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Music and Hearing Aids: An Unexpected Journey

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One thing everybody working with Brian can agree on is his extreme efficiency. In other words, Brian does not waste his time! When going to my first international conference, IHCON 2012, Marina, a fellow PhD student and I got a ride from Brian between the San Francisco airport and the conference venue in Lake Tahoe. We were very excited about the conference, admittedly more so because it was in sunny California, and had planned a few days of holiday before the conference. However, Brian had no patience for waiting for luggage, so he required that we only brought hand luggage since: “all you need is a pair of shorts and a couple of t-shirts.” Well, we did not agree with his assessment of essentials and could easily have filled a much larger suitcase but did after much effort managed to fit everything in our hand luggage. This efficiency, however, has also led to him being exceptionally prolific professionally. Rumor goes that he can write a paper in less than a day, which I can easily believe considering the speed by which he gives feedback. And not only is he fast, but he is also very thorough, and his feedback is always very extensive and insightful. During my PhD, we never scheduled meetings, but Brian's door was always open, and he was always willing to take time to discuss my project and able to answer questions even though he was in the middle of writing something on an entirely different topic. He would just finish the sentence and, after talking to me, go back and write the next sentence as if the disturbance never happened.

I did not plan to do a PhD with Brian and ended up in his lab by a stroke of luck. I was finishing my master thesis at the Technical University of Denmark (DTU), saw the PhD position advertised on the auditory mailing list, and applied immediately. Given my background in music and engineering, the topic of the project, music, and hearing aids,

was very attractive to me and getting Brian as a supervisor was definitely icing on the cake. It was a privilege and a wonderful experience getting to do a PhD in Cambridge with Brian. He is of course a brilliant scientist, being incredibly clear-minded, creative, and efficient, but he is also a great supervisor and I am grateful for the insightful input and kind mentorship that I have benefitted from ever since I started my PhD.

Brian's research covers a vast range of topics and this paper will touch upon one of the more applied ones, namely that of hearing aids and music. Hearing aids have been optimized for speech and not music, which is reasonable considering the importance of speech for communication and therefore daily life. However, this may also partly explain why many hearing-aid users, including Brian, are not satisfied with their hearing aids when listening to music. Given this and the fact that Brian is a keen amateur musician, it is not surprising that he chose to also research this topic.

To identify the problems associated with listening to music with hearing aids and the prevalence of those problems, we conducted an online survey targeted towards hearing aid users.[1] The survey showed that a large proportion of the respondents found their hearing aids helpful when listening to music but also revealed problems with distortion, acoustic feedback, insufficient or excessive gain, degraded tone quality, and lack of low-compared to high-frequency gain. Imbalanced frequency response can be problematic because it can affect the naturalness of the sound and sound quality. In fact, Moore and Tan reported lower sound quality ratings for music in conditions with a larger spectral tilt and Vaisberg et al. showed that even a small decrease in low-frequency gain is associated with a significant worsening in sound quality ratings.[2,3] Thus, a lack of low compared to high frequencies may in part explain the reported reduction in tone quality. Another related issue is the limited frequency range used in hearing aids. Modern hearing aids typically only process frequencies between about 100 and 8000 Hz and Moore and Tan showed highest sound quality ratings for music for a broadband condition (55 -16854 Hz) and a marked reduction in ratings when decreasing the higher cutoff frequency and even more so when increasing the lower cutoff frequency.[2]

Another potential issue is the use of dynamic range compression. Hearing loss makes it difficult to hear weak sounds but does not increase the highest comfortable sound level.

Hearing aids, therefore, apply gain to make weak sounds audible and use dynamic range compression to squeeze the dynamic range into a range that is audible and not uncomfortably loud. Compression is very relevant for music that often has a larger dynamic range than speech.[4] Unfortunately, dynamic range compression can in some cases lead to distortion and has been found to introduce cross-modulation between signals in different compression channels, making it harder to separate speech from different talkers.[5] We wanted to determine whether such cross-modulation would also affect listeners' ability to hear out individual instruments when playing together.[6] We did find a deleterious effect of dynamic range compression but found no effect of cross-modulation. Moreover, while there was no overall effect of compression speed, clarity ratings were worse for slow than for fast compression for some participants. The effect of compression speed was more pronounced in studies measuring sound quality ratings for music reporting significantly higher ratings for slow- compared to fast-acting compression.[7,8] This indicates that slow compression speed is generally preferable for music.

Figure 1: Happy reunion at International symposium on auditory and audiological research (ISAAR) 2015. Photo courtesy of Eva Helena Andersen (DTU).

Recent studies confirm that issues such as degraded sound quality are still a

problem.[9,10] But, although there is plenty of room for improvement, Brian's research has helped identify specific issues associated with using hearing aids for music. Hopefully, this knowledge can help in the development of future hearing aids that are better for music.

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