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Otology & Audiology Article Review

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- Page 06: Lorenzo Notarianni ✓:
  - A Participatory Design Approach to Develop an Interactive Sound Environment Simulator.
    - *Geir Hanssena and Yngve Dahl.*
    - *American Journal of Audiology, 2016, Vol. 25, 268–271.*
    - *The purpose of this study was that of providing an insight into the added value represented by a participatory and interactive sound environment simulator and how this may be beneficial towards communication, understanding and promoting a more engaging experience between patients and audiologists during consultation. Results suggest the viability and practicality of this approach.*
- Page 08: Lorenzo Notarianni ✓:
  - Design Considerations for Internet-Delivered Self-Management Programs for Adults With Hearing Impairment
    - *Jill Preminger and Ann Rothpletz.*
    - *American Journal of Audiology, 2016, Vol. 25, 272–277.*
    - *The objective of this research is to review components of successful Internet–based self-management programs and to evaluate group auditory rehabilitation programs in order to make recommendations for the design of future internet-based self-management programs.*
- Page 09: Lorenzo Notarianni ✓:
  - Using Cognitive Screening Tests in Audiology.
    - *Jing Shen, Melinda Anderson, Kathryn Arehart and Pamela Souza.*
    - *American Journal of Audiology, 2016, Vol. 25, 319–331.*
    - *As the population in many countries is ageing, older adults are living longer than ever and have an increased desire for social participation. As a result, audiologists are very likely to see an increased demand for service by older clients whose communication difficulty is caused by a combination of hearing loss and cognitive impairment. For these individuals early detection of mild cognitive impairment is critical for providing timely medical intervention and social support. The objective of this paper is that of providing a tutorial on the information about cognition in older adults, mild cognitive impairment, and cognitive screening tests to assist audiologists in identifying and appropriately referring potential cases of cognitive impairment.*
- Page 11: Lorenzo Notarianni ✓ :
  - Development of the Word Auditory Recognition and Recall Measure: A Working Memory Test for Use in Rehabilitative Audiology.
    - *Sherri L. Smith, Kathleen Pichora-Fuller and Genevieve Alexander1.*
    - *Ear & Hearing, 2016; Vol. 37, (6), e360–e376.*
    - *The purpose of this study was the development of the Word Auditory Recognition and Recall Measure (WARRM) designed to be used for concurrently assessing word recognition and auditory working memory performance in adults who may have pure-tone hearing loss. The procedure may possibly fill a gap by providing a clinically feasible, auditory working memory measure that could be used by clinicians to plan and evaluate audiological rehabilitation.*
- Page 12: Lorenzo Notarianni ✓:
  - Age-Related Differences in Listening Effort During Degraded Speech Recognition.
    - *Kristina Ward, Jing Shen, Pamela Souza, and Tina Grieco-Calub.*
    - *Ear & Hearing, 2017; Vol. 38, (1), 74–84.*
    - *The aim of this study was to quantify and explore age-related differences in executive control as it relates to dual–task performance, which is thought to represent listening effort, during degraded speech recognition between younger adults and older adults.*
- Page 14: Lorenzo Notarianni ✓:
  - Self-Reported Listening-Related Effort and Fatigue in Hearing-Impaired Adults.
    - *Sara Alhanbali, Piers Dawes, Simon Lloyd and Kevin Munro.*

        - *Ear & Hearing, 2017; Vol. 38, (1), e39–e48.*
        - *The objective of this study was that of addressing the quantification of self-reported effort and fatigue in listeners with hearing loss. Few attempts have been made to measure how hearing loss may increase listening effort and fatigue due to increased mental exertion. Three groups of hearing impaired adults with hearing aids, cochlear implants and single-sided deafness participated in this research and a group of normally hearing adults as the control group. The fatigue assessment scale (FAS) was used to quantify fatigue along with an effort assessment scale (EAS) developed for this study.*

- Page 15: Lorenzo Notarianni ✓:
    - Hearing impairment, cognition and speech understanding: exploratory factor analyses of a comprehensive test battery for a group of hearing aid users, the n200 study.
        - *Jerker Rönnberg et al.*
        - *International Journal of Audiology, 2016; Vol. 55 (11), 623-642.*
        - *The goals of this current n200 study were to assess the structural relations between three classes of test variables such as hearing cognition and aided speech in noise outcomes, and to describe the theoretical implications of these relations for the ease of language understanding (ELU).*
- Page 17: Lorenzo Notarianni ✓:
    - Perceived listening effort and speech intelligibility in reverberation and noise for hearing-impaired listeners.
        - *Henning Schepker, Kristina Haeder, Jan Rennies & Inga Holube.*
        - *International Journal of Audiology, 2016; Vol. 55 (12), 738-747.*
        - *The aim of this study was to assess perceived listening effort and speech intelligibility in reverberating and noisy conditions for hearing impaired listeners for conditions that are similar according to the speech transmission index (STI). Speech intelligibility and listening effort provide complementary tools to evaluate speech perception over a broad range of acoustic scenarios. Scaled listening effort was measured in four different conditions at five different STI generated using various contributions of noise and reverberant interferences.*
- Page 18: Lorenzo Notarianni ✓:
    - Simulated patients versus seminars to train case history and feedback skills in audiology students: A randomized controlled trial.
        - *Jane Hughes, Wayne Wilson, Naomi MacBean & Anne Hill.*
        - *International Journal of Audiology, 2016; Vol. 55 (12), 758-764.*
        - *The goal of this study was that to compare simulated patients versus seminars for training audiology students to take a case history and give feedback with adult patients. Simulated patient training provided no benefit over seminar training in audiology students learning case history and feedback skills with adult patients.*
- Page 19: Katrien Hoornaert ✓:
    - Clients' perspective on quality of audiology care: Development of the Consumer Quality Index (CQI) 'Audiology Care' for measuring client experiences.
        - *Michelle Hendriks, Judith Dahlhaus-Booij & Anne Marie Plass.*
        - *International Journal of Audiology, 2017; Vol. 56: (1), 8-15.*
        - *The Consumer Quality Index for Audiology Care results in a reliable and valid instrument to measure quality of audiology care. It is also interesting to map differences among audiology centres. The study showed that experiences with the accommodation and facilities, arranging appointments, waiting times and client participation differed significantly. Though the evaluation was positive, audiology care can be improved concerning patient-centredness.*
- Page 20: Anna Pugh ✓:
    - A tool for assessing case history and feedback skills in audiology students working with simulated patients.
        - *Jane Hughes, Wayne J. Wilson, Naomi MacBean & Anne E. Hill.*
        - *International Journal of Audiology, 2016; Vol. 55: (12), 765–774.*

    - *The Audiology Simulated Patients Interview Scale (ASPIRS) could easily be incorporated into practice within other non-academic settings and could be readily adapted to measure, monitor and evaluate the efficacy of training, skillsets and Continuing Professional Development for new and existing Audiologists. An interesting paper which I can see would have positive applications in daily practice and training.*

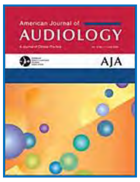
- Page 21: Anna Pugh ✓:
  - Screening, Education, and Rehabilitation Services for Hearing Loss Provided to Clients with Low Vision: Measured and Perceived Value Among Participants of the Vision-Hearing Project.
    - *McMahon, C M, Schneider J, Dunsmore, M, Gopinath B, Kifley A, Mitchell P, Wang J-J, and Leeder S R.*
    - *Ear & Hearing, 2017; Vol. 38, (1), 57–64.*
    - *Working as we do with older people, the prevalence of dual sensory impairments (DSI), and additional sensory and cognitive issues allied to hearing loss, are issues we confront daily in our clinics. This Australian paper looks at the efficacy of the novel approach of combining screening and rehabilitation provision. Services are generally focused on single issues and the complex implications of unmet need often falls through the gaps.*
- Page 22: Johanna Van Coillie ✓:
  - Provision, perception and use of trainable hearing aids in Australia: a survey of clinicians and hearing impaired adults.
    - *Dorothee Twardella, Ulla Raab, Carmelo Perez-Alvarez, Thomas Steffens, Gabriele Bolte & Hermann Fromme.*
    - *International Journal of Audiology, 2016; Vol. 55 (12), 787-795.*
    - *As the population is growing and the number of hearing aid candidates increases, we are searching for methods to reduce the needed time and effort as well as the number of appointments needed to fit hearing aids properly. However, the results of the survey show that trainable features on hearing aids do not yet achieve this aim. Although mostly positive outcomes were revealed, a personal setting by an audiologist is still required for hearing aids with trainable features.*
- Page 23: Tom De Neve ✓:
  - Usage of personal music players in adolescents and its association with noise-induced hearing loss: A cross-sectional analysis of Ohrkan cohort study data.
    - *Els Walravens, Gitte Keidser & Louise Hickson.*
    - *International Journal of Audiology, 2017; Vol. 56 (1), 38-45.*
    - *It appears reasonable to conclude from the Ohrkan study, that in subjects of this young age (15–16 years) the harmful consequences of PMP usage have not yet evolved. Noise-induced hearing loss is a slowly developing condition which takes many years to manifest. For this reason, a follow-up of the cohort is planned to analyse the influence of PMP use among future incident cases of audiometric notches*
- Page 25: Tom De Neve ✓:
  - Music-induced Hearing Loss in Children, Adolescents, and Young Adults: A Systematic Review and Meta-analysis.
    - *Carlijn le Clercq, Gijs van Ingen, Liesbet Ruytjens, and Marc van der Schroeff.*
    - *Otology & Neurotology, 2016; Vol. 37:1208–1216.*
    - *There were no significant differences in the prevalence of hearing loss and the prevalence of high-frequency hearing loss between children, adolescents and young adults who are exposed to loud music and those who are not. Deviations were found when there were increasing amounts of exposure, but not all correlations were reliable and the large spread of results hindered drawing reliable conclusions.*
- Page 27: Barry Downes ✓:
  - The relationship between hearing impairment and cognitive function: a meta-analysis in adults.

