

Feasibility of objective speech intelligibility tests in Ecological Momentary Assessment

Durchführbarkeit objektiver Sprachverständlichkeitstests im Rahmen des Ecological Momentary Assessment

Abstract

When using Ecological Momentary Assessment (EMA) to evaluate hearing problems in real life, typically only subjective speech understanding is assessed. This, however, is highly dependent on factors such as lip reading or speech context. Hence it could be beneficial to also include an objective speech intelligibility test in EMA. In this pilot study, objective speech intelligibility in everyday life was assessed with ten experienced hearing aid users over a period of 14 days as an optional task within EMA evaluating two hearing programs. We found that participants performed the objective speech intelligibility test on average in 94% of all EMA surveys in a variety of different acoustic situations.

Keywords: Ecological Momentary Assessment, speech intelligibility test, phoneme test, hearing aid evaluation, real-life testing

Zusammenfassung

Die Methode des Ecological Momentary Assessments (EMA) zur Bewertung von Hörproblemen im Alltag erfasst üblicherweise nur subjektive Sprachverständlichkeit. Diese hängt jedoch von Faktoren wie Lippenlesen und Sprachkontext ab. Deshalb kann es hilfreich sein, auch die objektive Sprachverständlichkeit zu evaluieren. In dieser Studie wurde die objektive Sprachverständlichkeit im Alltag mit zehn erfahrenen Hörgeräteträgern in einer EMA-Pilotstudie über einen Zeitraum von 14 Tagen ermittelt. Probanden führten den optionalen Sprachverständlichkeitstest im Schnitt für 94% aller Fragebögen und in sehr unterschiedlichen akustischen Situationen aus.

Schlüsselwörter: Ecological Momentary Assessment, Sprachverständlichkeitstest, Phonemtest, Hörgeräteevaluation, realitätsnaher Test

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1 Introduction

Hearing aid (HA) benefit is often evaluated using objective speech intelligibility tests during the fitting procedure. These tests are conducted in the laboratory or in a sound-insulated room either in quiet or in noise. The problem is that these isolated situations do hardly reflect real-life situations and are therefore only representative of real life to a limited extent. In everyday life HA benefit is usually assessed by retrospective questionnaires or by Ecological Momentary Assessments (EMA) comprising only subjective questions. However, questions in EMA about subjective speech understanding may be greatly influenced by the ability to lip read or the predictability of the spoken words from the context. Hence a measure for objective speech intelligibility in the typical environment of the HA users would be useful. However, such a speech intelligibility test possibly poses an even bigger burden on the participant than the usual EMA survey, because speech intelligibility testing may not be appropriate to conduct in some everyday situations. Hence the aim of this study is to analyze whether a speech intelligibility test can be integrated into everyday life and is carried out by the participants.

1.1 Methods

Ten native German-speaking experienced hearing aid users (mean age 69.7±11.1 years, 40.3±21.5 dB PTA) with symmetrical, moderate to severe hearing loss participated in the study. The study was approved by the Ethics Committee of the Friedrich-Alexander-Universität Erlangen-Nürnberg (23 May 2023, application 23-165-B). All participants gave written informed consent before the start of the study. The study lasted 18 days, with four days for acclimatisation to the new HAs and 14 days for the EMA field trial itself. There was one appointment at WS Audiology at the beginning and one at the end of the study. During the first appointment, Signia Pure 312 7AX HAs were fitted to the individual hearing loss with NAL-NL2 (including own voice training and fine-tuning) and paired with a smartphone (Samsung Galaxy S20). After fine-tuning, a second program was configured with a 6 dB gain reduction from 0.5 to 4 kHz. In the laboratory, three different speech intelligibility tests were carried out: (1) a logatome test streamed to the HAs, which was also used during the field trials, (2) the logatome test via free field, and (3) the Freiburg monosyllabic test via free field. Hearing programs alternated every day automatically with switching every night. During the field trial participants received up to ten notifications per day via the EMA app in which they were asked to complete a questionnaire followed by the optional logatome test. Six of the notifications were randomized throughout the day and up to four were triggered by ambient volume >0 dB SPL and >40% speech content of the environment. Objective data of the environment as determined by the hearing aid classifier was also collected for each minute of the study period (see [1] for more details). Skipping the logatome

