CoachLea: an Android Application to Evaluate the Speech Production and Perception of Children with Hearing Loss

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Abstract

Hearing loss can affect children’s language, speech, and social skills development. Hearing problems can result from im- paired auditory feedback due to various reasons such as trauma, a clin- ical condition, genetic alterations, and infections, among oth- ers. Early treatment is the key to successful hearing and speech rehabilitation if the hearing loss occurs before or during spoken language acquisition. In this work, we present CoachLea, an Android application to support the clinical evaluation and therapy of the speech production and perception of children with hearing loss. The app includes numerous daily exercises to capture speech and hearing data continuously and longitudi- nally using a game-like user interface. Speech exercises include the “Snail race”, “Animal Sounds”, and “Image identification”, whereas the hearing exercise consists of a word identification game based on minimal pairs with speech-in-noise recordings. In the long term, CoachLea aims to be a tool that supports the therapy of children with hearing loss.

Index Terms: Hearing loss, Speech production, Smartphone application, Cochlear implant, Hearing aid.

1. Introduction

Hearing loss can affect children’s oral communication, as au- ditory feedback plays a crucial role in monitoring the quality and intelligibility of speech; thus, hearing and speech rehabili- tation is essential for children during development of spoken language. The treatment for hearing loss depends on the severity and cause. For instance, children with mild to severe hearing loss generally use hearing aids that amplify sounds. In more profound hearing loss and deafness, making sounds louder is not enough to provide sufficient hearing for speech perception; thus, a cochlear implant is the most suitable treat- ment device because it bypasses the damaged portions of the ear and directly stimulates the auditory nerve. Regardless of the cause, children with hearing loss require assistance from audiologists, medical specialists in Otorhinolaryngology, and speech-language pathologists; thus, including assistive technol- ogy could contribute to the rehabilitation success.

Some smartphone-based applications have been developed to assess hearing perception. There are two types of mobile phone-based applications for hearing screening: tone-based audiometry test and speech-in-noise tests [1]. In a clinical setting, pure-tone testing is performed by reproducing tones at different frequencies through loudspeakers or headphones. One of the main difficulties of implementing this approach in smartphones is the hardware calibration, since the quality of the earphones influences the hearing thresholds. On the contrary, the speech- in-noise test assesses speech understanding in noisy environ- ments and does not require device calibration.

In this work, we present CoachLea, an Android-based ap- plication that aims to support hearing and speech rehabilita- tion of children with hearing loss. One of the main features of CoachLea is that the data collection process is performed using a game-like user interface. The application provides speech and hearing exercises that can be performed in a daily routine or indi- vidualy. On the one hand, CoachLea tests speech production using the “Snail Race” game (sustained phonation), “Animal Sounds” imitation game (vowel sequence), and “Image identifi- cation” game (word pronunciation). On the other hand, hearing perception is evaluated with the app using a “Minimal Pairs” ex- ercise, consisting of speech-in-noise recordings played through the smartphone’s loudspeakers. Furthermore, CoachLea pro- vides audio and text instructions to perform the exercises.

2. CoachLea

The name CoachLea, pronounced as Coach-Lea, is a wordplay between “cochlea” (which is the name for the inner ear and the Latin word for snail) and the green snail “Lea”, the character introduced in the app to guide with instructions, give feedback, and take part in one of the exercises. The user interface was designed to be as intuitive and easily used as possible by us- ing symbols and figures to navigate the app (Figure 1). Fur- thermore, CoachLea collects speech and hearing data using a game-like approach, so the child does not feel like doing a task but rather doing a leisure activity. Currently, CoachLea only supports German language; however, we are working to adapt the app to other languages.

Login process: when the application is used for the first time, the user is informed that CoachLea aims to collect speech and hearing data through exercises; thus, microphone usage and storage permissions have to be given to use the app. Once the user accepts the terms of use, a second login screen is displayed to enter basic profile information. Such information is never collected outside the smartphone without the authorization of the person(s) in charge of the child’s custody. The login process is meant to be supervised by an adult (Figures 1.a and 1.b).

Main screen: on the main screen, there are two large but-
Figure 1: Screenshots of the different functionalities and exercises. All images used are royalty free https://illustoon.com/.

tons with the images of “Lea” on top and a pink snail (called “Emily”) on the bottom (Figure 1.c). On the one hand, when the button with “Lea” is pressed, a list with all possible exercises will be displayed on screen (Figure 1.d), which allows performing any task individually. On the other hand, when the button with “Emily” is pressed, three pseudo-randomly chosen exercises will be provided to the child every day (Figure 1.e).

Instructions: CoachLea provides audio and text instructions (Figure 1.f) that can be accessed by pressing the question mark located next to the exercise name or in the top-right corner of the screen (during an exercise).

Speech games: three voice/speech exercises can be performed with CoachLea: “Snail Race”, “Animal Sounds”, and “Image identification”. The Snail Race was designed as a racing game between “Lea” and “Emily” (Figure 1.h), where the child controls the speed of “Lea” by producing the sustained phonation of the vowel indicated before starting the race (Figure 1.g). The Animal Sounds game was designed for the child to imitate the sound that makes the animal displayed on the screen (Figure 1.j). For instance, when the cat is shown, the child is expected to say “meow, meow...”. This exercise aims to collect data suitable for analyzing the vowel triangle. The Image identification game consists of pronouncing the word that represents the picture displayed on the screen (Figure 1.k).

Hearing game: hearing perception is evaluated using minimal pairs. Two pictures are displayed on the screen representing words that sound very similar but have different meanings, e.g., “Tasse” and “Tatze” (Figure 1.i). Then, the word of only one picture will be reproduced, and the child must select the image that represents the word understood by him/her. This exercise is performed ten times using different pairs and signal-to-noise (SNR) ratios. White noise is added to the recordings (SNR=25 dB) after the second minimal pair, and the SNR of the recordings decreases by 5 dB every two minimal pairs; thus, the recordings of the last two trials have an SNR of 10 dB.

Feedback: CoachLea always provides a positive message to the child when he/she completes an exercise (Figure 1.l).

3. Conclusions

CoachLea is an Android-based application with the primary goal of supporting the speech production and hearing rehabilitation of children with hearing loss. The application offers a game-like user interface to motivate the children to use CoachLea as a leisure activity rather than a task and, at the same time, collect data suitable for the monitoring of speech production and understanding. The source code of CoachLea can be downloaded from https://zenodo.org/record/6461551#.YlgzfTVCSUk.

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5. References