    - *D.S. Taljaard, M. Olaithe, C.G. Brennan-Jones, R.H. Eikelboom and R.S. Bucks.*
    - *Clinical Otolaryngology. Vol 41 (6), December 2016, pages 718-72.*
    - *This meta-analysis explored the impact of hearing loss and hearing intervention on cognition and confirmed that hearing impairment, whether treated or not, is associated with cognitive problems. Whilst treatment appears to improve cognition, the authors considered that conclusions about causal relationships are premature.*

- Page 29: Veronica Hoffman ✓:
  - Multisite Randomized Control Trial to Compare Two Methods of Tinnitus Intervention in Two Control Conditions.
    - *Henry J et al.*
    - *Ear & Hearing, 2016; Vol 37 e346-e359.*
    - *This study has implications for the treatment type and duration of patients with bothersome or severe tinnitus. Clinicians in this study were not tinnitus experts; they received short duration training and achieved similar outcomes for Tinnitus Retraining Therapy (TRT), Tinnitus Masking (TM) and Tinnitus Education (TED) within a relatively condensed treatment period of 6 months. A previous study conducted by this group found expert tinnitus audiologists in a controlled clinical setting achieved a TRT reduction of 29.5 point which is a significantly better outcome than the 13.5 point reduction reported in this study. Further studies looking at duration of training and the outcomes achieved for each treatment method would provide insight into optimising tinnitus training programs for clinicians in real world situations. This study also highlights the positive impact that fitting hearing devices to correct for hearing loss in conjunction with basic counselling can have on tinnitus patients within a short time frame.*
- Page 31: Melissa Babbage ✓:
  - Evidence of activity-dependent plasticity in the dorsal cochlear nucleus, in vivo, induced by brief sound exposure.
    - *Y. Gao, N. Manzoor & J.A. Kaltenbach.*
    - *Hearing Research 341 (2016) 31e42.*
    - *This in vivo study provides a clear demonstration of sound exposure can alter spontaneous neural activity over a time scale of several minutes without damaging the auditory periphery. This is an important first step in understanding the mechanisms of acute noise-induced tinnitus and how they differ from the mechanisms underlying chronic tinnitus. Studies that build on this research to show how long the changes in DCN activity persist and the relationship between these short term changes and the permanent changes seen in chronic tinnitus will be useful for clinicians in better understanding both forms of tinnitus and being able to counsel patients appropriately.*
- Page 33: Melissa Babbage ✓:
  - Top-down and bottom-up neurodynamic evidence in patients with tinnitus.
    - *Sung Kwang Hong, Sejik Park, Min-Hee Ahn & Byoung-Kyong Min.*
    - *Hearing Research 342 (2016) 86e100.*
    - *This study provides experimental evidence of impaired top-down and bottom-up auditory processing in patients with tinnitus. Although the applications of these findings clinically are not yet clear, the results do highlight the need for clinicians to keep in mind that, even in tinnitus patients with normal hearing, auditory processing may be compromised. This is particularly important when counselling tinnitus patients that report cognitive symptoms, such as impaired concentration. Research that clarifies the relationship of peripheral hearing loss to top-down and bottom-up abnormalities will be an important next step in better understanding the neuropathology of tinnitus and developing appropriate counselling and intervention strategies.*
- Page 35: Barry Downes ✓:
  - A review of the perceptual effects of hearing loss for frequencies above 3 kHz.
    - *Brian C. J. Moore.*

- *International Journal of Audiology 2016; 55:12, 707-714.*
- *In several countries, compensation for occupational noise-induced hearing loss (NIHL) is based on the mean estimated NIHL at 1, 2 and 3 kHz or 0.5, 1, 2 and 3 kHz. This is based on the assumption that hearing loss for frequencies above 3 kHz has no significant adverse consequences. This review assesses whether that assumption is valid.*

A Participatory Design Approach to Develop an Interactive Sound Environment Simulator



Geir Hanssena and Yngve Dahl.

American Journal of Audiology, 2016, Vol. 25, 268–271.

The technological progress in hearing aid technology means that an increasing number of advanced features are available to compensate for hearing loss yet, many of those that could benefit from hearing aids do not make use of them (Davis et al, 2007) as has been demonstrated by recent studies. In 2010, Hartley et al, reported 24% did not use their hearing aids and, in 2007, Davis reported that 57% did not use their hearing aids. As a primary cause of low prevalence of hearing aid use, poor user benefit and satisfaction have been identified as key factors (McCormack & Fortnum, 2013). Central to this context are the interaction between patient and practitioner, particularly the communicative aspects between the two and what Grenness et al, 2014 refer to as person-centred audiological rehabilitation.

The participatory design, or co-design, is an approach in which the hearing aid fitting stakeholders are actively involved in the process to help ensure that the final solution meets their requirements and is usable. The concept underlying this approach is that of user empowerment as users are considered as experts of their own domain and technology should ideally allow users to apply and develop their skills, knowledge, and experience.
The approach design is divided into three consecutive steps each serving different purposes: understanding the problem and the context of use, producing design solutions, and evaluating design solutions with hearing aid users and audiologists having been strongly involved at each step of the process.

Conventional tools such as the hardware and software risk are used not engaging the hearing aid users and preventing them from taking an active role in the consultation. And also mock up solutions were adopted during the design phase where the hearing aid user and the audiologist gradually built a solution together during the role play consultation.

For the evaluation of the design solutions the audiologist and the patients used a prototype solution, as they saw fit, throughout the hearing aid fitting. The hearing aid users would listen to the playback before providing subjective accounts of their listening experience and perception to sounds and the audiologist would refit the hearing aid typically while playback was still running.

It was observed that the prototype promoted iterative fitting process and particularly promoted multiple feedbacks between the user and audiologist where users could articulate their hearing experiences and this allowed for a more engaging experience. Concluding interviews highlighted how the prototype allowed audiologists to be more explorative in their approach and made them more confident.

References:

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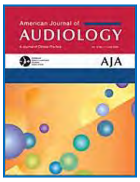
- *Hartley, D., Rochtchina, E., Newall, P., Golding, M., & Mitchell, P. (2010). Use of hearing aids and assistive listening devices in an older Australian population. Journal of the American Academy of Audiology, 21(10), 642–653.*

- *McCormack, A., & Fortnum, H. (2013). Why do people fitted with hearing aids not wear them? International Journal of Audiology, 52(5), 360–368.*
- *Grenness, C., Hickson, L., Laplante-Lévesque, A., Meyer, C., & Davidson, B. (2015). Communication patterns in audiologic rehabilitation history-taking: Audiologists, patients, and their companions. Ear and Hearing, 36(2), 191–204.*

Design Considerations for Internet-Delivered Self-Management Programs for Adults With Hearing Impairment



Jill E. Preminger and Ann M. Rothpletz.

American Journal of Audiology, 2016; Vol. 25 (3S), 272-277.

As with any chronic condition, there is no simple cure for hearing impairment and individuals affected may select from a variety of management techniques to mitigate the negative consequences associated with the condition (e.g. Laplante – Levesque, Hickson, & Worrall, 2011).
Commonly used management tools, such as hearing aids, have been shown to improve the quality of life related to hearing impairment (Chisolm et al, 2007) but residual participation restrictions and activity limitations typically remain (Cox, Alexander, & Beyer, 2003).
The idea of a linear progression from pre-awareness of hearing disability to the resolution of the condition (be it with hearing aids or cochlear implants) may not accurately describe the journey of adults with hearing impairment (Manchaiah, Stephens, & Meredith, 2011).
Other management techniques may be worthwhile such as, for example, Internet–delivered auditory rehabilitation has been shown to improve quality of life in experienced hearing aid users (Thoren, Oberg, Andersson, & Lunner, 2015). It is necessary that those affected by hearing loss adapt and learn how to self manage their communication problems and psychosocial concerns as roles and activities evolve over time.
Lorig and Holman (2003) described the framework of self-management programs that included 10 components comprising of three tasks, five skills, and two mechanisms. The application of this framework is based upon the specific goals of each individual's specific characteristics and set of limitations experienced because of hearing loss and serves to promote self-efficacy and self-tailoring. Self-efficacy is propaedeutic towards the belief that one will actually be able to implement the necessary skills to accomplish goals (Bandura, 1998) because individuals will probably not attempt behaviour-changing techniques if they believe that they would be unable to accomplish them.

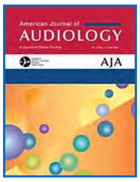
Thoren et al. in 2015 indicated that information, problem solving exercises, expert advice, and social support can be delivered successfully over the Internet to experienced hearing aid users. This paper recommends that the design of future Internet-based self-management programmes focus on the mechanisms of social support from both peers and communication partners, education to promote learning, and practice of self-management skills.

Successful group auditory activities include psychosocial activities, informational lectures and group discussion, communication strategies exercises, and inclusion of a frequent communication partner.

For this study, Preminger and colleagues performed a series of studies across 10 groups in which group auditory rehabilitation content and participation were systematically varied and the findings evaluated to determine the most efficacious auditory rehabilitation content. The HHIE (Ventry & Weinstein, 1982), and a disease specific (hearing impairment) QoL measures were used for evaluation purposes.

The role of patient involvement and engagement in auditory rehabilitation is widely understood and this paper provides yet more convincing recommendations towards the implementation of such activities.

Using Cognitive Screening Tests in Audiology



Jing Shen, Melinda C. Anderson, Kathryn H. Arehart, and Pamela E. Souza.

American Journal of Audiology, 2016; Vol. 25 (4), 319-331.

The likelihood of cognitive decline increases with age and, along with the shift in the distribution of the ageing population, there will be an increase in the proportion of audiology clients who may be affected by age related health issues, including degradation in cognitive abilities. Cognition is a concept that encompasses various abilities such as memory, attention, reasoning for acquiring knowledge and interacting with the environment. A normal level of cognition is fundamental for an individual's everyday functioning.