test was possible by giving a reason. The questionnaire included questions about the environment and subjective speech understanding in order to determine whether the subjective speech understanding perceived in the situation correlated to the objective speech intelligibility. The questionnaire consisted of up to 22 questions and the speech intelligibility test with twelve logatomes (see <https://osf.io/wxq5s/> for the full list of questions). The speech intelligibility test was included in the questionnaire within the same app and the participants had a single choice option from 5 possible response options after playing the sound file without getting feedback about their response. At the beginning of the study participants adjusted the sound pressure level of the streamed logatomes to a comfortable volume, which was then kept constant throughout the study. The logatomes consisted of vowel-consonant-vowel utterances with either “a”, “e” or “i” as embedding vowels. For each test there was a random selection (without replacement) of four phonemes from each vowel context. The audio files of the logatome test were recorded by Bellanova [2] and had been used previously in auditory training with the Schoolo method [3]. Here we chose the female speaker and the consonants /b/ /d/ /g/ /p/ /t/ /k/ /x,ç/ /f/ /ʃ/ /w/ /m/ /n/ /j/ /l/ /r/.

2 Results

2.1 Feasibility in everyday life

In total 1,131 questionnaires were completed during the study. Of those, 44.7% (505) were initiated by the user, and 55.4% (626) were triggered randomly or due to the acoustic situation. The objective speech intelligibility test was performed in 94.9% of the self-initiated questionnaires, in 93.1% of the random trigger questionnaires, and in 92.5% of the surveys that were triggered by the acoustic situation. Additionally, 43 questionnaires were started but not completed. From those, only 6 were prematurely aborted logatome tests. Figure 1 shows the distribution of the questionnaires across the participants. In the upper panel, blue parts are questionnaires in which the logatome test was performed, and orange parts are questionnaires with skipped logatome test. The lower panel shows the distribution across the different situations during which the EMA was done. While 37.5% of questionnaires were answered when participants were not actively listening to something, 25.4% were filled out during conversation and 25.0% while the radio or TV was playing.

For objective data on the situation, Figure 2 compares the distribution of situations during the whole study period and during the logatome tests. While there were slightly more surveys and logatome tests performed in quiet, all classifier situations are represented during the logatome test.

