Evidence-Based Interventions for Adult Aural Rehabilitation: That Was Then, This Is Now

Melanie Ferguson, Ph.D.,[1,2,3] David Maidment, Ph.D.,[1,2] Helen Henshaw, Ph.D.,[1,2] and Eithne Heffernan, Ph.D.[1,2]

ABSTRACT

More than a decade after Arthur Boothroyd published "Adult Aural Rehabilitation: What Is It and Does It Work?," the four cornerstones of adult aural rehabilitation are re-examined in terms of research that we and others in the field have undertaken. The focus is on novel advances in high-quality research relating to interventions to support self-management for hearing aids and other listening devices (sensory management), knowledge and skill (instruction), auditory and cognitive training (perceptual training), and motivational engagement (counseling). Much of this new research has a theoretical underpinning (e.g., behavior change theory) to better guide the development and evaluation of interventions, with a focus on self-management and patient-centered approaches. New and emerging technologies that support e- and m-health delivery of interventions provide greater personalization and interactivity to promote self-management of hearing loss. Looking to the future, there remains a requirement for a set of relevant and appropriate outcome measures to evaluate the effectiveness of interventions trialed in clinical studies. There is a continuing need for high-quality evidence, underpinned by contemporary theory, to increase the likelihood that translational adult aural rehabilitation research that aims to benefit patients will be applied in future clinical practice.

KEYWORDS: hearing aids, multimedia education, auditory training, cognition, motivational engagement, outcome measures

[1]National Institute for Health Research (NIHR) Nottingham Biomedical Research Centre, Nottingham, United Kingdom; [2]Hearing Sciences, Division of Clinical Neuroscience, School of Medicine, University of Nottingham, Nottingham, United Kingdom; [3]Queens Medical Centre, Nottingham University Hospitals NHS Trust, Nottingham, United Kingdom.

Address for correspondence: Melanie Ferguson, Ph.D., NIHR Nottingham Biomedical Research Centre, Ropewalk House, 113 The Ropewalk, Nottingham, NG1 5DU, United Kingdom (e-mail: melanie.ferguson@nottingham.ac.uk).

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In 2007, Arthur Boothroyd published his well-cited article entitled "Adult Aural Rehabilitation: What Is It and Does It Work?"[1] Using the World Health Organization's (WHO's) terminology,[2] Boothroyd's definition described adult aural rehabilitation as "the reduction of hearing loss-induced deficits of function, activity, participation and quality of life through sensory management, instruction, perceptual training, and counselling" (p. 63).[1] He concluded that a holistic approach combining sensory management, instruction, perceptual training, and counseling best met the goal for adult aural rehabilitation, and highlighted a need for high-quality evidence.

Here, we turn the clock forward more than a decade and examine these four cornerstones of adult aural rehabilitation to improve auditory function, activity, participation, and quality of life for people with hearing loss in terms of research that we and others in the field have conducted. Self-management and behavior change are at the core of many of these interventions. We focus on the need for high-quality research to provide rigorous evidence to inform clinical practice, highlight the emergence of theories to underpin aural rehabilitation research and self-management, and end with the requirement to have a set of relevant and appropriate outcome measures to evaluate the impact of interventions trialed in clinical studies.

SELF-MANAGEMENT: WHAT IS IT?

Hearing loss is a highly prevalent condition, ranked fourth in years of living with disability.[3] Globally, 466 million people have disabling hearing loss, estimated to be over 900 million by 2050.[4] In the United Kingdom, one in six of the population has hearing loss, with prevalence similar to countries such as Australia and the United States, and even higher in certain regions, such as south Asia and sub-Saharan Africa.[5] Hearing loss is a long-term condition, and with an increasingly aging population, this places ever-increasing demands on health and social care provision.[6] Self-management of long-term conditions can enhance the efficiency of health and social care provision. Furthermore, those with long-term conditions who play a role in their day-to-day management, and who are appropriately motivated and actively participate in their care, are more likely to adopt better health behaviors that lead to better patient outcomes.[7]

Self-management is defined by the U.S. Institute of Medicine (now part of the National Academies of Science, Engineering, and Medicine) as "the tasks that individuals must undertake to live with one or more chronic conditions. These tasks include having the confidence to deal with medical management, role management, and emotional management of their conditions."[8] Self-management focuses on behaviors relating to a specific health condition, which differs from self-care that has a broader context relating to behaviors to maintain good general health.[6] A recent meta-review has identified five distinct components of self-management,[9] shown in Table 1. In terms of interventions to support self-management, a taxonomy of self-management support describes a 14-item system that classifies the components of interventions. This includes four elements: mode of delivery; personnel who deliver the support; target of the intervention; and intensity, frequency, and duration of the intervention.[6]