Neuroscience research has attempted to explain age-related cognitive changes according to neural plasticity and compensatory mechanisms. Neuroimaging data show that the ageing brain goes through neuronal atrophy in multiple areas and this anatomical degeneration is accompanied by changes in the activation pattern and strength in those brain areas. A combination of these anatomical and functional changes is associated with older adults' performance in tasks involving working memory (Moscovitch, & Winocur, 1995; Reuter – Lorenz et al., 2000; Tulving, Kapur, Craik, Moscovitch, 6 Houle, 1994) and inhibitory control (Dempster, 1992; Hasher, Stolzfus, Zacks, & Garavan, 2002).
Some older adults may demonstrate cognitive performance that is equivalent to younger peers, others may demonstrate earlier or more rapid deterioration in cognitive abilities as converging evidence from cognitive psychology and neuroimaging research are shedding light on (Baltes & Baltes, 1990; Cabeza, Anderson, Locantore, 6 McIntosh, 2002; Christensen et al., 1999, Reuter-Lorenz et al., 2000).
Mild cognitive impairment is a clinical label used for describing decline in one or more cognitive abilities such as memory and attention that is severe enough to raise clinical concern even though their daily function may be largely preserved at this early stage (Albert et al, 2011; Petersen et al., 2014). This condition is thought to be an intermediate phase of cognitive impairment that may, although not always, precede dementia.

The clinician's ability to recognise potential cases of MCI early in its progression is a critical step for providing timely medical intervention and social support for these individuals, who have a higher risk developing dementia as Prince, Bryce, & Ferri, 2011 confirm.
Clinical diagnosis for mild cognitive impairment has to be made by a physician based on a comprehensive evaluation of a patient (Albert et al., 2011) yet audiologists are well positioned for assuming the role of detecting any cognitive problems and providing appropriate and timely referrals. Audiologists have the opportunity, and are encouraged, to have more detailed conversations with older individuals during their counselling. The average duration of an office visit is 20 minutes with primary physicians and 21 minutes with specialised physicians (Shaw, Davis, Fleischer, & Feldman, 2014) in contrast, In the audiology clinic the average visit is 1.2 hours during the first two months of the hearing aid fitting process (Kochkin et al., 2010).
The link between hearing loss and cognitive decline may lead to a higher incidence of cognitive impairment in audiological cases compared to that in the general population and research findings suggest that hearing loss in older adults is associated with lower cognitive functions (Lin , 2011), higher rate of cognitive decline, (Gurgel et al., 2014; Lin, Yaffe et al., 2013), and all-cause dementia 8Gurgel et al., 2014); Lin et al., 2011; Uhlmann, Larson, Rees, Koepsell, & Duckert, 1989).

Serving the ageing population, audiologists are likely to encounter cases of undiagnosed cognitive impairment and should thus be trained to recognise cognitive status abnormalities. Even if screening *for cognitive communication disorder is currently within the scope of practice in audiology (ASHA, 2004) many audiologists may still feel uncomfortable with addressing cognition in their practice, the barriers being those of a lack of information and / or skills for cognitive screening and access to resources for proper referral. In consideration of this, the field of audiology needs workshops and conference sessions on how to recognise cognitive abnormality and screen for cognitive impairment. Audiologists need to educate themselves on the proper procedures with someone who fails the test, and universities need to include cognition as a major thematic component in audiology graduate training programs..*

This very interesting paper suggests the potential which audiologists represent for cognitive decline screening even though adoption of cognitive screening testing in the audiological setting is not an easy or immediate process. It is realistic to expect that cognitive screening tests will not be included in the test battery in most audiology clinics for practical reasons such as limited appointment times. It is reasonable to envisage that this scenario can only change if cognitive screening tests are demonstrated to be directly beneficial for the outcome of an audiology service.

Development of the Word Auditory Recognition and Recall Measure: A Working Memory Test for Use in Rehabilitative Audiology.

Sherri L. Smith, M. Kathleen Pichora - Fuller, and Genevieve Alexander.

Ear and Hearing 2016; Vol. 37 (6), e360-e376.

Significant associations between cognitive or working memory measures and speech in noise performance have been found in numerous studies. Within the Audiology realm the measurement of working memory has become increasingly a matter of interest because it may play an important role in speech understanding, especially in complex listening conditions. The measurement may be a helpful addition to the rehabilitative audiological work flow (Pichora – Fuller & Singh 2006; Souza 2012). To date, most studies have used the reading span working memory measure but for a number of reasons it may not be the most clinically feasible test in audiology.
The test consists of a 100 monosyllabic words based on widely used speech recognition test materials. The 100 words are presented in recall set sizes of 2,3,4,5 and 6 items with 5 trials in each set size. The WARRM was administered to all participants in three listener groups under two processing conditions in a mixed model (between subjects – repeated measures) design. The between subjects factor was group, with 48 younger listeners with normal audiometric threshold, 48 older listeners with normal thresholds through 3000 Hz, and 48 older listeners with sensorineural hearing loss.

Word recognition performance on the WARRM was not affected by processing condition and was near ceiling for the younger normal hearing group and older normal hearing listeners with both groups performing significantly better than the older hearing loss participants (99 and 98% respectively) with both groups performing significantly better than the older hearing loss participants (83%). The recall results were significantly better for the younger normal hearing, older normal hearing, and older hearing loss listeners with no processing (93, 84, and 75% respectively) than the alphabet processing (86, 77, and 70%). In both processing conditions, recall was best for young normal hearing, followed by older normal hearing, and worst for older hearing loss listeners. WARRM recall scores were significantly correlated with other memory measures. In addition, WARRM recall scores were correlated with results on the Word in Noise test for the older hearing loss listeners in the no processing condition and for older normal hearing listeners in the alphabet processing condition.

The findings of this test demonstrate the feasibility of incorporating an auditory memory test into a word recognition test to simultaneously obtain measures on both word recognition and working memory. The recall score provides additional information beyond the pure-tone audiogram and word recognition scores that may help rehabilitative audiologists assess the listening abilities of patients with hearing loss. The WARRM test augments the information gathered during the standard audiological assessment by adding new information about auditory working memory for speech.

An extremely interesting paper highlighting how inter-individual differences in working memory may be an important indicator of who will achieve improvements in speech in noise performance when using certain hearing aid processing features. (Lunner 2003; Gatehouse et al. 2006; Foo et al. 2007; Moore 2008; Lunner et al. 2009; Rudner et al. 201; Arehart et al. 2013; NG et al. 2013, 2014; Desjardins & Doherty 2014; Souza & Sirow 2014).

WARRM may represent a feasible measure to measure working memory allowing the fitting of hearing aids based also upon the working memory capacity of the listener. A very exciting and promising aspect of this test is that administration time for the typical reading working memory test is approximately 20 to 30 minutes whereas, the WARRM takes approximately 10 minutes to administer.

Age-Related Differences in Listening Effort During Degraded Speech Recognition.

Kristina M. Ward, Jing Shen, Pamela E. Souza, and Tina M. Grieco-Calub.

Ear and Hearing 2017; Vol. 38 (1), 74-84.

25 younger adults and 21 older adults completed a dual–task paradigm that consisted of a primary speech recognition task and a secondary visual monitoring task. Sentence material in the primary task was either unprocessed or spectrally degraded into 8, 6, or 4 spectral channels using noise band vocoding. Performance on the visual monitoring task was assessed by the accuracy and reaction time of participants' responses. Performance on the primary and secondary task was quantified in isolation. The majority of the YA group consisted of undergraduate and graduate students attending North-western University, the OA group comprised participants from within the community of North-western University as well as from the greater Chicagoland area.

To assess the participants' selective attention and inhibitory control, the NIH Toolbox Flanker Inhibitory Control and Attention Test (McDonald 2014) was used. In this task, a row of arrows was displayed on the screen and the participants had to press either the leftward or rightward arrow key as quickly as possible to indicate the directionality of the middle arrow. The trials consisted of intermixed congruent and incongruent trials for a total of 20 trials. Unadjusted scale scores were derived for each participant by combining the reaction time scores in milliseconds from the trials on which they correctly responded with the accuracy of each response.

For the speech recognition, sentences (primary task) were presented bilaterally at 65 dB SPL with a fixed inter-sentence silent interval of 5 sec. It was requested of participants to listen to each sentence and repeat it aloud as accurately as possible, even if it required guessing. Responses were scored live with a point awarded for each of the 3 or 4 predetermined keywords correctly repeated for each sentence.

For the secondary task (visual monitoring), greyscale images were presented sequentially on a computer monitor at a rate of 300 msec per image with an interstimulus interval of equivalent duration. Participants were instructed to press a key as quickly as possible when the same picture occurred twice in a row. Performance was based on a reaction time between the onset of the display of the repeated image and the participant's key press, and accuracy, defined as the proportion of trials in which a repeated image elicited a key press.

In addition to the primary and secondary task baseline measurements, participants performed these tasks simultaneously as part of the dual task paradigm. Participants were instructed to listen to each sentence and repeat it aloud as accurately as possible, the designated main goal, while simultaneously monitoring the visual stream for repeating images to the best of their ability.

After statistical analysis, the results demonstrated how the older adults experienced significantly greater declines in secondary–task accuracy during degraded speech recognition than that experienced by younger adults and this is consistent with previous work (Shannon et al. 1995; Eisenberg et al. 2000; Friesen et al. 2001; Baskent 2006). This may be due to age-related differences for executive control. Both younger and older adults showed declines in secondary task accuracy and reaction time with increased spectral degradation of the primary speech recognition task, this being consistent with previous studies that demonstrate greater listening effort under conditions of reduced spectral information (Harvais – Adelman et al. 2012; Pals et al. 2013; Winn et al. 2015).

The present study contributes to the knowledge of how age influences dual task performance, hence providing further evidence of the efforts older adults may experience. However, it must be noted that the paper outlines some limitations to the test setup as, for example, even though both groups demonstrated age typical hearing, the audiometric thresholds of the younger and older adults were not matched at all frequencies; older adults had poorer high frequency thresholds than younger adults on average and even small differences in audiometric thresholds can effect degraded speech recognition (Dubno & Ahlstrom 1997).

Self-Reported Listening-Related Effort and Fatigue in Hearing-Impaired Adults.

Sara Alhanbali, Piers Dawes, Simon Lloyd, and Kevin J. Munro.

Ear and Hearing 2017; Vol. 38 (1), e39-e48.

The aim of this study was to extend previous knowledge by investigating both self–reported listening effort and self-reported fatigue in adults with different types of hearing impairment and hearing solutions and to compare them with an age-matched control group with normal hearing. It was hypothesised that individuals with hearing loss would report increased levels of listening effort and fatigue compared to the control group. A second aim was to investigate the relationship between the self-reported levels of effort and fatigue. It was hypothesised that, in the case of increase fatigue because of hearing loss, there would be a positive correlation between the self-reported levels of listening effort and fatigue.

