Phonak Insight

April 2016

Automatic and directional for kids

Scientific background and implementation of pediatric optimized automatic functions

Children spend their time in a variety of listening situations throughout their day at home, outdoors and at school. Particularly, many school situations are noisy and can be very challenging for a child to hear, understand and perform well in the classroom even when a Roger system is routinely used by the teacher. The benefits of automatic programs and directional microphones have been clearly established for adults in noisy environments. An in-depth analysis of multiple classrooms with children who have hearing loss, across multiple countries, revealed that as much as 1/3 of a child's school day is spent in situations where it is difficult to understand and fully participate. This analysis resulted in the development and implementation of two innovative functionalities in Phonak Sky V hearing instruments: AutoSense Sky OS, the new pediatric automatic operating system and the new 'Roger and directional' setting offering an adaptively activated fixed beamformer in the Roger program with and without an active Roger microphone.

Introduction

Today, most children with hearing loss are integrated into regular schools and classrooms. School environments can present several challenges to a child's ability to hear, understand and perform. In general, even normal hearing children need a better signal-to-noise ratio (SNR) compared to adults since their language skills are still developing. Furthermore, children with hearing loss need even better SNRs than normal hearing children in order to understand at comparable levels.[1, 2] These children need a better SNR not only for understanding and academic performance, but also for social and emotional integration into the class.[3] Modern teaching styles tend to be interactive, which create additional challenges for a child who is already having difficulty hearing and keeping up with classroom activity and instruction.

Supporting a child's integration is essential. Children with hearing loss are often supported by a network of audiologists, teachers and other professionals, but success in the classroom also depends greatly on the performance and use of the hearing solution they use.[4]

Early studies have investigated and analyzed the acoustics of school environments. However, these studies only looked at situations where the teacher stands in front of the classroom for teaching, called frontal instruction. More recently, the listening environments of school days, in and outside of the classroom, for children of different ages have been investigated .[5, 6] This comprehensive soundscape showed high variations, throughout the day for children of all ages.

The current study investigated students' hearing situations all day long, in and outside the classroom. The goal was to investigate the performance of our hearing instruments for children in various school environments where Roger may or may not be used. This analysis led to an optimized AutoSense OS tailored for the specific listening needs of children, called AutoSense Sky OS and also to an improved Roger program now offering a 'Roger and directional' setting.

Analysis of school environments

The first step was to investigate the performance of students with hearing loss throughout the school day using a qualitative user research approach. For this purpose, we selected four hearing impaired students aged between 9 and 15 years, with moderate to severe hearing loss. They were integrated into 4 different regular schools in Switzerland in order to learn about the everyday challenges they face in the classroom. Furthermore, we selected a second group of students, aged between 7 and 16 years who attended a school for hearing impaired students only.

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The aim with the second group of students was to learn about the problems and challenges which motivated them to move to a specialized school for children with hearing loss. Many students lived at the school during the school week as it was situated too far from home to commute on a daily basis.

Interviews were conducted with the students at school and at home. Furthermore, investigators visited all five schools and accompanied the students through an entire school day. The observations during activities throughout the day were discussed with the students. Specifically, students were asked how well they could understand the teacher and their peers in specific situations and whether any sounds were uncomfortable. The combination of observations and follow-up interviews resulted in a qualitative hearing performance estimation for listening situations throughout the children's day. This hearing performance estimation includes the variables 'speech understanding' and 'comfort'.

Furthermore, audio- and video recordings were performed during the school days and labeled by listening situation. Labeling enabled an analysis of how often specific listening situations occurred. Together with the rated importance of each listening situation retrieved by the interviews, the relevance of each listening situation could be estimated. With the estimation of hearing performance and the estimation of relevance, the benefit of improving a certain listening situation could also be determined.

Outcome of qualitative user research

The teaching style at schools these days is very interactive and not comparable to the frontal instruction style, which adults of today experienced as children.[7] The older the students are, the more interaction is expected. Additionally, multimedia has found its way into the classrooms. As a result, the level of hearing difficulties seem to correlate more with classroom teaching styles and less with acoustic properties or subject area. This conclusion led to a categorization of listening environments at school, which are related to the teaching styles.