Within audiology, there is growing awareness of the value of digital and online methods to assess, screen, diagnose, and manage people with hearing loss.[10] Telehealth encompasses telemedicine (remote diagnosis and treatment of patients using telecommunications technology), e-health (healthcare practice that is supported by electronic processes), and m-health (delivery of healthcare by mobile technologies, such as smartphones and tablets using wireless technology). In particular, the rapid growth in the use of mobile technologies globally has seen numerous developments in m-health. Advantages include greater accessibility, interactivity, and personalization

Table 1 Core components of Self-management of Long-term Conditions (LTCs)[9]

Provision of education about the LTC
Psychological strategies to support adjustment to life with a LTC
Strategies specifically to support adherence to treatments
Practical support tailored to the specific LTC
Social support as appropriate

of e-health and m-health tools alongside delivery of tools and services at low cost,[10] all of which can lead to improvements in self-management of hearing loss. There are an increasing number of technological developments within adult aural rehabilitation, many of which are highlighted in this article, and some of which are likely to be a "game-changer" in terms of how services are delivered in the future.

EVIDENCE-BASED PRACTICE AND THE NEED FOR HIGH-QUALITY RESEARCH

Evidence-based practice in healthcare stems from evidence-based medicine that was introduced in the mid-1990s,[11] and provides an interdisciplinary approach to clinical practice. Evidence-based practice integrates individual clinical expertise, patient values, and preferences, alongside the best available clinical research evidence[12] to guide clinical decision-making and procedures. A hierarchy of evidence, core to the principle of evidence-based practice, ranks studies based on the rigor of the research methodology. Typically, expert opinion is the lowest form of evidence leading through to case studies, cohort studies, randomized controlled trials (RCTs), with systematic reviews that include meta-analyses providing the highest level of evidence.

Research evidence is more likely to have an impact on clinical practice when the evidence provided is comprehensive and of high quality, such as Cochrane systematic reviews. This is particularly true when such evidence is incorporated into national clinical guidelines. For example, in the United Kingdom, the National Institute for Health and Care Excellence (NICE) develops guidelines that provide clinical recommendations to inform decision-making in the publicly-funded National Health Service (NHS), with the aim of improving the quality of healthcare. NICE guidelines are based on a series of systematic reviews that address important research questions relating to specific clinical conditions, and also may examine cost-effectiveness. Typically, only RCTs are included to evidence clinical effectiveness. NICE guidelines on "Hearing Loss in Adults: Assessment and Management" were published in 2018.[13]

Although RCTs provide high-level evidence, they usually cannot be conducted without preliminary development and feasibility or pilot work to inform them. To do so can result in poorly defined interventions that are difficult to evaluate, and are less likely to be implemented into clinical practice. Guidance on developing and evaluating complex interventions has been provided by the United Kingdom's Medical Research Council.[14] This framework describes a process from development through to implementation that includes four main stages: (1) *development*, identification of the evidence-base, underpinning theories and process; (2) *feasibility/piloting*, testing procedures, estimating recruitment and retention, determining sample size; (3) *evaluation*, assessing effectiveness, understanding change process, assessing cost-effectiveness; and (4) *implementation*, dissemination, surveillance and monitoring, long-term follow-up. We are increasingly using this framework to develop our research program.[15,16]

THEORETICAL UNDERPINNING TO SUPPORT DEVELOPMENT OF INTERVENTIONS

Development and evaluation of an intervention based on theory is more likely to lead to an effective intervention than using an empirical or pragmatic approach.[14] A theoretical underpinning can provide an understanding of how an intervention might affect change in terms of what might be expected and achieved. Building on four decades of work in the field of health psychology, audiology has in recent years focused on some of the more popular models to understand, predict, and promote health-related behavior.[17] These include the Health Belief Model,[18] the Transtheoretical Model,[19] and the Theory of Planned Behavior[20] (for review, see the article by Coulson et al[17]).

While it has been a positive development to see these models used to guide research within audiology, there is a well-developed body of literature in the field of health psychology to suggest that these models do not, and cannot, reliably explain the variability in health behaviors.[21] To address the limitations, a new approach has been developed that has at its

core a psychological model of human behavior, the COM-B system of health behavior change.[22]