Four groups of 50 English speaking adults were recruited for this research and a minimum sample size of 40 participants per group was estimated to provide 80% statistical power to detect a clinically significant difference with medium sized effect (r= 0.3; Field 2009) between the groups (alpha =0.05), based on a between-groups analysis of variance. The self-report scale used was the FAS (Fatigue Assessment Scale) comprising of 10 short items (Michielsen et al. 2004). The overall score of FAS is calculated by summing the responses obtained for each individual question. The total score ranges from 0 to 40, with higher scores indicating more fatigue. To investigate the correlation between FAS and EAS, FAS scores were converted into percentages.

As the authors were not aware of any validated scale to measure self–reported listening effort in daily life of people with hearing loss, a self-assembled scale , referred to as EAS, was used. Three of the questions were obtained from the SSQ hearing scale (Gatehouse & Noble 2004), which is a validated scale assessing different aspects of hearing disability.

Potential candidates were recruited in each site by audiologists reviewing hospital records for those that met the inclusion criteria. For each hearing impaired group, the questionnaires were posted initially to 80 potential participants. Participants in the control group were approached directly through social groups and were checked for candidacy to participate in this study.

Preliminary analysis shows a weak but significant correlation between FAS and EAS and supports the hypothesis that there is an association between effort and fatigue. Hearing impaired adults reported high levels of listening effort and fatigue in their daily life and 2 out of 10 reported extreme levels of fatigue. 5 out of 10 reported extreme levels of effort. Another interesting result was that adult hearing aid users, those with cochlear implant and single-sided deafness experienced similar levels of effort and fatigue suggesting that these cannot be predicted from hearing level.

This test demonstrated how all hearing impaired groups experienced significantly increased effort and fatigue compared to the control group. Another very significant conclusion made by the authors is that similarity in listening-related effort and fatigue between the different hearing impaired groups suggests that aspects of listening experience via self-reported effort are not predicted by the severity of hearing impairment as was demonstrated by factor analysis and the low correlation between the fatigue assessment scale with the effort assessment scale. The authors suggest that factors other than hearing disability influenced the FAS ratings such as the age of the participants, chronic illness along with hearing difficulty and these factors need be considered. Further research, requiring a controlled longitudinal study could investigate further the effectiveness of hearing devices on listening effort and fatigue but, due to the cross-sectional design of the test, it was not possible to assess this in this research.

Hearing impairment, cognition and speech understanding: exploratory factor analyses of a comprehensive test battery for a group of hearing aid users, the n200 study

Jerker Rönnberg et al.

International Journal of Audiology, 2016; Vol. 55 (11), 623-642.

Recent advantages in hearing aid technology provide benefit to some, yet still far from all can take advantage of the advanced signal processing strategies available in modern hearing aids (Kiessling et al, 2003; Lunner & Sundewall-Thoren, 2007; Souza et al, 2015).
The differences in benefit arise even when individuals have similar audiograms. Some of these differences can be because of factors such as temporal processing ability and specific cognitive functions (Pichora – Fuller et al, 2007); Ronneberg et al, 2011; Humes et al, 2013; Ronnberg et al, 2013, 2014; Schoof & Rosen, 2014; Fullgrabe et al, 2015).

The current study is the first investigation in a series of studies named n200 based on the number of participants in each test group. Data collection for the first group has been completed and forms the basis for a cross-sectional study of over 200 experienced hearing aids users with bilateral, symmetrical mild to severe sensorineural HL who were recruited from the patient population at the University Hospital of Linkoping. The test has been extended to include a longitudinal study with three test occasions from T1 to T3, with 5 years between test occasions, and two control groups of around 200 persons each. The two control groups of around 200 persons, one consisted of individuals with normal hearing and the other of individuals with hearing loss that do not use hearing aids. This current paper looks at the data collected from 200 participants with hearing loss who use hearing aids.

The aim of this current paper is threefold: firstly to present a test battery which is based on well-established tests as well as new cognitive experimental measures; to statistically examine how the test variables from the three classes of tests are structurally related to each other, taking age into account; to address theoretical and clinical implications from the overall picture of the data. The focus of the current study was to present the overall pattern of data, meaning that detailed analysis of specific hearing and cognitive predictor variables and specific outcome test conditions , subjective or objective, are not included this study.

With the current test battery of hearing, cognitive and outcome variables, the following general predictions were made. Firstly, since the ELU model consists of independent, but interacting cognitive components (e.g. Ronnberg et al, 2013), one general expectation is that all cognitive variables would be subsumed under one factor in an overall exploratory factor analysis. Secondly, because of the different hearing and cognitive functions they tap into, one expectation was that the outcome variables would result in one context driven factor (mainly HINT, Hallgren t al, 2006) and Samuelsson & Ronnberg test, 1993) and one where context is less important (mainly the Hagerman, 1982). The hearing variables would also be split up into sensitivity (i.e. thresholds) on one hand and suprathreshold, temporal fine structure tests on the other hand (mainly STM and TFS –LF). Thirdly, it was predicted that performance on the outcome tests that are relatively context independent (e.g. Hagerman sentences) would be associated to a higher degree with the hearing and cognition factors than would performance on the context dependent tests (Ronnberg et al, 2013; Ronnberg et al 2013; Samuelsson & Ronnberg, 1993). Fourthly, it was expected that the measures of inner/outer hair cells and temporal fine structure would be related to speech understanding in noise, via relations to cognitive components (Stefelt & Ronnberg, 2009). Fifthly, it was expected that hearing sensitivity (i.e. thresholds) would relate to the cognitive functions, but less so than in previous work because the *current test battery included online cognitive processing and excluded episodic memory functions (Ronnber et al, 2011, 2014).*

A very engaging publication demonstrating how the Ease of Language Understanding is defined at a cognitive level and assumes that processing of spoken input involves rapid multimodal binding of phonology, completed at around 150-200ms after stimulus presentation. This holds important implications that need to be addressed and certainly not to be undervalued during hearing aid therapy with particular regard to the aged population undergoing treatment.

Perceived listening effort and speech intelligibility in reverberation and noise for hearing-impaired listeners

Henning Schepker, Kristina Haeder, Jan Rennies & Inga Holube.

International Journal of Audiology, 2016; Vol. 55 (12), 738-747.

A number of studies have investigated the detrimental effects of interfering noise and reverberation on speech intelligibility in the normal and impaired human auditory system. While the normal auditory system enables good speech discrimination even in adverse signal to noise ratios or long reverberation times whereas impaired auditory systems are often already degraded at more favourable signal to noise ratios or shorter reverberation times (e.g. George et al, 2010).

Twenty one listeners with mild to moderate sensorineural hearing loss participated in this test with an average age of 70.2 years ranging from 59 to 82. For the assessment of scaled listening effort and speech intelligibility scores, sentences spoken by a male speaker were taken from the Oldenburg sentence test (OLSA, Wagner et al, 1999). An additive long term spectrum stationary background noise was generated and used for mixing different signal to noise ratios.

Measurements were split across three different sessions of 45-90 minutes each. In the first session, pure-tone audiometry, including air- and bone-conduction as well as uncomfortable loudness level measurements, was conducted. Subsequently a categorical loudness scaling was performed to determine the individual speech presentation level. In the following two sessions, listening effort and speech intelligibility measurements were performed.

In general, listening effort decreased and speech intelligibility increased with increasing Speech Transmission Index. For simulated impulse responses consisting of white Gaussian noise exponentially decaying in time, a good agreement between conditions of different relative contributions of noise and reverberation was found. The STI slightly overestimated the effect of reverberation on the perceived listening effort and underestimated its effect on speech intelligibility. Including the average hearing loss in the calculation of the STI led to a better agreement between STI predictions and subjective data.

Speech intelligibility and listening effort provide complementary tools to evaluate speech perception over a broad range of acoustic scenarios. In addition, when incorporating hearing loss information, the STI provides a rough prediction of listening effort in these acoustic scenarios.

More and more evidence is emerging on the possible correlations between listening effort and cognitive load and this study provides yet another interesting insight on the detrimental effects adverse listening situations can have on the hearing impaired listener.

Simulated patients versus seminars to train case history and feedback skills in audiology students: A randomized controlled trial

Jane Hughes, Wayne J. Wilson, Naomi MacBean & Anne E. Hill.

International Journal of Audiology, 2016; Vol. 55 (12), 758-764.

Supervised clinical placements, where students are placed in working clinics under the supervision of qualified clinicians, remain the cornerstone of student clinical training in many audiology programmes around the world. To make the most of these placements, students must be adequately prepared for the clinical challenges they are likely to encounter. In the past, this preparation has typically involved more traditional training methods such as didactic lectures, group tutorials, laboratory practicals and/or group seminars. More recently, alternative methods have been considered involving simulations such as mannequins, computer–based simulations, and/or simulated patients. This study compared two methods of preparing first year audiology students for clinical placement; a more traditional method using seminars versus an alternative method using simulated patients.

The research design was a randomised controlled trial using two groups and two treatments with cross over. The participating audiology students completed the study over a 12 week period. The participants in this study were the 24 audiology students, five simulated patients, two clinical educators and three independent examiners. The procedure for this present study, as shown in the figure, was subsumed within the clinical audiology course that hosted it.
The videos of all participating students at the three assessment occasions (weeks 2, 7, and 12) were reviewed offline by the three independent evaluators.

Students were assessed on three different occasions and by three different independent evaluators.

Student group 1 received assessment 1 (week 2), simulated patient training (weeks 3-6), Assessment 2 (week7), seminar training (weeks 8-11), Assessment 3 (week 12) and student group 2 received assessment 1 (week 2), seminar training (weeks 3-6), Assessment 2 (week 7), simulated patient training (weeks 8-11), Assessment 3 (week 12).

The cost per student group was AUD$1360 for the simulated patient training and AUD$570 for the seminar training. The cost for the simulated patient training per group was made up of 8 hours of simulated patient (amateur actor) time, 8 hours of clinical educator time and 20 hours of clinic room hire. The cost of seminar training per group was made up of 6 hours of clinical educator (lecturer) time and 6 hours of lecture room hire.