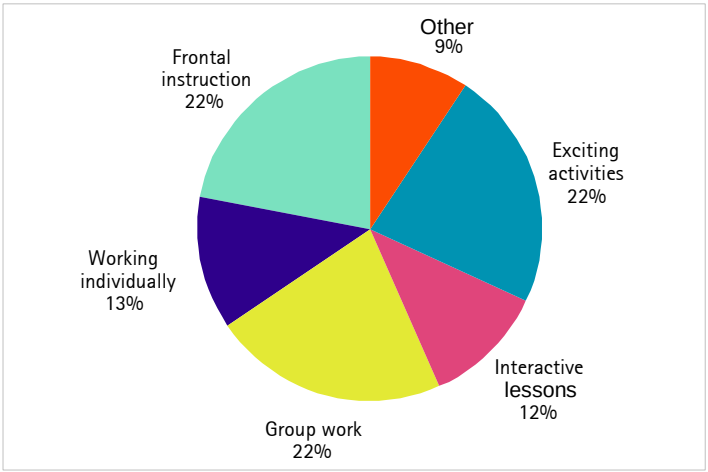

Figure 1: Occurrence distribution of different listening situations across several schools (51 hours).

Figure 1 shows the listening situations with respective time proportions, averaged over all schools. The listening situation **frontal instruction**, with the teacher talking in front of the whole class, occurred 22% of the time, which implies a high relevance for this listening situation. The hearing performance during **frontal instruction** is reported by the students as being mostly satisfying with regards to speech intelligibility, since teachers are using the Roger system consistently. It is also evident that **working individually** is not associated with listening problems. Many students even turn off their hearing instruments to concentrate more on the task, especially during exams.

In contrast, **group work** is reported as an unsatisfactory listening situation. Students are commonly split into groups of two to three students. Since most often all the groups stay in the classroom, the acoustic listening environment is noisy, even if the overall level is not necessarily loud. Unfortunately, Roger is not often used in these situations due to the time constraints of fast- paced dynamic classroom lessons. These circumstances lead to conversations with poor SNR levels, and often lead to poor hearing performance for the student with hearing loss. Furthermore, **group work** occurs often and in a variety of subject areas, such as language lessons and math. **Group work** and **peer conversation** occurred 22% of the time, which implies a high relevance for this listening situation.

Regarding comfort, the second variable of hearing performance, the greatest dissatisfaction was reported when other children were yelling. These situations mostly occurred while children were playing in class breaks, during team sports and during transitions between different activities in the classroom, e.g. the students have to choose team partners for group work, or when students prepare themselves in the locker room for recess. These situations are summarized as **exciting activities**.[4] These situations were reported by most of the students as being far too loud and very uncomfortable.

To verify these findings, similar analyses were completed in schools in Germany, USA, South America and also China.

Real life recordings

During the school-day observations, each student wore his own hearing instruments and also recording equipment, that included a second modified hearing instrument which did not generate acoustic output, but instead, recorded the microphone input. The modified hearing instruments were placed on the student's head, close to his or her own hearing instruments, to guarantee the same acoustic condition and thus to capture the same sound as their own hearing instruments. This allowed a performance evaluation of the hearing aid signal processing in all listening situations. The recording system was portable, such that the student was not hindered in any way and could participate and behave as usual in activities.

The recorded listening situations, first analyzed in the lab to see how signal processing is applied by the hearing instruments in the

various acoustic situations. This analysis showed that relevant and unsatisfying situations, such as **group work** and **yelling** are unique to children's daily listening environments and are not optimally recognized in the signal processing unit. These results emphasize the need for an operating system tailored to the specific listening environment of the user and led to the creation of AutoSense Sky OS, specifically built for the listening environments of a child's life. AutoSense OS was retrained by using additional hours of classroom recordings from the current study to develop the pediatric automatic classifier, AutoSense Sky OS. Once retraining was completed, the recorded listening situations were used in the lab to analyze how signal processing is applied by the hearing instruments in the various acoustic situations. As a result, AutoSense Sky OS offers an improved precision for recognizing group work and peer conversation situations and for detecting yelling as unwanted noise in comparison to AutoSense OS, which is optimized for the listening situations of an adult's daily life. Thus, the new AutoSense Sky OS treats these listening situations according to the reported needs of the students who experience them.

Furthermore, to improve speech understanding in group work situations and any conversation in noisy environments, the Roger program has been enhanced to access the adaptively activated directional microphones of the hearing instruments. This gives students the proven benefits of directionality in the classroom even when Roger is in use.

Functionality of AutoSense Sky OS

AutoSense Sky OS is based on the Venture operating system for adult hearing instruments, AutoSense OS, and shares the main program structure and functionalities. It adapts seamlessly to different hearing situations and environments by fading sound cleaning features and directional modes in and out, and adapting the gain automatically. The architecture of AutoSense Sky OS is based on programs which represent typical hearing situations and, if required, can be adapted to each user's needs with Phonak Target fitting software.