The Behavior Change Wheel is an overarching framework, specifically developed to characterize behavior change interventions and link them to the analysis of the target behavior.[22] The COM-B system forms the "hub" of the Behavior Change Wheel, with core components predicting behavior via capability, opportunity, and motivation. *Capability* is the individual's psychological and physical capacity to engage in the activity, which includes having the necessary knowledge and skills. *Opportunity* considers factors that lie outside of the individual that make the behavior possible or prompt it. *Motivation* considers brain processes that energize direct behavior, including habitual processes and emotional responses, as well as analytical decision-making. The Theoretical Domains Framework (TDF)[23] enables theoretical constructs relating to behavior change to be mapped directly to the COM-B system. The behavior change technique (BCT) taxonomy[24] enables users to specify the smallest components of interventions that can bring about behavior change. In doing so, the BCT taxonomy provides a common language by which to develop, define, and report behavior change interventions in terms of their active ingredients. Components of the Behavior Change Wheel, namely the COM-B system, TDF, and the BCT taxonomy, are being increasingly utilized in audiological rehabilitation research to improve understanding of the underpinning mechanisms of health behavior change and to theoretically inform intervention development and assessment.[25–27]

INTERVENTIONS IN ADULT AUDITORY REHABILITATIONS

The following sections discuss how the four cornerstones of adult aural rehabilitation have developed over the previous decade. In particular, we draw on our own research strategy, shown in Fig. 1. The three primary areas of research are e-health and self-management, listening devices, and listening and cognition. The areas of research are underpinned by core principles of optimal intervention, delivery methods, health behavior (primarily the COM-B system of health behavior change), and patient-centered approaches. Our research focuses primarily on adults with mild to moderate hearing loss (MMHL), which make up the largest group of those with hearing loss (92%).[28]

Figure 1 Research strategy for our mild to moderate hearing loss program. Rectangles represent the primary international research and the dark gray circles represent the underpinning principles.

SENSORY MANAGEMENT

Hearing Aids

Hearing aids are the main intervention for adults with hearing loss.[29] Based on the WHO International Classification of Functioning, Disability and Health (ICF) Core Set for Hearing Loss,[30] hearing aids reduce auditory deficits associated with body structure and function (i.e., hair cell damage). Hearing aids subsequently aim to reduce activity limitations, and ultimately aim to improve participation restrictions in an individual's everyday life.[31,32]

In 2007, Boothroyd[1] highlighted that the use of hearing aids to improve participation was "often assumed rather than confirmed." That same year, Chisolm and colleagues[32] published a landmark systematic review with a meta-analysis that aimed to address this by evaluating the published evidence on the effectiveness of hearing aids for adults with sensorineural hearing loss. The review reported on 16 studies, including RCTs and non-RCT designs. There were only two RCTs that could be included in the meta-analysis, and only one RCT that

randomized the whole participant sample.[33] The review concluded that although there were no demonstrable benefits of hearing aids to generic health-related quality of life, there was a medium to large beneficial effect to hearing-specific health-related quality of life.

In 2015, a Cochrane review on hearing aids for adults with MMHL[28] was prompted for two reasons. First, the Chisolm systematic review[32] included only studies published up until 2004; so more than a decade on, the time was right to update the published evidence. Second, in 2014 several UK NHS clinical commissioning groups were considering withdrawing the free provision of hearing aids for adults with MMHL. There was therefore a clear need to have high-quality, up-to-date evidence on the effectiveness of hearing aids in adults with MMHL to inform clinical and healthcare commissioning decision-making.

A protocol was developed following the strict guidelines laid down by the Cochrane collaboration;[34] only RCTs were included. The control groups used either no hearing aids or placebo hearing aids programmed to deliver no effective gain. The primary outcome was hearing-specific health-related quality of life, with participation as the key domain. Secondary outcomes were generic health-related quality of life and listening ability. Five RCTs were included up to March 2017 with a total of 825 participants. Data from three RCTs were included in the meta-analyses, which demonstrated that hearing aids for adults with MMHL provided (1) a large beneficial effect on hearing-specific health-related quality of life, with moderate quality evidence; (2) a small but significant beneficial effect on generic health-related quality of life, with moderate-quality evidence; and (3) a large beneficial effect on listening ability, with moderate-quality evidence (Fig. 2). There were no reports of adverse effects within any of the included RCTs, so this was rated as very-low-quality evidence.

The Cochrane review confirmed the conclusion relating to improvements in hearing-specific health-related quality of life reported by Chisolm et al,[32] and also demonstrated that hearing aids were effective in improving generic health-related quality of life and listening ability, which had not been shown previously. Importantly, the level of evidence for each outcome domain was rated as moderate (from categories of high, moderate, low, very low). This is unusual as relatively few systematic reviews report moderate or high quality evidence. The Cochrane review concluded that "hearing aids are an appropriate intervention, and the evidence is compatible with hearing aids as the first-line management option in those who seek help for hearing difficulties."[28] This Cochrane review has been used to inform the clinical evidence for the NICE guidelines on hearing loss leading to the recommendation to "Offer hearing aids to adults whose hearing loss affects their ability to communicate and hear."[13] Furthermore, a health economic analysis showed that hearing aid versus no hearing aid was cost-effective. The incremental cost-effective ratio was £4,102 GBP (~ $5,759 USD) per quality-adjusted life year (QALY) gained, falling firmly within

