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Hearing Aid Satisfaction in Real-Life Environments in Momentary and Short-Term Retrospective Assessments

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ABSTRACT

Ecological Momentary Assessment (EMA) is the method of choice when hearing aid features are to be tested where they are later used to compensate for hearing loss. However, small performance differences detected in laboratory settings are often not evident in EMA data. It then remains unclear whether these differences are inconsequential in real-life situations or whether they go undetected due to the EMA design. After all, real-life listening is temporally highly variable and often modified by self-acting interventions such as volume change or prompting talkers to speak louder. Such interventions may partially obscure hearing problems or differences between hearing programs in the EMA responses. A methodologically motivated EMA study researches the effect of two different time intervals on the assessment of real-life hearing experiences: current situation vs. most difficult situation encountered in the past 30 minutes. For this purpose, experienced hearing aid users are fitted with devices that alternate between two different programs A and B on a daily basis. The main hypothesis is that the short-term retrospective surveys will reveal a stronger contrast between programs A and B than the surveys which refer to momentary situations. This contribution reports preliminary findings from the ongoing study.

Keywords: *ecological momentary assessment, hearing aid rehabilitation, hearing aid evaluation*

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1. INTRODUCTION

In recent years, hearing aids have increasingly been evaluated in real-life situations using ecological momentary assessment (EMA) [1]. EMA encompasses a set of study methods in which participants repeatedly report on their perceptions and emotions, usually with reference to their current situation. As a result, EMA is context-sensitive and can indicate situations where particular hearing aid features might be beneficial.

As the term already implies, experiencing and assessing should ideally occur close in time. Accordingly, EMA designs commonly allow only for a brief delay of a few minutes [1]. As individuals can often readily modify their acoustic environment when listening becomes uncomfortable [2], this approach may not effectively capture challenging and adverse listening situations where advanced hearing aid features can truly demonstrate their full potential and strengths. For example, take a noisy environment where an individual asks their conversation partner to move to a quieter place early in the conversation. This results in an improved listening environment that may have a higher chance of being captured by random sampling, possibly due to its longer duration compared to other situations that are not as optimized.

Therefore, to increase the sensitivity of the EMA method in detecting performance differences, it seems worth considering to ask also about the immediate past, where memory bias may not be overly detrimental. Moving beyond the momentary and towards what we classify as a variant of 'coverage EMA' [3, 4] offers further advantages, such as allowing individuals to report on situations where immediate reporting may not be appropriate due to factors like safety, cognitive load or social norms [5].

With these considerations in mind, we set out to answer the following main research question: Can surveying the most

difficult situation in the preceding 30-minute time interval increase the sensitivity of the EMA method in detecting performance differences compared to surveying the current situation only? We hypothesize that satisfaction ratings for hearing aids will exhibit a greater contrast between the two programs in short-term retrospective EMA data compared to momentary EMA data.
To investigate this, we provided participants with hearing aids with two installed programs - one basic program and another program that had advanced features - for a duration of two weeks. The programs alternated on a daily basis without intervention by the participants, who were only able to adjust the volume. As the study is still ongoing, this contribution intends to present initial findings.

2. METHODS

2.1. Participants

Nine German speaking experienced (>3 year) hearing aid users (8 male, 1 female), recruited from a volunteer database, with mean age 70 years (sd: 9.3) with moderate to moderately severe hearing loss participated in the study. Their mean pure tone average in the frequencies 0.5, 1, 2, and 4 kHz was 44 dB HL (sd: 12.8) in the better and 50 dB HL (sd: 9.9) in the worse ear. Participants gave written informed consent prior to the study. The study was approved by the ethics committee of Carl von Ossietzky University Oldenburg (Drs. EK/2022/065).

2.2. Experimental procedure

2.2.1. First appointment

At the outset of the study, participants completed two paper-based questionnaires, namely the HEARLI-Q [6] and the AStra [7], at home. In the university's soundproof booth, a pure tone audiogram was conducted using a Unity audiometer and HDA200 headphones. Subsequently, the participants were fitted with Signia Pure 312 7AX hearing aids with closed click sleeves, using the fitting formula NAL-NL2 for experienced listeners. An own voice training was performed, and the gain was fine-tuned according to participants' needs. The hearing aid fitting was verified and validated with in-situ measurements and a speech test. Two hearing programs were configured, differing in adaptive directionality and noise reduction, hereinafter referred to as *basic* and *advanced*.
Additionally, participants were provided with a Galaxy S20 smartphone (Android 11) with a preinstalled EMA app. Hearing aids were connected to the app via Bluetooth. Together with the study lead, participants configured a Do-Not-Disturb (DND) time for their regular sleeping hours. They also had the option to adjust this DND time or configure additional, shorter DND periods throughout the study.