These programs are chosen because they most appropriately cover a range of different listening situations. In total, AutoSense Sky OS includes sound cleaning features and seven individual adjustable programs. AutoSense Sky OS follows the same operating principles as the adult system, providing dedicated program parameters for the exclusive programs Speech in Loud Noise, Music and Speech in Car while blending a combination of non-exclusive programs (Calm, Speech in Noise, Comfort in Echo, Comfort in Noise). The blending is carried out according to the constantly changing listening environments in real life and according to the continuous combinations of sounds.

AutoSense Sky OS improves listening situations like group work activities and peer conversation by:

- detecting group work as Speech in Noise with up to 30% greater precision than the adult operating system and
- activating the fixed directional mode at lower levels with Venture hearing instruments, which may lead to improved SNR levels in noisy conversations.

AutoSense Sky OS also more accurately classifies yelling and shouting as unwanted noise with up to 39% more precise activation of the program Comfort in Noise or Speech in Noise, depending on the speech content of the yelling situation.

To validate this improvement, 15 children were recruited for an additional study to assess whether AutoSense Sky OS improved listening comfort, listening fatigue, desire to continue device use, and reduced desire for manual adjustment. Preliminary results from the first 6 subjects will be reported here. Subjects were placed in a classroom environment surrounded by 5 speakers of uncorrelated recordings of students at recess, naturally with significant amounts of yelling. The yelling noise was presented at 75 dBA. It was verified via hearing instrument monitors that the scene was accurately classified as Comfort in Noise by AutoSense Sky OS rather than Music by the adult operating system. While listening to the scene, the subjects answered 5 questions on a touch screen monitor. One question was presented per page on the monitor and the child was able to use a button on the page to toggle between programs A and B. Comfort in Noise (AutoSense Sky OS) and Music programs (AutoSense OS) were assigned to the buttons and were randomized with each question. The first 6 subjects rated the comfort in noise program better than the music program across every domain (Figure 2). The results show greater tolerance and comfort and reduced fatigue and need for manual adjustment and device removal with AutoSense Sky OS.

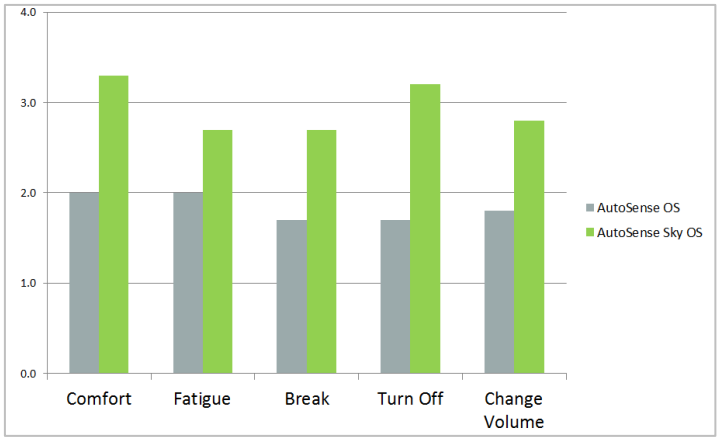

Figure 2. Average results of the double blinded A/B comparison. Subjects switched between the AutoSense OS selected program (Music) and the AutoSense Sky OS program (Comfort in Noise) in the yelling scene and rated the following domains:
Comfort: 5 = very comfortable / 0 = very uncomfortable
Fatigue: 5 = doesn't make my ears tired at all / 0 = makes my ears very tired
Break: 5 = would not need a listening break / 0 = would need a listening break
Turn off: 5 = would not turn off / 0 = would turn off
Adjust volume: 5 = would not adjust volume / 0 = would adjust volume

Functionality of Roger and directional

Roger technology significantly improves the intelligibility of the teacher's voice at school and the ease of listening for hearing impaired students. With previous technology platforms and with all other hearing instrument manufacturers, Roger signals are integrated with the ambient sound picked up by omnidirectional hearing instrument microphones. The Venture platform provides the possibility to activate any directional mode simultaneously with the Roger input. When activated by the fitting software within the Roger program, the directional mode adapts between Real Ear Sound (RES) and a fixed directional setting, depending on the presence of background noise and according to the amount of Speech in Noise detected by AutoSense Sky OS. The microphone mode setting that is activated in the presence of background noise depends on the fitting of the HCP and can be customized between three settings: Omnidirectional, Real Ear Sound and the adaptively activated Fixed directional setting. The fixed beamformer (a cardioid pattern of reduction) is the default directional setting and an optimal choice for school-related group work. The fixed beamformer is the optimal directional mode to enhance speech understanding within angles between 0° and 90° for the direction of speech arriving to the hearing instrument microphones.