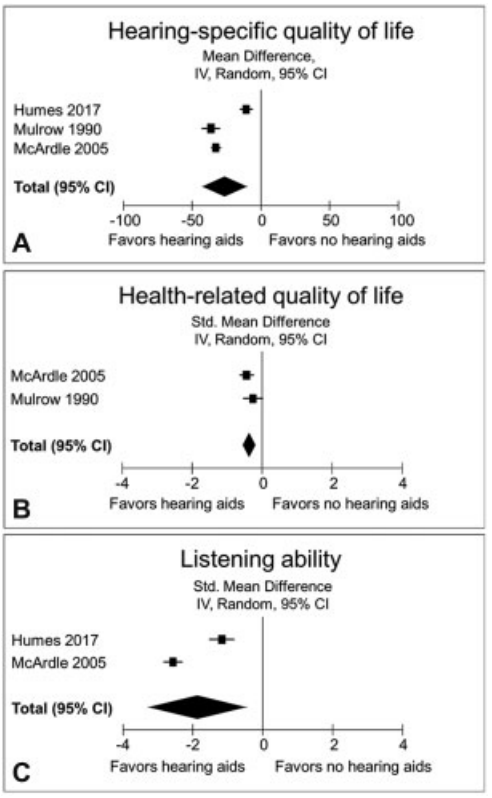

Figure 2 Forest plots of hearing aids vs. no/placebo hearing aids for (**A**) hearing-specific health-related quality of life, (**B**) health-related quality of life, and (**C**) listening ability. (Modified from the original publication[28]).

the threshold for cost-effective interventions for use within the NHS, which is set at £20,000 GBP (~ $28,076 USD) per QALY. Another recent Cochrane review,[35] which was also used to inform the NICE guidelines, reports that self-management to support hearing aid users improves participation and communication.

Alternative Devices to Hearing Aids

Despite being shown to be clinically and cost-effective,[28] the majority of people who could benefit from using hearing aids do not access them.[36–38] For those who do obtain hearing aids, estimates of nonuse range from 3 to 24%.[28] A commonly reported reason for not using hearing aids is that difficulties are still experienced when listening to and understanding speech in noisy situations.[39] In 2007, three techniques existed to address this difficulty: noise reduction, directional microphones, and remote wireless microphones. Ten years on, there has been a proliferation of technological innovations, including personal sound amplification products (PSAPs) and smartphone "hearing aid" apps that work via wired or wireless earphones. Of particular interest are hearing aids that now connect wirelessly via Bluetooth to smartphones and tablet computers. Accessibility to smartphone technologies for the typical first-time hearing aid user is steadily improving. In the United Kingdom, the over 55-year-old group is experiencing the fastest year-on-year rise in smartphone ownership than any other age group, increasing more than threefold from 19% in 2012 to 71% in 2017.[40]

Conventional hearing aid programs need to be adjusted by a trained audiologist using specialist equipment in the clinic. By comparison, smartphone-connected hearing aids can be fitted and adjusted by the audiologist remotely, without the need for the user to visit the clinic. These devices allow the user to personalize their programs, such as adjusting the gain and frequency response, via an app in any listening situation. There are also additional benefits, such as not requiring additional assistive listening devices to stream telephone conversations as the smartphone can be used as a remote microphone. These additional functionalities enable the potential for alternative service delivery models that could increase accessibility and affordability of hearing healthcare for adults, identified as a high-priority need in the United States.[41–43]

But what is the evidence for these new alternative devices compared with conventional hearing aids? We conducted a systematic review to assess the effectiveness of a range of alternative listening devices (e.g., smartphone "hearing aid" app, PSAP, hearable, smartphone-connected hearing aid, assistive listening device) based on a published protocol.[44] The review evidence showed that alternative listening devices improve speech-in-noise performance compared with unaided and/or conventional hearing aids. However, evidence for whether alternative listening devices improve hearing-specific health-related quality of life, generic health-related quality of life, and listening abilities is inconsistent. Using the Downs and Black quality assessment,[45] we rated the quality of each study as either poor, fair, good, or excellent. Current evidence in this area is poor-to-good quality and subject to bias due to limitations in the study design.[44,46] Based on the principles of evidence-based practice, we therefore recommend the need for high-quality evidence, namely RCTs, in this area.

