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Hearables in Hearing Care: Discovering Usage Patterns Through IoT Devices

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Abstract. Hearables are on the rise as next generation wearables, capable of streaming audio, modifying soundscapes or functioning as biometric sensors. The recent introduction of IoT (Internet of things) connected hearing aids offer new opportunities for hearables to collect QS quantified self data that capture user intents and thereby provide insights to adjust the settings of the device. In our study 6 participants shared their QS data capturing when they remotely changed their device settings over 6 weeks. The data confirms that the participants preferred to actively change programs rather than use a single default setting provided by an audiologist. Furthermore, their unique usage patterns indicate a need for designing hearing aids, which as hearables adapt their settings dynamically to individual preferences during the day.

Keywords: Hearables, quantified self

1 Introduction

Hearables may be the wearable of the future. They fit on or in the ear, providing audio playback, soundscape argumentationn[3], or integrate biometric sensors. More than $28 million have been raised from crowdfunding for hearables since 2014[2]. Smartphone users stream audio for more than 60 minutes per day[6], giving hearables audio streaming a wide appeal.

Hearing aids are a medical device subcategory of hearables, which offer advanced capabilities for augmenting listening scenarios, including amplification, noise reduction and speech enhancement. The latest generation of hearing aids connects to smartphones through Bluetooth, enabling them to communicate with other apps or cloud services supporting the IFTTT standard, effectively making them IoT connected devices.

Hearing aids primarily support enhanced speech intelligibility in challenging listening scenarios characterized by speech in noise or multiple talkers. However, only a small fraction of the 360 million people suffering from hearing loss[7], including 48 million (20%) Americans [4], use hearing aids.

This paper investigates the usage patterns of hearing aid users based on user initiated program and volume changes through a pilot study of 6 weeks. These adjustments are converted into time series data saved in the cloud using IFTTT to transfer data. Previous studies have primarily used logging from the hearing aid devices, whereas IoT devices may potentially learn from QS data to dynamically adapt the hearing aids to behavioral patterns.

We wish to investigate how QS user generated IFTTT data describing intents could provide insights for personalizing the settings of hearables throughout the day

IoT connected devices and time series data, based on per minute use, can provide a better hearing experience for people using hearables and hearing aids.

2 Method

6 participants (median age 61) which had used hearing aids for more than 5 years were recruited for the study. Half of the participants were retired, while the other half are still working. Participants were equipped with two Oticon Opn^{TM} hearing aids connected their own iPhones using Bluetooth. All user initiated program selection or volume changes were logged as time series data stored over a 6 week period.All participants were provided with a Google Drive account used for data collection, allowing them to retain full ownership of the data.The hearing aids were fitted based on audiograms by an audiologist to provide individualized frequency dependent amplification for each each subject. Rather than a single optimized setting the hearing aids were fitted with four alternative programs providing increasing amounts of speech intelligibility in challenging listening scenarios:

– Pinna omni: resembling frontal focused omnidirectional perception of the natural ear with no noise reduction, no directionality, only amplification.

– YouMaticLX low: similar to pinna omni but gently increasing directionality and noise reduction when encountering complex listening environments.

– YouMaticLX high: similar to pinna omni but strongly enhancing directionality and noise reduction even in simple listening environments.

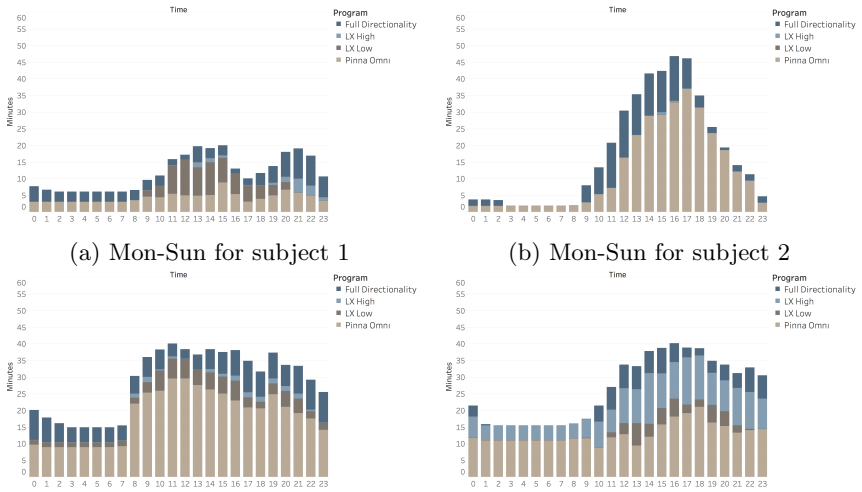
– Full directionality: similar to YouMaticLX high with constant directionality and noise reduction in all listening environments.

3 Results and Discussion

The program patterns in Fig. 1 & 2 ranging from pinna omni, (beige) YouMatic LX low (brown) YouMatic LX high (light blue) to full directionality (dark blue), illustrate the large differences between users, their contrasting needs throughout the day, as well as their changing preferences for weekday vs weekend activities. General trends towards increased support during the day can be seen for users 1,5 and 7. Conversely less need of support in the evening is reflected in the behavior of user 2. In addition the distinct versus round sound represented by the

YouMatic LX low (brown) versus high (light blue) may indicate how preferences for the former increases speech intelligibility, whereas the latter provides a less intense listening experience. Likewise the program usage on weekdays could be driven by the demands of work related activities, while the preferences on weekends might to a larger degree reflect individual baselines defining their cognitive processing needs[1, 5].

These results show how QS user generated data may capture preferences for personalizing the listening experience to the changing context. The usage patterns highlight individual needs for selecting contrasting programs rather than the default one size fits all setting often provided by an audiologist. The shared user generated QS data might potentially be used to learn behavioral patterns enabling the devices to automatically adapt their of settings and thus optimize the user experience of hearables.



(a) Mon-Sun for subject 1

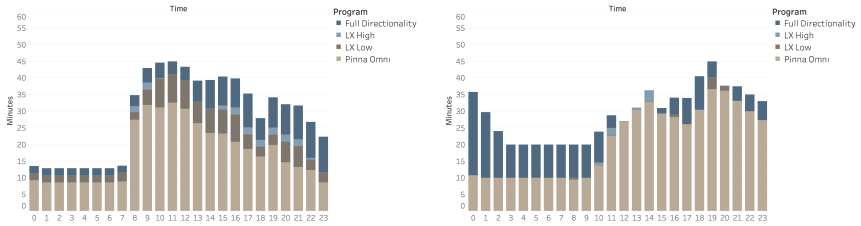
(b) Mon-Sun for subject 2

(c) Mon-Sun for subject 5

(d) Mon-Sun for subject 7

Fig. 1: Average program time in minutes for each hour for 4 test subjects. The use of pinna omni (beige), LX low (brown), LX high (light blue) and full directionality (dark blue), varies for each test subject as well as over the course of the day.

These results show how QS user generated data may capture preferences for personalizing the listening experience to the changing context. The usage patterns highlight individual needs for selecting contrasting programs rather than a medium one size fits all setting often provided by default. The shared user generated QS data might potentially be used to learn behavioral patterns enabling the devices to automatically adapt their settings and thus optimize the user experience of hearables.



(a) Mon-Fri for subject 5

(b) Sat-Sun for subject 5

Fig. 2: Comparison of weekday and weekend patterns for subject 5. Notice the distinct pattern of less support in the weekends.

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