared to interrupted masking noise.

In Chapter 6, a study is presented with the objective to predict speech recognition in quiet and in noise from fitting parameters (e.g., T and C levels), electrically evoked compound action potential thresholds, and impedances in a large group of Cochlear™ adult CI users. Important parameters to predict speech recognition in quiet and in noise were identified. The mean aided thresholds, T levels, and the electrical dynamic range were found to be associated with speech recognition performance in CI users with late onset of severe hearing impairment. Elevated aided thresholds result in worse speech recognition in quiet and in noise. CI users with a DR of 40-60 CL were found to have better speech recognition, both in quiet and in noise. For CI users with early onset of severe hearing impairment, worse speech recognition in quiet and in noise was found for CI users with higher T levels. Measures to express the impedance profile across the electrode array were also identified as predictors of speech recognition in quiet and in noise in this group.

Chapter 7 presents a scoping review on the available literature concerning the use of manual and automatically switching devices by hearing aid and CI users. The literature was synthesized to investigate if users of hearing devices appreciate and adequately use the ability to switch between programs in various listening environments. The review showed that, despite the high number of manual and automatically switching devices that are sold each year, there are remarkably few studies about the use of multiple programs or automatic switching modes for various listening environments. No studies were identified that concerned the use of manual and automatically switching devices in CI users, and no studies were found that examined the accuracy of the use of the appropriate selection of programs.
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for specific listening environments. Although the evidence is weak, the review indicated that at least some hearing impaired individuals use the possibilities of multimemory hearing aids, and that an automatic switching device might be a good solution for those who are not able, or willing, to switch between programs in different listening environments.

The final chapter, **Chapter 8**, discusses the main findings and clinical implications. In addition, suggestions for further research are presented. The findings of the studies in this thesis indicate that self-administered speech recognition tests can be used as an alternative to tests in the clinic. The outcomes of the self-administered tests can be used by CI centres to identify those CI users who require intervention in the clinic. Then, resources can be spent on these CI users and the number of visits can be reduced for CI users who do not have a clinical need. Furthermore, important predictors of speech recognition have been identified which can be used by clinicians and CI centres to improve their fitting practices and subsequently improve the performance of CI users. Additionally, the fitting of automatic and manual programs for various listening environments can be improved by identifying CI users who would benefit from and prefer to have manual programs.