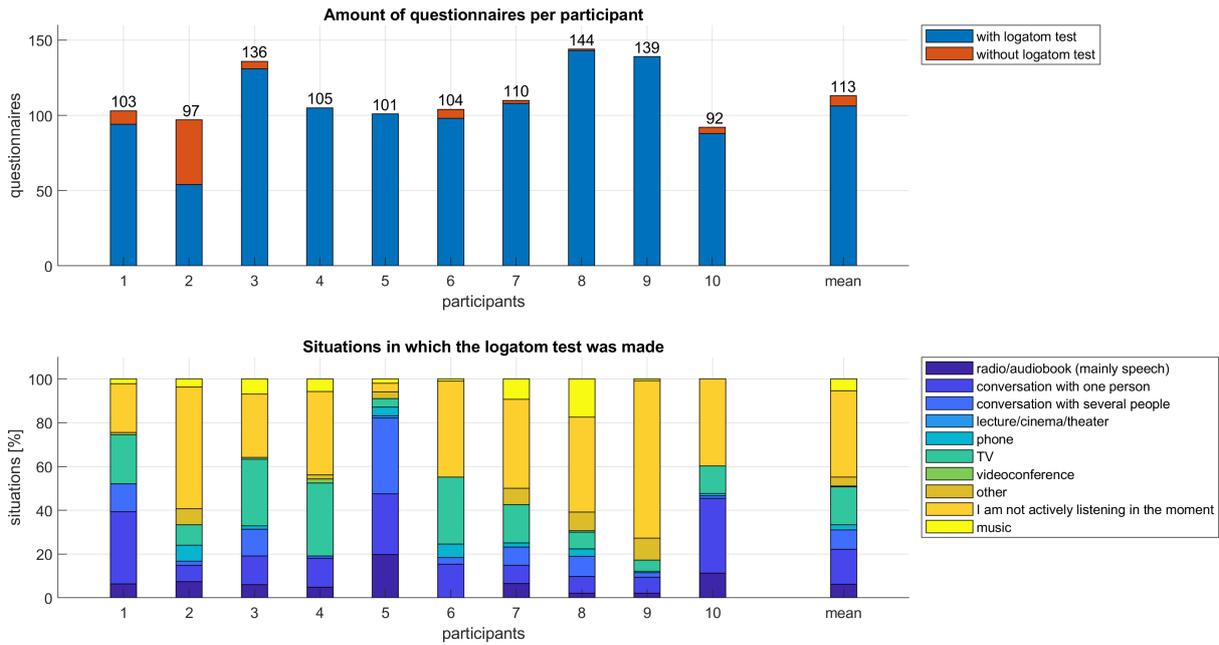


Figure 1: Amount of (top) and subjectively indicated type of (bottom) situations during the logatome test

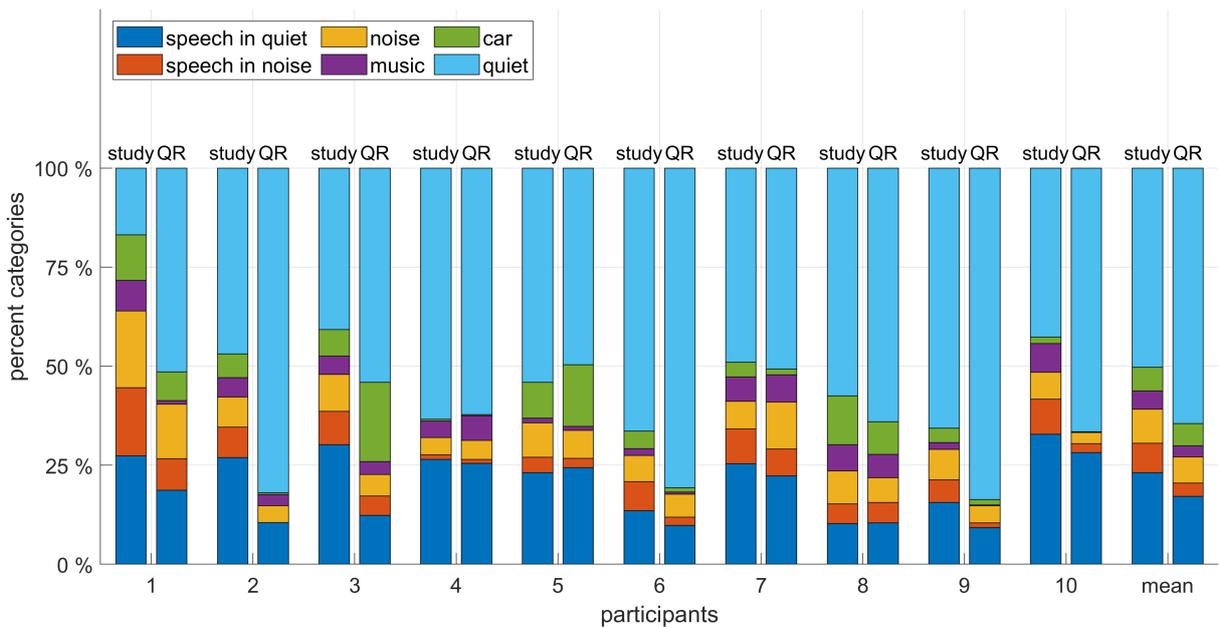


Figure 2: Distribution of situations according to the hearing aid situation classifier across the entire study duration (left bar for each participant) and during the questionnaire and logatome test (right bar)

2.2 Duration

Figure 3 shows the time taken for each questionnaire and logatome test. The questionnaire had a median duration of 160 (IQR 129–201) seconds and the logatome test of 67 (IQR 63–74) seconds.