To begin to address this, and in accordance with the UK Medical Research Council's guidance for evaluating complex healthcare interventions,[14] we have completed a mixed-methods development study to better understand how smartphone-connected listening devices operate.[16,27] The usability of smartphone-connected listening devices in their everyday lives was assessed in adults with MMHL. Results from semistructured interviews were considered in relation to the COM-B system, whereby the behavior of interest was the use of listening device to self-manage hearing loss (Table 2). All participants valued the ability to personalize and adjust their own hearing programs to meet their individual needs and preferences. In addition, users of smartphone-connected hearing aids reported that these devices were less stigmatizing and provided them with a greater sense of control, resulting in less frustration, greater participation, and greater device use.[16,27] Thus, the additional functionalities

Table 2 Summary of Key Findings Assessing the Usability of Smartphone-connected Listening Devices in Relation to the COM-B System

Smartphone-connected listening device	Capability	Opportunity	Motivation
Smartphone-connected hearing aid	✓ *Easy to use and adjust*	✓ *Improved participation*	✓ *Control and confidence*
Personal sound amplification product (PSAP)	✗ *Difficult to use and adjust*	? *Perceived sound quality mixed*	✓ *Discreet and less noticeable*
"Hearing aid" application wireless headphones	✗ *Difficult to use and adjust*	✗ *Sound delay intolerable*	? *Young and trendy*
"Hearing aid" application wired headphones	✗ *Difficult to use, adjust, and pair*	? *Helpful in quiet only*	✗ *Self-conscious*

provided by smartphone-connected hearing aids empower patients to take a more active role in managing their own hearing healthcare, which are likely to result in improved outcomes.

This work lays the foundation for a clinical trial to assess the clinical- and cost-effectiveness of smartphone-connected hearing devices, which is in line with one of the research recommendations in the NICE guidelines for hearing loss.[13,47] Furthermore, given changes in U.S. legislation concerning the Over-the-Counter Hearing Aid Act of 2017, which aims to improve accessibility and affordability to hearing healthcare, we also plan to assess smartphone-connected hearing aids in the context of self-fitting and over-the-counter (OTC) service delivery models.[43,48] We propose that smartphone-connected listening devices could complement OTC hearing aid delivery practices, allowing users to adjust and personalize their hearing aid programs to support self-management, potentially resulting in improved device benefit and satisfaction. Furthermore, we recognize that appropriate education and support will be paramount for optimal use of listening devices.

KNOWLEDGE AND SKILL

Knowledge of hearing aids and communication strategies in patients, non-audiological healthcare professionals, and the general public is poor.[49] Many first-time hearing aid users have difficulties using their hearing aids, and report they did not know or could not remember how to use them.[50] Even experienced hearing aid users have reported difficulties using their hearing aids.[51] Good-quality information is core to self-management of hearing loss,[35] and is reflected in UK national clinical guidelines (e.g., NICE, BSA).[13,52]

Since 2007, there have been several developments providing better information and education for hearing aid users, such as communication programs,[53] modified hearing aid user guides,[54,55] and educational programs delivered by telephone[56] or the Internet.[57] In terms of delivery, a Cochrane review[58] found that multimedia education about medication delivered via DVD/PC was more effective than traditional education alone (oral/written instructions) at increasing knowledge and skills around medication use. We have developed a multimedia educational program (C2Hear) that contains a series of interactive video tutorials (or reusable learning objects RLOs). C2Hear was developed using a participatory approach involving hearing aid users and hearing healthcare professionals to ensure it meets the needs of the end-users.[59] C2Hear is underpinned by learning theory that posits that learning is greatest when the learner actively engages with the educational materials.[60] RLOs include (1) visual illustration of concepts, (2) activity and engagement with content, and (3) self-assessment.[61]

C2Hear was evaluated in a high-quality RCT of 203 first-time hearing aid users.[15,62] The RLOs were delivered by DVD for TV (15.2%) or PC (50.6%), or via the Internet

(32.9%), and were shown to be effective across a range of measures. Post-fitting, there was significantly greater hearing aid use (15%) for those who did not wear their hearing aids all the time in the RLO+ group compared with controls. There was significantly better knowledge of practical and psychosocial issues, and significantly better practical hearing aid skills, in the RLO+ group, with large clinical effect sizes (ES = 0.83–0.94). The RLOs were rated as highly useful (9/10, where 0 = not useful, 10 = highly useful). The majority agreed the RLOs helped their understanding (97%), held their interest (92%), would be referred to if they had problems with hearing aids (88%), were preferable to written information (83%), and improved confidence (81%). A health economic analysis showed that the RLOs were a cost-effective intervention. Take-up and adherence of RLOs was high (78 and 97%, respectively), and half of the participants watched the RLOs two or more times, suggesting self-management of hearing aids and communication. The Cochrane review on self-management of hearing loss[35] highlighted that this was the only intervention shown to encourage the use of hearing aids.