2.2.2. EMA field trial

During the two-week field trial, the hearing program was scheduled to alternate each day at 4 am or whenever the Bluetooth connection between hearing aid and smartphone was re-established afterwards. Participants had no control over the hearing program; however, they could use the EMA app to adjust the volume of the hearing aids. Six times per day, they received a random prompt to complete a survey which expired after 3 minutes. Participants could initiate a survey at any time and were encouraged to do so when they were dissatisfied with their hearing experience in any way. Following a survey, there was a 45-minute refractory period during which no further prompts were issued.

2.2.3. Questionnaire

The questionnaire consisted of two parts: In the first part, participants were asked about their mood, the current environment they were in, which was broadly categorized into *home*, *mobility*, *society*, *work*, and *other*, the listening task using the Common Sound Scenarios scheme [8], and their overall listening experience quality including hearing aid satisfaction, sound quality, and listening effort using 7-point categorical scales. Next, participants were asked if the listening situation or their experience of it had changed within the last 30 minutes. If so, they completed a second part of the questionnaire, which focused on the worst listening experience in the last 30 minutes. If they were unable to choose between different situations, they were instructed to select the most recent one. The same set of questions as in the first part of the questionnaire were then posed for this situation. Additionally, participants were asked if answering the survey would have been possible in that situation, whether they tried to alter the listening situation in any way, and to what extent they were bothered by doing so.
The present preliminary analysis concentrates on the environments in which surveys were taken and the ratings of hearing aid satisfaction. The corresponding item in the momentary and retrospective sections of the questionnaire read: "How satisfied are you with the hearing aids in this situation?" and "How satisfied were you with the hearing aids in this situation?" respectively. The following response options were provided: very satisfied / satisfied / somewhat

satisfied / neutral / somewhat dissatisfied / dissatisfied / very dissatisfied.

2.2.4. Second appointment

During the second appointment, participants returned the equipment and completed a shortened version of the HEARLI-Q and AStra, which specifically focused on the study hearing aids. Moreover, a standardized exit interview was conducted, inquiring about the study's burden, clarity of the tasks, and the quality of the study hearing aids compared to the participants' personal hearing aids.

2.3. Analysis

In this interim analysis, only descriptive analyses were conducted. Percentages and means were calculated for each study participant separately and then aggregated across the group. Regarding the ratings of hearing aid satisfaction, three variables are to be distinguished:

- *momS*: satisfaction in the current situation
- *retroS*: satisfaction in the most difficult situation during the previous 30 minutes. If no situational or perceptual change was reported, the ratings were assumed to be identical to the current ratings.
- *md30S*: satisfaction in the most difficult situation during the previous 30 minutes (excluding ratings for the current situation)

The variable *retroS* was created from raw data and includes direct inputs from participants when a different situation or perception was evaluated than the current situation (*md30S*), complemented by values from *momS* when participants indicated that the situation or perception had remained unchanged in the past 30 minutes. Thus, *momS* and *retroS* variables encompass the same number of valid values. Analogously, the listening environments were labeled as *momEnv* when referring to current situations and *md30Env* when referring to the most difficult situation in the preceding 30 minutes.

RESULTS

A total of 768 questionnaires were filled out by the participants, with 45 being incomplete, resulting in 723 questionnaires available for analysis. Of these, 48.5% were submitted after prompting, and 51.5% were self-initiated. On average, 80 (sd 15.9) questionnaires were completed by each study participant. In 124 surveys, participants reported a change in their situation or perception in the previous 30 minutes, which corresponds to a proportion of 17.2% and in 28 surveys, the participants made efforts to change or improve their hearing situation.

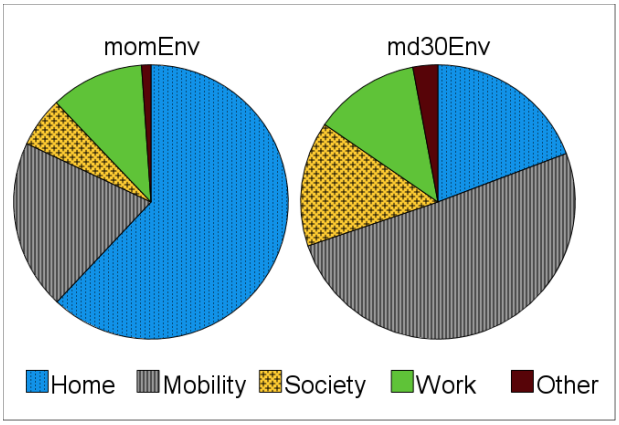

Figure 1. Distribution of current environments (*momEnv*) and the environments of the most difficult situation in the 30-min recall period (*md30Env*).