This paper provides an interesting insight for those involved in teaching and training. Both simulated patient training and seminar training resulted in equivalent improvements in the abilities of the participating first year audiology students to make a case history from and give feedback to simulated patients playing the role of co-operative adult clients in a basic diagnostic audiology setting. The study found that lower fidelity seminar training was adequate for teaching basic audiological skills to this study's participating audiology students compared to the more expensive simulated patient training and this is consistent with similar findings by De Giovanni et al, 2009; Lee et al, 2008; Matsumoto et al, 2002; Mounsey et al. 2006; Norman et al, 2012; Papadakis et al, 1997).

This paper does not argue for a wider abandoning of simulated patient training in audiology as it is deemed useful in the greater context of deliberate instructional design.

Clients' perspective on quality of audiology care: Development of the Consumer Quality Index (CQI) 'Audiology Care' for measuring client experiences

Michelle Hendriks, Judith Dahlhaus-Booij & Anne Marie Plass.

International Journal of Audiology, 2017; 56 (1): 8 - 15.

To measure and compare the quality of the audiology care in audiology centres in the Netherlands, a Consumer Quality Index 'Audiology Care' was developed following a strict methodology consisting of both qualitative and quantitative methods. An important strength of this standardised method for developing questionnaires and for measuring, analysing and reporting patients' and clients' experiences with health care is that clients are involved in the development.

In the qualitative phase, clients (n = 14) were invited for a focus group discussion, but people indicated that they were not able to participate because of their hearing impairment. Therefore, people were asked to answer 3 open questions via e-mail. 8 quality aspects were deduced from the responses. Questions for each of these quality aspects were formulated, resulting in a first version of CQI Audiology Care.

Two small-scale surveys were performed: one group (n = 188) filled out the first version of the CQI Audiology Care, a second group (n = 118) indicated how important they evaluated the different quality aspects. Based on these results, the questionnaire was adjusted and tested again, now in a large-scale pilot (n = 1793).
The importance questionnaire showed some aspects which were very important: sufficient expertise concerning hearing impairment, being taken seriously and getting matters explained in a clear and understandable way. The least important were the facilities present in the audiology care centre.

The final version consisted of 59 questions. The questionnaire consists of 7 scales representing quality aspects important to clients:

- *Expertise of employees*
- *Conduct of employees*
- *Arranging appointments*
- *Waiting times*
- *Client participation*
- *Effectiveness of treatment*
- *Accommodation and facilities*

This results in a reliable and valid instrument to measure quality of audiology care. It is also interesting to map differences among audiology centres. The study showed that experiences with the accommodation and facilities, arranging appointments, waiting times and client participation differed significantly.

The questionnaire can also be used to improve the transparency about the quality of audiology care and help (future) clients choose the care that best fits their personal preferences. Though the evaluation was positive, audiology care can be improved concerning patient-centeredness.

A tool for assessing case history and feedback skills in audiology students working with simulated patients

Jane Hughes, Wayne J. Wilson, Naomi MacBean & Anne E. Hill.

International Journal of Audiology, 2016; Vol. 55 (12), 765–774.

All of us working and supporting students and learners in Audiology will recognise the need for consistency in practice, and the efficacy and benefits of real-life learning opportunities to reinforce theory. This new study establishes a verifiable, reliable tool to measure, monitor and influence students' skills at case history taking, and dialogue and interaction. It would appear that in most educational settings, students have been monitored on an ad hoc basis with the preferences and opinions of the supervisors as guidance. This tool presents reliability and consistency of measurement, and is based on previous tools used in similar disciplines such as Speech Pathology.

The Hughes Study used five "simulated patients" (SPs); these are actors or real patients who have learned a script to go through various scenarios with the students. SPs have been shown to provide real-life experience without risks for students, and provide opportunities to practise, adapt behaviours and develop skills. Twenty four first year Masters Degree students, all of whom had completed foundation courses in acoustics, psychoacoustics, the auditory system, otoscopy, pure-tone audiometry, speech audiometry, masking, tympanometry and acoustic reflex, interpreting results and simple statistics. They were evaluated by two clinical educators and three independent evaluators

The Audiological Counselling Evaluation (ACE, English et al 2007) has been used in the past to demonstrate learning by students, but it is primarily a counselling skills tool, and so doesn't reflect the students' clinical skills. Based on the Speech Pathology Standardised Patient Interview Rating Scale (SPIRS) (Hill et al 2015) it evaluates six clinical skills : verbal communication, non-verbal communication, interpersonal skills, interviewing skills, professional practice skills and specific clinical skills, the ASPIRS (Audiology Simulated Patients Interview Scale), provides reliable measurements of teaching benefit using a Likert scale of 1 (unacceptable) – 5 (excellent)

The reliability and consistency of the Assessors' marking provided for the robustness of the Tool, and demonstrated its flexibility in student Audiology clinical skill measurement. The study also considered the differences between "Hawk" and "Dove" Assessors and evidenced that the tool balanced out those professional preferences, I suspect that my students will say that I'm a "Hawk" rather than a "Dove", so I found this an interesting element of the study by Hughes and her colleagues.

The paper concludes by asserting that ACE and now ASPIRS are the only tools to measure this element of training Audiology students, and demonstrate its effectiveness. I think that ASPIRS could easily be incorporated into practice within other non-academic settings. In the UK, most of our larger companies provide training and in-house induction, and ASPIRS could be readily adapted to measure, monitor and evaluate the efficacy of training, skillsets and Continuing Professional Development for new and existing Audiologists.

An interesting paper which I can see would have positive applications in daily practice and training.

English K., Naeve-Velguth S., Rall E., Uyehara-Isono J. & Pittman A. 2007. Development of an instrument to evaluate audiologic counseling skills. J Am Acad Audiol, 18, 675–687.
Hill A.E., Davidson B.J. & Theodoros D.G. 2015. An investigation of the Standardised Patient Interview Rating Scale (SPIRS) for the assessment of speech pathology students in a simulation clinic. Int J Prac-Based Learn Health Social Care, 3, 58–76.

Screening, Education, and Rehabilitation Services for Hearing Loss Provided to Clients with Low Vision: Measured and Perceived Value Among Participants of the Vision-Hearing Project.

McMahon, C M, Schneider J, Dunsmore, M, Gopinath B, Kifley A, Mitchell P, Wang J-J, and Leeder S R.

Ear and Hearing 2016; Vol. 38 (1), 57–64.

Working as we do with older people, the prevalence of dual sensory impairments (DSI), and additional sensory and cognitive issues allied to hearing loss, are issues we confront daily in our clinics. This Australian paper looks at the efficacy of the novel approach of combining screening and rehabilitation provision. Services are generally focused on single issues, and the complex implications of unmet need often falls through the gaps.

The paper presented by McMahon and her colleagues reported the success of pilot "Hearing Screening and Education Model" (HSEM) within a low vision clinical setting, over 2010 and 2013. Over three hundred clients participated in hearing assessments, including those who had previously been hearing aid wearers, people who used their aids less than one hour a day, those who were monaural hearing aid users despite a binaural hearing impairment, and those who did not currently own hearing aids (classed as unmet needs). In addition to assessing the participants levels of visual and hearing impairments, the study also considered factors such as living alone and financial status, general health and gender. Most of the participants were older people, 85 and beyond, and the researchers suggest that this may have an impact of the help-seeking behaviours and benefits of the HSEM

I found one of the most interesting aspects of the paper was the issue around perceived benefit of the HSEM, and in particular the opportunity to speak about dual sensory impairment, as being the most valued by the study participants, and that 78% considered it important for professionals in other disciplines to have an awareness of the impact of DSI. Over 70% considered it important to have both hearing and vision testing in the same clinic, and that it would encourage people to have both senses tested.

However the research was confounded by the age-old issue of reluctance to take up hearing help even when facilitated so comprehensively. Despite most of the participants stating that they thought it was a good idea, and that it should encourage more people to have their hearing assessed, over 60% of the participants didn't take the offer of help any further.
This reluctance did not dent the researcher's enthusiasm that a holistic approach may prove effective for service development for people with DSI, that greater service collaboration should be viewed as a progressive measure, and further qualitative research would provide more information for service delivery.

An interesting and relevant paper which should make us all consider the impacts of dual sensory loss in our client populations.

Provision, perception and use of trainable hearing aids in Australia: a survey of clinicians and hearing impaired adults

Els Walravens, Gitte Keidser & Louise Hickson.

International Journal of Audiology, 2016; Vol. 55 (12), 787-795.

This study set out to obtain information on the impact of trainable hearing aids among clinicians, hearing aid users and candidates. Two online adaptive surveys were developed to evaluate provision, uptake and experience or expectation of trainable hearing aids. There were 259 clinicians, 81 hearing aid users and 23 candidates for hearing aids who filled out the survey.

Most of the clinicians activated trainable features, however only for a selection of users, and reported positive findings. Reasons to not activate these features were mostly because the hearing aid controls had already been disabled for management or client preference. One third of the clinicians reported that they had no access to trainable aids or they were unsure about the presence or activation of trainable features. The remaining clinicians never activated these features.
One in five users reported having used trainable aids and 93% would train again. Over 85% of the remaining hearing-impaired adults were interested in trainable aids.

Positive reports from most providers and users who had experience with the trainable feature support the provision of trainable aids to selected clients.

There is a big lack of awareness and knowledge about existence and operation among clinicians and users about trainable features. This is caused by the low quantity of research and evidence-based guidelines for usage. This article surveyed 259 clinicians, which is a small group, and therefore more research is needed to increase the knowledge to set up evidence-based guidelines for usage.

Most positive outcomes came from younger users, who are usually more familiar with technology in general. As the majority of hearing aid users are over 70 years, a selection of users should be made for whom these features can be activated. If the manipulation of the hearing aid itself already causes some problems for the user, it is not advised to introduce trainable features.
However, when the trainable features are activated on the target group, providers reported more client involvement and an improved outcome after usage.