The early DVD-based platform limited user interactivity and provided a one-size fits all solution. Due to the rapid increase in use of smartphone technologies in the over 55-year-old group,[40] we have since repurposed and developed the C2Hear RLOs for delivery through smartphone technologies, known as m2Hear. These repurposed RLOs, termed "mobile-enabled RLOs (mRLOs)," were developed to be delivered via a custom-built web-based platform. The original RLOs have been split into short segments and grouped into relevant short approximately 1- to 2-minute mRLOs using the TDF, and mapped to components of the COM-B system in terms of which aspects of health behavior they target for change. The web-based platform enables increased individualization, interactivity, and inclusivity. Individualization meets the personal needs of the user, enabling them to directly select the information that they need and that is relevant to them. Greater interactivity is supported by building in activities within the app to better engage the user and facilitate learning. Involving communication partners (CPs) in the learning process leads to greater inclusivity.

A study to assess the communication tactics RLO after it had been reworded for the general public rather than patients, and further modified for a web-based platform, showed interesting findings when the mRLO was used jointly by both hearing aid users and a CP. The hearing aid users found the mRLO useful in highlighting their own communication challenges to CPs. In the context of joint working, the mRLO resulted in novel discussions between CPs and the hearing aid user about communication in challenging situations, and prompted CPs to change their behavior to help improve communication.[63] C2Hear has been used with non-audiological healthcare professionals, such as residential care home assistants and nurses.[64] Results showed increased learning and practical skills relating to hearing aids and communication. Finally, an RCT that investigated the early delivery of C2Hear at the assessment rather than fitting appointment showed a significant increase in hearing aid self-efficacy in those who received C2Hear rather than the standard hearing aid booklet.[65]

The final stage of the Medical Research Council's guidelines for developing and evaluating complex interventions[14] focuses on dissemination. This is not just about academic publications and presentations, but about taking research findings into healthcare. In late 2015, the C2Hear RLOs were further refined and placed on YouTube, named C2Hear Online (www.youtube.com/C2HearOnline). There was a fourfold increase in unique views in the second year of release, and the total number of views has exceeded 150,000 views across more than 50 countries. C2Hear has been developed for the U.S. audience, and a Chinese version is under development. Further work is ongoing with specialists in implementation science within the United Kingdom to implement the C2Hear RLOs into routine clinical practice.

AUDITORY AND COGNITIVE TRAINING

In 2007, Boothroyd stated that the goal of perceptual (auditory or audiovisual) training

was not to target function, but rather to make better use of that function through enhancement of perceptual skill.[1] Yet at that time, the degree of generalizable benefit to real-world communication skills was not always clear, and carryover to participation and quality of life was typically "assumed rather than measured."

Although hearing aids are effective,[28] users often face disproportionate difficulties in challenging everyday situations, such as listening to speech in background noise.[66] Listening to speech in noise relies not only on peripheral hearing ability, but also on central auditory processing and cognition.[67] Computer-delivered auditory training is a low-cost self-management intervention that can be tailored and made widely available to individuals online at home and via smartphone technologies. Thus, auditory training interventions can provide additional support for hearing aid users without the need for clinical appointment time, and increasing access to those who do not or cannot access hearing healthcare. Effectiveness of auditory training can be assessed by measuring (1) improvements in performance for the trained auditory task(s) (on-task learning) and (2) generalized improvements in untrained tasks (transfer of learning), which can occur on a continuum from near to far transfer depending on the degree of overlap with tasks that are trained. For auditory training to be a successful intervention for people with hearing loss, any on-task learning must be generalized to functional benefits in their everyday listening.

In 2013, we published a systematic review of the literature assessing benefits of computer-based auditory training for adults with hearing loss,[68] which showed robust evidence for improvements in performance for trained auditory tasks. However, transfer of learning to improvements in untrained outcomes of speech perception, cognition, and self-reported activity and participation (thus evidence for real-world benefits that extend beyond the trained tasks) was highly variable. The published evidence was shown to be of very low to moderate study quality, highlighting the need for further high-quality research. Since this review was published, there has been a steady growth in auditory training research including some high-quality RCTs.[69–71] We are currently updating our systematic review to include the evidence and meta-analyze data published since 2013.[72]