The distribution of environments is shown in Figure 1. Among current environments, *home* dominated with an average of 62%, followed by 20% *mobility* and only 6% for society. In contrast, only 19% of the most difficult situations in the 30-minute retrospective recall referred to environments, while 51% referred to *mobility* and 15% to *society*.

Figure 2 displays the categorical distribution of ratings for hearing aid satisfaction for *momS*, *retroS*, and *md30S* for both hearing aid programs. At first glance, the data distribution appears similar, particularly with regards to the low contrast observed between the auditory programs across all recall periods. When considering only the surveys reporting a change in situation or perception during the previous 30 minutes (*md30S*), a small difference in satisfaction with the hearing programs is apparent in the empirical data. The proportion of the highest category "very satisfied" was about twice as high for the advanced program compared to the basic program. Given the relatively small proportion of surveys reporting situational or perceptual changes within the preceding 30-min recall period, the differences disappear in the complemented variable *retroS*.

DISCUSSION

Empirical results indicate that the short-term retrospective assessment resulted in a similar contrast in satisfaction ratings for both hearing aid programs, as compared to the strictly momentary assessment. This

suggests a potential trend that does not support the main hypothesis. However, it is important to note that the sample size in the current study is still too small to draw definitive conclusions, thus caution is advised in interpreting these preliminary results.

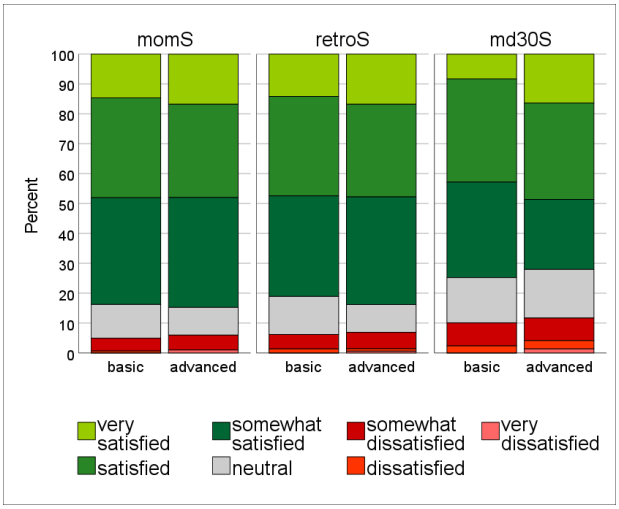

Figure 1. Satisfaction with the basic versus the advanced hearing aid program in the current hearing situation (*momS*), in the most difficult situation during the 30-minute recall period including surveys reporting no situational change (*retroS*), and in the most difficult situation during the 30-minute recall period after situational change (*md30S*).

A change in situation or perception was reported only in about 17% of the surveys. The situations described retrospectively included a larger proportion of mobility and societal environments than those in momentary assessment. This finding supports observations from previous EMA studies conducted by our research group, which have indicated that these types of situations are to some extent associated with delayed assessment, and that more complex social situations may be underrepresented when using a strictly momentary sampling design [5, 9]. At this point, we are unable to determine whether the proportion of 17% changes in the previous 30 minutes observed here are accurate or may underestimate the true occurrence. Because a shorter version of the questionnaire was offered if the situation did not change, it is possible that some participants intentionally or unintentionally overlooked existing differences. On the other hand, the study participants were highly motivated to support research.

Nonetheless, the design of the EMA questionnaire is admittedly challenging, as it requires a two-stage decision-making process. After participants describe and evaluate their current hearing situation, they must then recapitulate the past 30 minutes with regard to any changes in situation or perception before selecting the relatively most difficult situation. In the exit interview, although all participants found the study's task clear and understandable, the answers to the question of how easy or difficult it was for them to distinguish between the current and retrospective evaluation were less clear-cut: easy (n=1), rather easy (n=3), difficult (n=4), and very difficult (n=1). It remains unclear whether mandating the second part of the survey would have led to more reports of situational changes. However, it is likely that such a requirement would have imposed an increased burden on participants and possibly led to demotivation.
To conclude, the preliminary results suggest that providing participants with the option to report their most challenging situation from the past 30 minutes only generates a small number of additional ratings. While they cover different environments than strictly momentary ratings, they do not seem to substantially enhance the contrast between the evaluated hearing programs.

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