As the population is growing and the number of hearing aid candidates increases, we are searching for methods to reduce the needed time and effort as well as the number of appointments needed to fit hearing aids properly. However, the results of the survey show that trainable features on hearing aids do not yet achieve this aim. Although mostly positive outcomes were revealed, a personal setting by an audiologist is still required for hearing aids with trainable features.

Usage of personal music players in adolescents and its association with noise-induced hearing loss: A cross-sectional analysis of Ohrkan cohort study data

Dorothee Twardella, Ulla Raab, Carmelo Perez-Alvarez, Thomas Steffens, Gabriele Bolte & Hermann Fromme.

International Journal of Audiology, 2017; Vol. 56 (1): 38–45.

Goal:
This article describes PMP (Personal Music Player) usage among adolescents, sociodemographic determinants and association with audiometric notches.

Study design:
The population:
n= 2143 (54% female) adolescents (mostly aged 15-16), no exclusion criteria were applied.
Audiometric evaluation & questionnaires:
Tympanometry and audiometry (125 – 8 kHz). Both students and parents completed standardised questionnaires (music listening behaviour, sociodemographic and medical history).
Estimation of Noise exposure due to PMP usage:
Estimation of noise dose was based on self-reported volume (% of maximum volume) and self-reported duration of use converted to noise exposure levels for a 40 hour week. The actual output of the PMP was not measured. The corresponding dBA output per % volume setting was based on average results measured by Portnuff et al., 2011.

Findings:
Among the study sample (aged 15-16):

- *High exposure to music from self-reported PMP usage was highly prevalent: noise exposure exceeds noise at work limits:*
  - *+/- 25% > AV80 **
  - *+/- 20% > AV 85 **

    **These noise exposure levels were compared to the 'noise at work' limits which pertain to a 40 h working week: the lower exposure action value of 80 dB(A) (AV80) and the upper exposure action value of 85 dB(A) (AV85) of Directive 2003/10/EC of the European Parliament and of the Council (2003)*
- *Listening duration and volume level of PMP users was significantly different between socially disadvantaged groups. Generally listening duration and volume were higher in groups such as:-*
  - *Those attending vocation training schools*
  - *Processing a migration background*
  - *Less educated parents*
  - *Marital status of the parent being single*

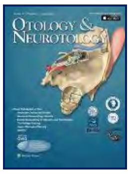
- *Male teenagers appear to listen to music at higher volume control settings than female teenagers. But no significant difference in the duration of PMP use was found between boys and girls. On the other hand, the percentage of users was higher among females than among males.*
- *Indications of hearing loss were found in only 2.3 % of the sample and were not associated with PMP usage. Again, no statistically significant association could be found between hearing loss indicators and PMP use.*
- *Typical PMP duration of use estimates are relatively similar to other comparable studies, differences of 'risky listening' appear to arise from differences in the estimation of SPL's. Since a 3 dB increase is equivalent to doubling the PMP duration with respect to the risk of hearing loss, it is likely that the observed difference in mean SPL will result in large differences in percentage of risky listening, while minor differences in PMP duration are less important.*

Conclusion:
It appears reasonable to conclude from the Ohrkan study, that, in subjects of this young age (15–16 years), the harmful consequences of PMP usage have not yet evolved. Noise-induced hearing loss is a slowly developing condition which takes many years to manifest. For this reason, a follow-up of the cohort is planned to analyse the influence of PMP use among future incident cases of audiometric notches.

Critical notes:

(+) This study is one of the bigger studies in the field presenting a nice description of the PMP usage in adolescents as well as sociodemographic determinants and associations with hearing loss.
(-) The actual output level of the PMP was not measured. The study used questionnaires to estimate the volume setting and user time. The actual output level of the PMP has a major influence on the calculation of the noise dose and can lead to important differences in risk calculation (equal energy rule: exposure level + 3 dB -> exposure time/2 as mentioned earlier).

Music-induced Hearing Loss in Children, Adolescents, and Young Adults: A Systematic Review and Meta-analysis



Carlijn le Clercq, Gijs van Ingen, Liesbet Ruytjens & Marc van der Schroeff.

Otology & Neurotology, 2016; Vol. 37: 1208–1216.

Goal:
The aim of the study was to provide an overview of music–induced hearing loss and its symptoms in children.

Study design:
Eight electronic databases were searched (last 4/2015), for all articles describing hearing levels in children and young adults exposed to music. Two reviewers independently screened all articles, the studies of medium- and high-quality were reviewed, and audiometric data from high-quality articles were additionally included in the meta-analysis.

Outcome measures were evaluated in three separate categories:
- *Hearing levels in children and young adults exposed to music during leisure-time*
- *Temporary threshold shifts directly after exposure to music*
- *Subjective hearing-related symptoms*
    - ⇨ *A meta-analysis was performed to calculate average hearing thresholds*
    - ⇨ *Hearing thresholds were additionally compared between 'users' and 'non-users' of PMP*

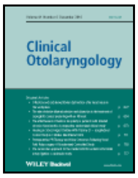
Population:
The 33 studies comprised a total of 26,379 participants, ranging between 15 and 8,710 participants per study. The median age was 20 years with an interquartile range of 16.9 to 21.6 years.

Results:
- *General remarks:*
    - *The use of more consistent definitions of normal and abnormal hearing (such as classified by Niskar et al 1998), would contribute to better comparable studies.*
    - *Although the general use of PMPs is likely to be reported truthfully, reports on, for instance, listening volume can suffer from social desirability. This further complicates drawing reliable conclusions on dose-effects. To study these dose-effects, objective measurements of music exposure are required.*
    - *Less research is done on the effect of music exposure in elementary school children than in, for example, university students. Hence more studies are required in the elementary school population.*
- *The weighted average of prevalence of hearing loss (>15 dBHL) for the population was 9.6 %.*
- *For high frequency hearing loss, a weighted average of 9.3% was found.*
- *Tinnitus was experienced by a (weighted average) of 38.8%. Permanent tinnitus was reported by a range of 0 to 2.2% of the population (depending on the study).*
- *The meta-analysis showed:-*
    - *weighted average hearing thresholds at standard audiometric frequencies (0.125-8 kHz) did not exceed 15 dBHL. FIG 2A*
    - *31.2 % of participants had mean hearing thresholds exceeding 15 dB HL at high frequencies 3, 4, and 6 kHz.*
    - *Figure 2B shows average hearing levels when stratified for the use of PMPs. Hearing threshold levels in both groups were comparable in lower frequencies yet diverted at*

higher frequencies. Hearing thresholds at high frequencies 4, 6, 8, 10, 12.5, and 16 kHz were significantly poorer in PMP users compared with control subjects.

Conclusion:
There were no significant differences in the prevalence of hearing loss and the prevalence of high - frequency hearing loss between children, adolescents and young adults who are exposed to loud music and those who are not. Deviations were found when there were increasing amounts of exposure, but not all correlations were reliable and the large spread of results hindered drawing reliable conclusions.

The relationship between hearing impairment and cognitive function: a meta-analysis in adults



D.S. Taljaard, M. Olaithe, C.G. Brennan-Jones, R.H. Eikelboom and R.S. Bucks

Clinical Otolaryngology. Vol 41 (6), December 2016, pages 718-72.

This is the first meta-analysis to explore the impact of hearing loss and hearing intervention on cognition. The purpose of this study was to examine the evidence-base for the relationship between hearing impairment and cognition and to consider the impact of hearing intervention on cognitive function, in order to clarify outcomes and to suggest directions for further research.

Epidemiological evidence suggests a relationship between peripheral hearing loss and cognitive function in adults over the age of 60. Such studies reveal poorer cognitive function in those with hearing loss, especially in memory and executive function, with a faster rate of decline in cognition in adults over 55 years of age and an increased risk of incident, all-cause dementia. Studies published in recent years have increased awareness of the potential role of hearing aids and cochlear implants as a protective strategy against cognitive decline. However, not all studies have found a significant relationship between hearing impairment and cognition or a significant effect of intervention on cognition.

Method
A particular focus of this meta-analysis was to address the issue of the variety of tasks and domains used to report cognitive function which have been used in the studies selected for this meta-analysis.

A systematic search of the literature was undertaken with great thoroughness, even to the extent of contacting some study authors for further data and asking key authors in the field if they were aware of any other relevant published or unpublished studies. This process led to the inclusion of 33 studies and produced 40 samples. These studies were first categorised by sample type:-

- *Is cognition poorer in individuals with untreated hearing impairment compared to individuals with normal hearing?*
- *Is cognition poorer in individuals with treated hearing impairment compared to those with normal hearing?*
- *Is cognition associated with degree of hearing impairment in untreated individuals?*
- *Is cognition associated with degree of hearing impairment in treated individuals?*
- *Does cognition improve after hearing intervention?*

This subset of analyses explored one further question:-
- *How is hearing impairment associated with cognitive ability across different domains of cognition?*

The domains of cognition and the tests that measure these domains as used in the studies which were meta-analysed are presented in helpful detail in the article. The domains of cognition which were described:-

- *Attention and processing speed*
- *Short-term memory and working memory*
- *Long-term memory*
- *Executive function*
- *Semantic and language knowledge*

The authors noted that very few of the studies outlined a clear rationale for why they assessed a particular aspect of cognition or why they used a particular method of assessing hearing impairment. The authors questioned the validity of some of the tasks used in cognitive tests when used with hearing impaired individuals; tasks that involve hearing are harder for those with hearing impairment. It was suggested that tasks with a visual alternative may be a better test of cognition and may have greater validity for this population. The results of this study support this, as the biggest differences between groups existed in the 'Attention and Processing Speed' domain, although this effect was still small. These domains would suffer most when tasks are cognitively demanding and processing resources are being directed towards managing hearing impairment.

It was the authors' view that until a sufficient number of studies, using the same well-justified cognitive measures, are available, there will continue to be a lack of clarity in this field. This article contains a number of other, very insightful suggestions for further research.

