Assessment of cochlear implant hearing outcomes using ecological momentary assessment (EMA) in both controlled and real-world settings

Zachary M. Smith1, Qingqing Meng2, Marisa Poulos3, Jessica Monaghan4, and Jorge Mejia4

1 Cochlear Limited, Sydney, Australia
2 National Acoustics Laboratories, Sydney, Australia

Introduction
Evidence from laboratory tests of speech understanding in quiet and noisy conditions demonstrate the high effectiveness of cochlear implants (CIs) for individuals with severe-to-profound hearing loss. However, benefits in real-world listening conditions are more challenging to capture and are thus less understood. Common retrospective methods, such as questionnaires, to assess real-world hearing performance and device benefits of devices may be inaccurate and unreliable due to recall bias and insufficient knowledge of the acoustic environment. To address this, we used an Ecological Momentary Assessment (EMA) smartphone app to record current or very recent, subjective feedback ratings alongside objective acoustic parameters of the listening environment of adult CI recipients, in both controlled laboratory settings and in the real world. Using EMA, we aimed to characterise the acoustic features of environments that CI users find most challenging, and the internal factors (such as cognition, attention, personality, and lifestyle) which influence their self-ratings on perceived environmental noisiness, device benefit, and speech understanding.

Methods

Participants
• 20 CI users between 50 and 82 years (mean 64 years; 10 female)
• Unilateral/bilateral CI implantation (Cochlear Ltd devices), >12 months CI experience (mean 11 years)

Procedures

Laboratory portion
• Cognitive tests: M-ACE, Reaction Time, Test of Everyday Attention
• Questionnaires: Big 5 Personality, Everyday Listening Questionnaire (ELQ)
• NAL Dynamic Conversation Test (NAL-DCT) and EMA survey under 5 simulated listening environments at realistic levels

• 41-speaker ambisonic setup in anechoic chamber

EMA surveys in daily life
• iOS app
• Acoustic feature logging
• 4 weeks, minimum 2 surveys per day

EMA Survey Questions

• Assessment of speech understanding (EMA) and measured comprehension scores are significantly correlated (r = .78, p < .001).
• EMA self-reported noise, effort, impact, and frustration increase with noise level and decreasing SNR.

Results – Laboratory

Comprehension scores drop with increasing noise and decreasing SNR.

EMA Speech understanding and Device benefit decrease at more challenging SNRs.

Results – Daily Life

EMA surveys were captured in a range of locations. The majority of surveys were conducted indoors, mostly at home. This portion of the study was potentially biased by COVID lockdowns in Sydney in mid-2021.

Linear mixed-effects modeling

Acoustic features

Self-rated communication difficulty (Listening effort, Conversational participation, Frustration, and Speech Understanding) was best predicted by the sound level of the environment alone.

Audiological and cognitive factors

Reported device benefit was higher for bilateral CI subjects, longer device experience, and better cognitive measures.

Summary

Under controlled simulation of realistic listening environments, speech comprehension scores (NAL-DCT) and self-rated speech understanding (EMA) were significantly correlated and in agreement.

Through in situ self-ratings and concurrent recording of key acoustic features, EMA can provide valuable insights into the real-world experiences and challenges of CI recipients.

The information from EMA has the potential to better tailor technologies for individuals’ everyday needs and evaluate the functional efficacy of these technologies in the real world.

Acknowledgements and References

This study was funded by Cochlear Limited