3 Discussion

An average of 93.8% of logatome tests carried out indicates that a speech intelligibility test can be integrated into everyday life. If participant 2 was removed from the evaluation (because he skipped the logatome test when

he thought the situation had already been evaluated), the average percentage of logatome tests performed is 97.4%. The average time required for the questionnaire including the logatome test of just over 3 minutes is in line with the suggested time frame for EMA surveys of Stone and Shiffman [4].

This was a pilot study with only ten participants recruited from a database of regular test participants which are likely more motivated and willing to perform tests in everyday life than the average hearing aid user. Future studies should verify results with a larger, more heterogeneous subject sample. Here we opted for 12 logatomes per test to keep the test short and the burden low. This resulted in an 8.3% quantization step of scores in each

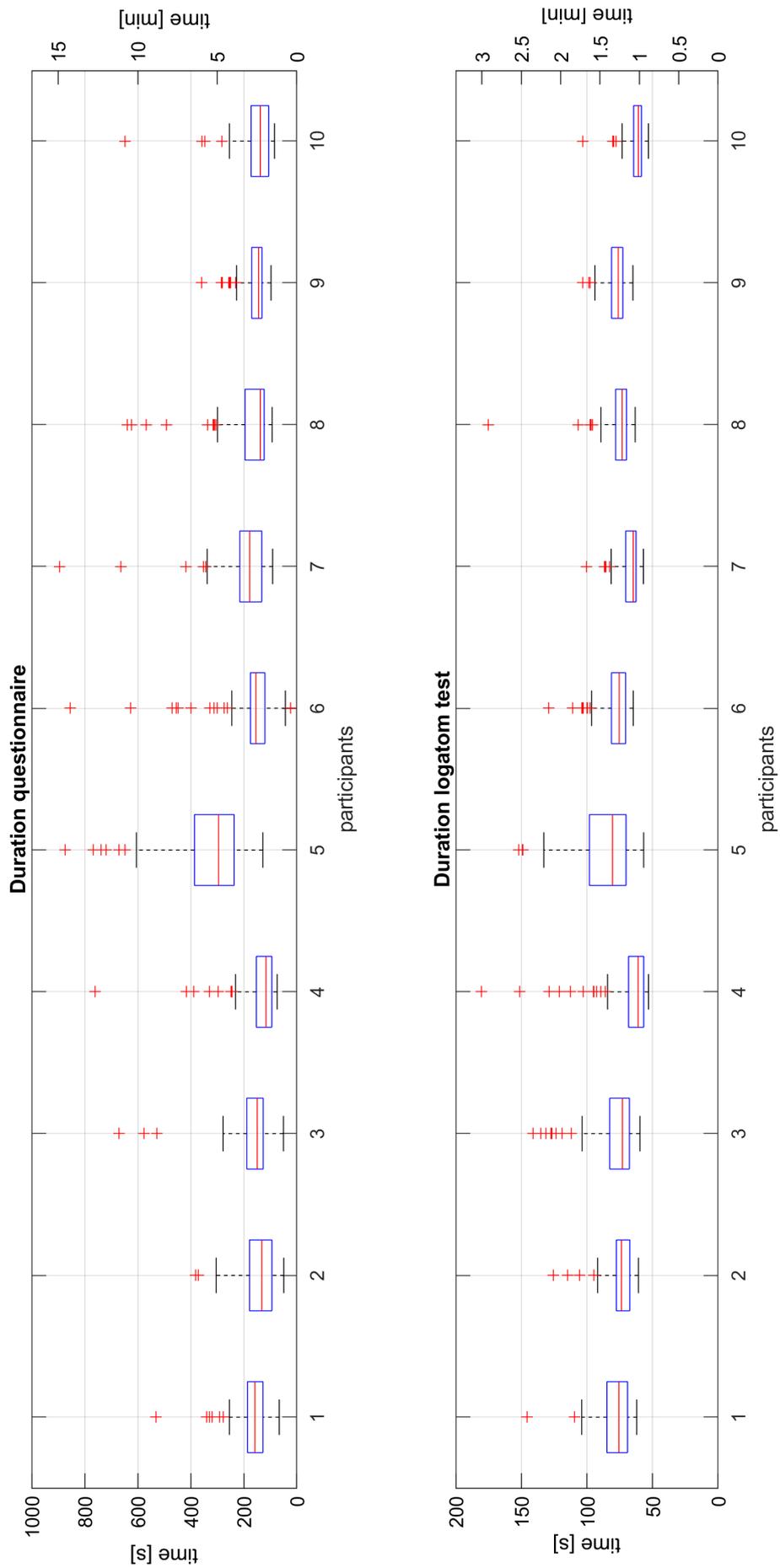


Figure 3: Boxplot of the duration of the questionnaire in total (upper plot) and the logatome test only (lower plot)

test and tests needed to be pooled over several situations to reach a better resolution. It remains an open question if a longer or more difficult test is feasible as well.

4 Conclusion

Our pilot study suggests that an objective speech intelligibility test can be performed in everyday life within an EMA study and is completed in a variety of situations. Further research is necessary to determine the optimal length and difficulty of the test.

Notes

Conference presentation

This contribution was presented at the 26th Annual Conference of the German Society of Audiology and published as an abstract [5].