Results
Whilst meta-analysis is a robust means of determining the effect of hearing impairment or its treatment on cognition, the number of studies in some of these meta-analyses was small. For example, the conclusion that there was a difference in cognition between those with treated and those with untreated hearing impairment was based on just three studies. However, the weight of evidence across all meta-analyses offered two consistent findings:-

1. *Hearing impairment is associated with cognitive difficulties and that treatment improves cognitive outcome.*
2. *What the evidence cannot reveal is the mechanisms by which hearing impairment and cognition are related.*

The results revealed that better hearing is associated with better performance across all cognitive domains examined, including attention and processing speed, short-term/working, and long-term memory, executive functioning, semantic processing and word knowledge, although the effects were all small. These effects were not impacted by the age of the participants, the time with treatment, or whether the tasks were 'visual' or 'verbal' in nature.
Overall, the results indicate that individuals with hearing loss have poorer cognition compared to individuals with normal hearing, whether or not that hearing loss is treated. However, the size of the difference compared to those with normal hearing was less than half in treated hearing impaired samples than in untreated.

A fascinating article which should be read by any audiology professional working with hearing impaired adults to gain a greater understanding of the status of the current evidence on the association between hearing loss and cognitive function. This article is as interesting for its proposals about the nature of further research as it is for its evaluation of the current evidence-base.

Multisite Randomized Control Trial to Compare Two Methods of Tinnitus Intervention in Two Control Conditions.

Henry J et al.

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Tinnitus is the perception of sound that has no source outside of the auditory system. The condition, which is generally not curable, is symptomatic of an auditory disorder which is not a disease itself. Follow-on effects of bothersome and severe tinnitus include cognitive, emotional and sleep disorders which can impact on performance of everyday activities.

This study looked at the effectiveness of two commonly employed sound therapy based approaches to tinnitus management, Tinnitus Masking (TM) and Tinnitus Retraining Therapy (TRT), in reducing tinnitus severity. In addition, a non-specific Tinnitus Education (TED) group was also investigated with the three interventions then compared with a Waitlist Control Group (WCG).

The three hypotheses of the study were:-

1) Over the first 6 months of treatment TM and TRT will decrease tinnitus severity in Veterans with bothersome tinnitus relative to TED and WLC and TED will decrease tinnitus severity relative to WLC Outcome: Partial Support

2) Over 18 months of treatment TM and TRT will decrease tinnitus severity in Veterans with bothersome tinnitus relative to TED Outcome: No Support

3) When TM, TRT and TED techniques are administered to Veterans with bothersome tinnitus by audiologists in four Veterans Affairs (VA) sites for a period of 18 months, treatment effectiveness will not differ across the four sites. Outcome: Support

12 audiologists without prior tinnitus specialisation were trained across 4 clinical sites in the USA via videoconferencing for an initial 3 hour period. They then underwent 3.5 hours additional training in either TM (following J Vernon guidelines and protocols), TRT (guidelines and protocols developed by P Jastreboff) or TED (no formal technique, audiologists answer questions but don't recommend particular management technique). Each technique had a flip chart and guidelines to help with consistency of services and sessions were of similar length.

Participants were 148 US Veterans who experienced bothersome tinnitus who did not suffer from other psychological disorders or dementia. Participants were alternately assigned to one of the four groups.

Prior to the first appointment, detailed history questionnaires and Tinnitus Handicap Inventory (THI) questionnaire were sent to the Veterans. They then underwent an initial intensive audiology and tinnitus assessment. Those in the TM and TRT groups identified as having aidable hearing loss were fitted with ear level combination devices while those with normal hearing received ear level masking devices/sound generators. TED group audiologists could fit hearing aids or combination devices using the clinical judgment they would employ with regular hearing loss patients.

Follow-up intervention/counselling appointments were then carried out at 3, 6, 12 and 18 months, with written questionnaires and an interview conducted prior to the counselling session at each time interval. At the final 18 month session, audiometric and tinnitus testing were also repeated. WCG was only monitored at 0, 3, and 6 months as previous studies had shown no change after this time.

Reduction in Tinnitus Handicap Inventory (THI) score was used to assess the success of treatment; a reduction on 20 points is recognised as clinically significant "strong improvement", a 7-19 point reduction was seen as "modest improvement".

TRT, TM and TED groups all saw a reduction in THI scores after 6 months compared with WLC as shown in the graph below; this effect was sustained at 18 months. No significant difference between the outcomes for TRT, TM and TED groups was found and after 6 months there was no further significant reduction in tinnitus severity. No significant difference in outcome was found between the 4 audiology clinic sites offering treatment.

Overall approximately half of each of the three treatment group participants achieved a modest or strong improvement in THI, TM (55%), TRT (59%) and TED (46%). Interestingly, Veteran's already wearing hearing aids prior to treatment and those with lower baseline THI scores were less likely to show modest or strong improvement. No other baseline characteristics were found to significantly impact on results. It may be that those already wearing aids have already reduced their tinnitus severity to a plateau level prior to the study.

This study has implications for the treatment type and duration of patients with bothersome or severe tinnitus. Clinicians in this study were not tinnitus experts; they received short duration training and achieved similar outcomes for TRT, TM and TED within a relatively condensed treatment period of 6 months. A previous study conducted by this group found expert tinnitus audiologists in a controlled clinical setting achieved a TRT reduction of 29.5 point which is a significantly better outcome than the 13.5 point reduction reported in this study. Further studies looking at duration of training and the outcomes achieved for each treatment method would provide insight into optimising tinnitus training programs for clinicians in real-world situations. This study also highlights the positive impact that fitting hearing devices to correct for hearing loss in conjunction with basic counselling can have on tinnitus patients within a short time frame.

Evidence of activity-dependent plasticity in the dorsal cochlear nucleus, in vivo, induced by brief sound exposure.

Thomas J. Brozoski & Carol A. Bauer.

Hearing Research, 341 (2016), 31-42.

This study investigated the immediate effects of exposure to moderate to intense sound on activity in the dorsal cochlear nucleus (DCN). Previous studies have shown that following intense noise exposure spontaneous activity increases in the fusiform cells of the DCN and this increase persists for up to at least 6 months. This hyperactivity is thought to result from decreases of inhibitory and increases in excitatory synaptic transmission in the DCN, possibly triggered by the loss of primary afferent input following hair cell damage. These changes are widely believed to underlie chronic tinnitus, but they emerge too slowly to explain acute tinnitus, which develops within seconds or minutes following moderate sound exposure that does not permanently damage the hair cells. The authors propose that a possible mechanism for acute tinnitus is activity-dependent plasticity, such as long-term potentiation (LTP).

The authors measured the levels of multi- and single-unit spontaneous and stimulus-evoked activity in the DCN of anaesthetised hamsters before and for 20 minutes following two minute periods of exposure to tones at either 109 or 85 dB SPL. The stimulus frequency was selected to either correspond to the unit's best frequency (BF) or fall within the borders of its inhibitory side band. The level and duration of exposure were selected to produce acoustic overexposure without inducing significant injury to the primary afferents and to resemble stimuli that have previously been shown to induce acute tinnitus in humans.

The results showed that significant changes in rates of spontaneous activity and responses to BF tones could be induced by acute tone exposure. The direction of the changes was found to depend on the frequency of the BF of the unit relative to the stimulus frequency. In recording locations that corresponded closely to the frequency of the tone, the effect was a transient decrease in spontaneous activity followed by a gradual increase of spontaneous activity that did not return to baseline during the 20 minute period of observation (shown in the figure below). When the stimulus intensity was reduced to 85 dB SPL, the enhancement was weaker than with the 109 dB SPL tone, but still significantly increased relative to baseline recordings. This increase in spontaneous activity was accompanied by only minimal impairment of tuning curve thresholds.

When recordings were performed on units with BFs below or above the exposure frequency, the initial suppression of spontaneous activity immediately after exposure tone offset was followed by a long lasting decrement in spontaneous activity.
Single unit recordings also showed that exposure to a tone with the frequency close to the unit's BF resulted in a decrease in maximal firing rate to BF tones, whereas when the frequency of exposure fell within the inhibitory side band the maximal firing rate to a BF tone was increased. It is concluded that the fact that the responses to stimuli were shifted in directions opposite to those for spontaneous activity indicates that the mechanisms controlling the levels of spontaneous activity are separate from those controlling responses to sound.

The authors suggest that the fact that increases in spontaneous activity were induced by stimuli that caused little or no changes in response thresholds suggests that the underlying mechanism is an activity-dependent process, rather than one that required damage to cochlear receptors. This mechanism is therefore different from what has been suggested previously to explain most cases of noise-induced hyperactivity. Possibilities include LTP, which is an enhancement of synaptic efficacy that often results when there is co-activation of pre- and post-synaptic membranes, or alterations in the intrinsic membrane properties of neurons.

These results are the first reporting evidence for induction of activity-dependent plasticity in fusiform cells of the DCN under conditions that are similar to those known to cause acute noise-induced tinnitus in humans. The authors suggest that these changes may represent a neural correlate of acute noise-induced tinnitus. The increase of spontaneous activity shown in this study offers a starting point for studying the mechanism of acute noise-induced tinnitus. Knowledge of this mechanism is likely to provide insight into how changes in the balance of excitation and inhibition on the time scale of minutes may eventually become permanent.

This in vivo study provides a clear demonstration of sound exposure can alter spontaneous neural activity over a time scale of several minutes without damaging the auditory periphery. This is an important first step in understanding the mechanisms of acute noise-induced tinnitus and how they differ from the mechanisms underlying chronic tinnitus. Studies that build on this research to show how long the changes in DCN activity persist and the relationship between these short term changes and the permanent changes seen in chronic tinnitus will be useful for clinicians in better understanding both forms of tinnitus and being able to counsel patients appropriately.

Top-down and bottom-up neurodynamic evidence in patients with tinnitus.

Sung Kwang Hong a, b, Sejik Park c, Min-Hee Ahn a, Byoung-Kyong Min.

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It has been reported that tinnitus influences auditory selective attention, however the direction of causation between tinnitus and cognitive processes of attention remains unclear. Preliminary evidence has supported the claim that tinnitus impairs 'executive' attention. However, evidence also shows that tinnitus perception can be subject to bottom-up processes that contribute to the allocation of perceptual processing resources. The authors of this paper investigated whether top-down or bottom-up attentional processes were altered in patients with tinnitus, independent of peripheral hearing loss.

In this study, EEG recorded during a top-down directed task (a classic oddball paradigm) was compared to that recorded during a bottom-up directed task (a passive listening paradigm). To avoid possible confounding effects of distorted auditory input due to peripheral auditory damage, 15 patients with tinnitus but no hearing loss were recruited and compared with 15 control subjects.