Our own research examining home-delivered auditory and cognitive training interventions for people with hearing loss and hearing aid users builds on basic principles of neuroplasticity[73] and perceptual learning[74] to generate high-quality evidence (Table 3). First, we examined the benefits of a 4-week phoneme discrimination training program in an RCT of 44 adults with mild hearing loss who did not use hearing aids.[71] Results showed significant posttraining improvements for untrained measures of self-reported hearing and cognition, in particular those that index executive function, with moderate effect sizes (group conversation, $d = 0.68$; divided attention, $d = 0.53$; working memory updating, $d = 0.50$). Executive function relates to the cognitive control processes that enable us to achieve goals and get things done, for example, attentional control, working memory, and inhibition.[75] Adherence to training was high (80% completed the requested training duration, with no dropouts); therefore, we examined participants' motivations to train using self-determination theory[76] as an analysis framework. Self-determination theory is an approach to motivation concerned with supporting people's natural tendencies to behave in effective and healthy ways.[76] Results showed that engagement and adherence to training was influenced by both intrinsic (e.g., a desire to achieve higher scores on the training task) and extrinsic motivation (e.g., their hearing difficulties).[77]

In a second study, we further examined the benefits of phoneme discrimination training in a 1-week repeated measures study of existing hearing aid users with MMHL, using a battery of complex speech and cognitive outcomes. Results showed significant post-training improvements for a cognitively demanding listening task (competing speech) of 2.3 dB signal-to-noise ratio (SNR) with a moderate effect size ($d = 0.47$) and improvements for a dual-task of listening and memory at a challenging SNR (0 dB SNR) with a moderate to large effect size ($d = 0.77$), following just 3.5 hours of training.[78]

In a third study, we asked whether training cognition directly could offer greater improvements to hearing aid user's real-world listening[79]

Table 3 Overview of our Auditory and Cognitive Training Research Studies

Reference	Study design	Sample size	Participants	Training task	On-task learning?	Transfer to improvements in untrained measures of speech perception?		Transfer to improvements in untrained measures of cognition?	
						Simple	Complex	Simple	Complex
Ferguson et al[71]	RCT	44	Adults with mild hearing loss	Phoneme discrimination in quiet	✓	✗	✓ *Self-report: complex (group) listening*	✗	✓ *Divided attention, working memory updating*
Henshaw and Ferguson[78]	Repeated measures	30	Adult hearing aid users with mild-moderate hearing loss	Phoneme discrimination in noise (multitalker babble)	✓	*Not assessed*	✓ *Competing speech*	*Not assessed*	✓ *Dual-task (listening and memory)*
Henshaw and Ferguson[79]	RCT	57	Adult hearing aid users with mild-moderate hearing loss	Cogmed working memory training	✓	✗	✗	✗	✗

using Cogmed working memory training. Cogmed is a series of 12 adaptive tasks of visual and verbal working memory that has previously been reported to result in improved sentence repetition skills in a pilot study of children with cochlear implants.[80] The RCT of 62 existing hearing aid users with MMHL allocated participants to either an adaptive Cogmed training or to a nonadaptive version of the same training protocol (active control). Results showed that although performance improved significantly for the trained visual and verbal working memory tasks, this type of learning did not result in transfer to generalized improvements in complex speech perception or cognitive outcomes shown for our previous auditory training studies. As such, it may be critical to train the executive underpinnings of successful speech understanding in context.[81] Indeed, published generalized benefits have been shown to be greatest for training programs that use combined auditory–cognitive training tasks.[70,82–84]

Our current research aims to improve real-world listening by training cognition embedded within task-relevant (speech) stimuli using two purpose-designed auditory–cognitive training programs. In line with the UK Medical Research Council guidance for the development and assessment of complex interventions,[14] we will first assess the feasibility of a large-scale clinical trial, then, if feasible, run that trial to examine the benefits of providing auditory–cognitive training alongside hearing aids for new patients within the UK NHS.

MOTIVATIONAL ENGAGEMENT

Evidence in other healthcare disciplines has shown that motivational engagement benefits patients in areas such as smoking cessation, alcohol addiction, and drug rehabilitation programs.[85–87] More recently, motivational engagement has been used to enable people with hearing loss to take an active role in their management and to express their needs and preferences. The Ida Institute has developed motivation tools (line, box, and circle) to facilitate collaborative interactions between the audiologist and the patient. These tools are based on the theoretical principles underlying the Transtheoretical Model.[19]

The motivation tools are specifically designed to guide the audiologist to identify where the patient lies within the rehabilitation process so that they can better support, engage, and coach patients during appointments. The tools are intended to open a dialogue to facilitate shared decision making, identify individual needs, set joint goals, and support self-management—all of which are guiding principles of adult rehabilitation.[52]

In collaboration with the Ida Institute, we have developed an ethnographic video of how to use the motivation tools in clinic (https://youtu.be/-SK53u6RHZE). In addition, we have conducted a feasibility study based on a quasi-RCT design in 68 first-time hearing aid users to establish how the tools can be used in UK NHS audiology clinics, and how effective they are.[88] The study showed that the tools could be successfully incorporated into the UK audiology clinic structure. Audiologists who used the tools were positive about their use, and reported that when the tools were used in the assessment appointment they appeared to tap into patient's needs and motivations more readily than the standard clinical history. Furthermore, the tools promoted more patient-centered discussions allowing patients to better express their needs.