Children have access to the Roger program based on the fitting philosophy of the HCP:

1. Roger program is the default and only program setting (e.g. young children who cannot yet manage their own hearing instruments and are not fitted with AutoSense Sky OS). These children can now have access to directional microphones no matter where they spend their time.

2. AutoSense Sky OS is the default start-up program. Roger program is available and switches automatically with RogerReady between the two modes, dependent on the signal of the Roger microphone.

For both cases, while the child is receiving a Roger signal, the directional setting of the hearing instrument microphones adapts to the environmental noise to optimize listening and provide directional benefit as required with an estimated 3 dB improvement in SNR for peer voices and for the teachers voice when in the near field.

The use of the Roger and directional setting was validated with 6 children in a classroom setting. Classroom noise was presented from the rear plane and speech from a peer talker was presented at 315 degrees (Figure 3). The peer talker and the background noise were presented at 65 dBA, resulting in a 0dB signal to noise ratio. Preliminary data from 6 of the validation subjects showed a significant benefit for the Roger and directional fixed beam setting (Roger+DM) over the Roger and omnidirectional setting (Roger+Omni). Figure 4 shows speech recognition of sentences in noise was 37% better on average with the Roger+DM program compared to a Roger+omni program (Wolfe, 2016).[9]

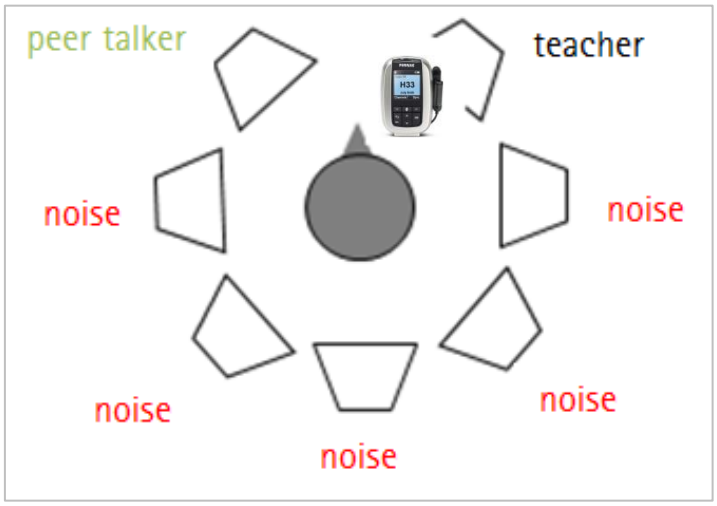

Figure 3. Classroom scenes with peer talker at 315 degrees in noise.

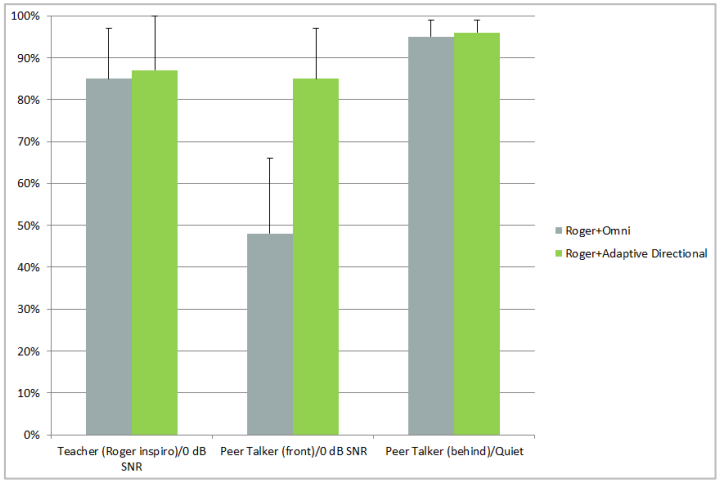

Figure 4. Preliminary results of Roger + omni and Roger + DM for 1. The teacher using the inspiro transmitter, 2. The peer talker front in noise and 3. The peer talker from behind in quiet. N=6. Error bars represent 1 standard deviation.

Summary

AutoSense Sky OS is based on AutoSense OS and is tailored to the listening environments of children with a focus on improving understanding for group work and peer conversations when Roger is not available and also on improving comfort in situations where children are very loud and yelling. Both improvements support young students by reducing listening effort and improving comfort in exciting activities with loud and yelling voices.

The Venture platform allows, for the first time, directionality within the Roger program, simultaneous to the Roger input. The Roger and directional setting, adaptively activates the fixed directional microphone depending on the presence of background noise and according to the amount of Speech in Noise detected by AutoSense Sky OS.

These two new features bring improvements in several listening situations where children spend a significant amount of time. Both AutoSense Sky OS and the Roger and directional setting are available for the first time with the Phonak Sky V pediatric family of hearing instruments.

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