Granger causality analysis was performed in order to investigate the neurodynamic causal connectivity across principal brain regions in auditory processes. This analysis aimed to clarify the communicative directional flow of auditory information in controls vs. those with tinnitus. EEG alpha and theta activity during the auditory tasks was analysed as these oscillations have been considered to be possible electrophysiological correlates of sustained attention and top-down regulation in memory systems.

The amplitude of the P300 recorded using an oddball paradigm is positively related to the degree of attention. The tinnitus group demonstrated significantly reduced P300 amplitudes compared to healthy controls (shown in figure below), indicative of an impairment in top-down attentional processing. The N100 amplitude (reflecting bottom-up selective attention) was also different between the healthy and patient groups, suggesting both impaired bottom-up and top-down auditory processing in subjects with tinnitus.

Granger analyses also indicated impaired top-down modulation of auditory processing in subjects with tinnitus, shown by a lack of activation of the anterior cingulate cortex (ACC) during target processing in that group. The ACC has been found to be involved in top-down inhibitory control and conflict monitoring processing. The tinnitus group also had significantly reduced evoked theta power compared to the healthy group during the processing of target stimuli. As EEG theta activity has been observed when a person engages in memory retrieval and takes on cognitive load, this finding suggests that patients with tinnitus have cognitive deficits in auditory memory processing.

The authors divided tinnitus patients into two subgroups based on their P300 amplitudes to further investigate whether the EEG neurodynamics of a higher attentional resourcing group (larger P300; T1) behave differently from those of the lower attentional resourcing group (smaller P300; T2) in top-down and bottom-up processes. P300 amplitude tests revealed a significant difference compared to the control group for the T2 group only during the oddball task, but for the T1 group only in the passive listening task.

Granger causal connectivity of evoked theta activity consistently confirmed a double dissociation between the T1 and T2 groups in both top-down and bottom-up tasks. The T2 group had a causal connectivity dominated abnormally during the oddball task (top-down processing), whereas the *differences between the healthy group and the T1 group was observed during the passive listening task (bottom-up processing).*

As a reduction in P300 amplitude was shown from the healthy group to the T1 group and from the T1 group to the T2 group, the T1 group does not seem to be as deficient in top-down processing as the T2 group. The T1 group reported significantly higher rating of tinnitus annoyance, suggesting that patients with tinnitus can be categorised into at least two subgroups with both neurophysiological and behavioural differences.
Overall, the results of this study provide neurophysiological and neurodynamic evidence that both top-down and bottom-up dysfunctions can cooperatively contribute to tinnitus symptoms, independent of peripheral hearing normality. The authors acknowledge that it is still unclear whether this impairment is induced principally by peripheral cochlear damage or "hidden" hearing loss, or by an abnormality in cognitive circuitry. A future study using the same experimental paradigm comparing patients with tinnitus with and without hearing loss will provide more information on the relationship between hearing function and tinnitus pathology from the viewpoint of top-down and bottom-up processing.

This study provides experimental evidence of impaired top-down and bottom-up auditory processing in patients with tinnitus. Although the applications of these findings clinically are not yet clear, the results do highlight the need for clinicians to keep in mind that even in tinnitus patients with normal hearing, auditory processing may be compromised. This is particularly important when counselling tinnitus patients that report cognitive symptoms, such as impaired concentration. Research that clarifies the relationship of peripheral hearing loss to top-down and bottom-up abnormalities will be an important next step in better understanding the neuropathology of tinnitus and developing appropriate counselling and intervention strategies.

A review of the perceptual effects of hearing loss for frequencies above 3 kHz

Brian C. J. Moore.

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Introduction
Noise-induced hearing loss (NIHL) loss usually first becomes apparent in the audiogram for frequencies close to 4 kHz, although the exact frequency where the effect is greatest can vary from 3 to 6 kHz. In several countries, compensation for occupational NIHL is based on the mean estimated NIHL at 1, 2 and 3 kHz. The use of the average NIHL at 1, 2 and 3 kHz or 0.5, 1, 2 and 3 kHz for compensation purposes, assumes that hearing loss for frequencies above 3 kHz has no material adverse consequences. The purpose of this review was to assess whether that assumption is valid.

There are many studies showing that frequency components above 3 kHz contribute to speech intelligibility for people with normal hearing. Such studies formed the basis for the Articulation Index and its successor, the Speech Intelligibility Index (SII). The results of a number of studies have made it clear that, for those with normal hearing, frequency components above 3 kHz make a sizable contribution to intelligibility, especially for speech in the presence of background sounds. There are also several research studies showing that, for people with mild-to-moderate high-frequency hearing loss, speech intelligibility is improved when amplification is provided for frequencies above 3 kHz. Other studies involving participants with different degrees of hearing loss indicate that, overall, the evidence is strong that the audibility of frequencies above 3 kHz is important for speech intelligibility and that NIHL for frequencies above 3 kHz has adverse effects on the ability to understand soft speech and on the ability to understand speech in background sounds, especially when the background sounds come from a different spatial location to the target sounds.

Effects on speech intelligibility expected from the Speech Intelligibility Index (SII)
A standard method for predicting speech intelligibility is the SII. The method is based mainly on the audibility of the speech and does not take into account the adverse effects of hearing loss on the ability to discriminate sounds that are well above the detection threshold. Although it has its limitations, for lowpass or highpass filtered speech presented in quiet or in a steady background sound, the SII generally gives accurate predictions. The SII method incorporates a weighting function whereby the information at different frequencies is assigned a weight according to its relative importance. The overall weight assigned to frequencies above 3 kHz depends on the speech material. For 'average speech' the total weight assigned to frequencies above 3 kHz is approximately 23%.

Although approaches vary in different countries, to calculate the expected effect of NIHL for a given individual, the first stage is to estimate the expected hearing loss for a non-noise exposed individual of that age and gender. Once the age-expected hearing loss is estimated, it is subtracted from the actual hearing loss. This gives an estimate of the noise-induced component of the hearing loss. As the author of this article illustrates in some detail, the noise-induced component of the hearing loss at frequencies above 3 kHz can lead to some increase in difficulty in understanding soft speech in quiet and a marked increase in difficulty in understanding speech in background noise. The SII is based mainly on the proportion of the speech that is audible but not all of the effects of noise exposure are revealed by the pure-tone audiogram. The SII does not take into account such effects as reduced frequency selectivity and degeneration of neurons in the auditory nerve. Additionally, the extra component of hearing loss at 4 and 6 kHz produced by noise exposure reduces the ability to judge whether sounds are coming from in front or behind, and above or below, and increases the smallest detectable change in location of a sound. So, the author concludes that calculations based on the SII probably underestimate the effects of NIHL.

Predicting self-reported hearing difficulty based on audiometric thresholds

It has been argued that self-assessment should be the 'gold standard' for determining the effects of hearing impairment in everyday life. However, since a person claiming compensation for hearing loss might give an exaggerated report of the adverse effect of their hearing loss, self-report is not considered appropriate when assessing individual claims for compensation. Most of the studies that have reported correlations between self-reported hearing difficulty and audiometric thresholds have been based on participants with a wide range of ages and types of hearing loss. Although, for the hearing-impaired population in general, self-reported hearing difficulties are predictable to some extent from audiometric thresholds for frequencies up to 3 kHz, this does not necessarily mean that hearing loss for frequencies above 3 kHz is unimportant. Furthermore, for a population restricted to those with significant noise exposure, the average of 1, 2, 3, and 4 kHz as a predictor led to better agreement with self-reported difficulties than the average of 0.5, 1, and 2 kHz.

Predicting measured speech intelligibility from the audiogram

Smoorenburg (1992) published a study of the effects of NIHL on the ability to understand speech in quiet and in noise and of the relationship of that ability to the audiogram. This study had three strengths for the purposes of the present review:-

1. *All participants were selected because they were exposed to relatively intense noise at work, so the population was representative of those seeking compensation for NIHL.*
2. *The participants in the study were not actually seeking compensation for their hearing loss and had no motivation for exaggerating the extent of their hearing difficulties.*
3. *The ability to understand speech in noise was measured for three background noise levels, so that an accurate composite estimate of that ability was obtained. All participants were younger than 55 years to minimize the effects of age.*

Smoorenburg found that:-

- *The speech reception threshold (SRT) for speech in quiet (the speech level required for 50% of sentences to be identified correctly) showed the highest correlation with audiometric thresholds at low frequencies.*
- *The best three-frequency predictor of the SRT for speech in quiet was the average audiometric threshold at 0.5, 1, and 2 kHz. However, most of the participants had low SRTs for speech in quiet (90% had SRTs lower than 30 dBA), indicating that they had little difficulty in understanding soft speech.*
- *For speech in noise, the SRT (the speech-to-background ratio required for 50% of sentences to be identified correctly) showed the highest correlation with audiometric thresholds at high frequencies.*

Although correlation does not prove causality, these findings suggest that hearing loss at 4 kHz, and probably at 5 kHz, is important in determining the intelligibility of speech in noise for people with NIHL; the higher the audiometric threshold at 4 and 5 kHz, the worse is the intelligibility. The findings of this 1992 study were broadly confirmed in another study published in 2011, confirming the importance of high-frequency hearing for the ability to understand speech in noise.

Conclusions

There is very strong evidence that NIHL for frequencies above 3 kHz has adverse effects on the ability to understand speech, especially in background noise. Hearing loss for frequencies above 3 kHz also adversely affects the ability to localise sounds and to hear certain kinds of environmental sounds. Therefore, the audiometric threshold at 4 kHz, and possibly also at 6 kHz, should be taken into account when considering compensation for occupational NIHL in a medico-legal context. A major complaint of people with NIHL is difficulty in understanding speech in noise. A good predictor of the ability to understand speech in noise for people with NIHL is the average audiometric threshold at 2 and 4 kHz.

The author makes a strong, evidence-based case for change to how NIHL is assessed for compensation purposes and it's surprising that, given the evidence reviewed in this article, country variations in medico-legal practice still mean that some significant, higher frequency effects of NIHL are still not taken into account.

Reference

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