Competing interests

Nadja Schinkel-Bielefeld, Kaja Strobel and Rodrigo Carbajo Benito are employees of WS Audiology.

References

- Schinkel-Bielefeld N, Carbajo Benito R, Babel T, Jürgens T, Strobel, K. Measuring Objective Speech Intelligibility and Listening Effort in Ecological Momentary Assessment. DAGA 2024 - 50. Jahrestagung für Akustik; 2024 Mar 18-21; Hannover. 2024. Available from: https://pub.dega-akustik.de/DAGA_2024/files/upload/paper/243.pdf
- Bellanova M. Development of a Logatome Test for the Evaluation of Signal Processing Algorithms in Hearing Aids on a Microscopic Level [dissertation]. Erlangen: Friedrich-Alexander-Universität Erlangen Nürnberg; 2016. Available from: https://opus4.kobv.de/opus4-fau/files/7455/Dissertationsschrift_Bellanova.pdf
- Schumann A, Serman M, Gefeller O, Hoppe U. Computer-based auditory phoneme discrimination training improves speech recognition in noise in experienced adult cochlear implant listeners. *Int J Audiol*. 2015 Mar;54(3):190-8. DOI: 10.3109/14992027.2014.969409
- Stone AA, Shiffman S. Capturing momentary, self-report data: a proposal for reporting guidelines. *Ann Behav Med*. 2002;24(3):236-43. DOI: 10.1207/S15324796ABM2403_09
- Babel T, Carbajo Benito R, Jürgens T, Strobel K, Schinkel-Bielefeld N. Feasibility of objective speech intelligibility tests in Ecological Momentary Assessment. In: Deutsche Gesellschaft für Audiologie e.V., editor. 26. Jahrestagung der Deutschen Gesellschaft für Audiologie. Aalen, 06.-08.03.2024. Düsseldorf: German Medical Science GMS Publishing House; 2024. Doc179. DOI: 10.3205/24dga179

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