The feasibility study also showed that the patients reported several benefits at the hearing assessment and fitting appointments compared with a "standard care" control group. These included greater self-efficacy and readiness to follow the recommendations of their audiologist, reduced anxiety levels, and higher levels of shared decision making. Furthermore, across this and another study, self-efficacy, readiness, and positive expectations predicted satisfaction with hearing aids when measured 6 to 10 weeks post–hearing aid fitting.[89]

A limitation of the motivational engagement study was that the tools were used only in patients who had already opted to receive hearing aids. Therefore, we are currently running an RCT to assess the effectiveness of the Ida Institute's online-delivered "Why Improve my Hearing" telecare tool. The telecare tool incorporates the motivation line tool, asking the patient "How important is it to improve your hearing." In the RCT, patients complete the telecare tool before their initial hearing assessment appointment. The telecare tool encourages the patient to think about how and why improving their hearing in different situations could affect their daily life. Encouraging patients to use the telecare tool and reflect on their individual needs before they come to clinic could save time during the appointment. Further, the telecare tool could also result in the patient being better prepared ahead of time to work with the audiologist on matters that are important and relevant to them.

OUTCOME MEASUREMENT

Several important factors must be considered when selecting outcome measures to assess the effectiveness of an intervention. In particular, it is essential to choose measures that are representative of the goals of the intervention.[1] For example, a self-report measure may be more appropriate than a laboratory speech perception test where the goal is to improve communication in daily life.[1,90] It is also important to select measures that have the ability to detect the benefits of the intervention.

Our previous research aimed to identify optimal tests (e.g., dual task of listening and memory) for assessing the impact of auditory training on speech perception.[78,81] The results suggested that tests that are sufficiently challenging (i.e., not too easy and not too difficult) in terms of listening and cognition may be better able to detect the benefits of auditory training. However, our data also showed that as the complexity of outcomes increased, test–retest reliability of the measures decreased.[91] It is therefore important to be mindful of this issue in outcome selection.

In addition, it is crucial to utilize high-quality outcome measures. Ideally, measures should be developed through a series of methodologically sound qualitative and quantitative studies.[92,93] The resultant instruments should possess measurement properties (e.g., reliability, responsiveness) that meet the required standards.[94] Currently, there is a lack of recognized, gold-standard, hearing-specific outcome measures.[95,96] Consequently, recent research has set out to improve the quality of hearing-specific measures.[96,97] In line with this, we used best practice techniques to develop a hearing-

specific measure: the Social Participation Restrictions Questionnaire (SPaRQ). These techniques included (1) semistructured interviews with patients, clinicians, and researchers to generate items;[98] (2) cognitive interviews with patients to assess content validity;[99] and (3) Rasch analysis to assess psychometric properties.[100] The resultant SPaRQ consisted of a 10-item social perceptions subscale (e.g., feeling isolated is a group) and a 9-item social behaviors subscale (e.g., participating in group conversations). Each subscale had strong measurement properties, including internal consistency and construct validity.

Finally, it is vital to select outcome measures that assess outcome domains (e.g., quality of life, communication) that are valued by key stakeholders (e.g., patients, clinicians, funders, and policy-makers) to enhance the relevance, utility, and impact of research.[101] Accordingly, Core Outcome Sets (COSs) are being developed for numerous health conditions, including tinnitus and conductive hearing loss.[102,103] A COS is a shortlist of outcome domains for a condition that key stakeholders agree are critically important measure as a minimum requirement in research and/or practice.[101] Recently, there have been calls to develop a COS for sensorineural hearing loss.[28,35] At present, there is considerable heterogeneity in outcome measurement in sensorineural hearing loss research. For example, a systematic review demonstrated that 51 different questionnaires were used in 122 adult hearing loss studies.[95] This heterogeneity impedes the comparison of the results of different trials and the synthesis of evidence in systematic reviews, as well as increases the risk of outcome reporting bias.[101] Therefore, the quality and credibility of sensorineural hearing loss research would be enhanced by greater standardization in outcome measurement.

CONCLUSIONS

Just over a decade on from the seminal discussion article of Boothroyd,[1] there have been considerable advances in research that has examined the four cornerstones of adult aural: hearing aids and other listening devices, knowledge and skill, auditory and cognitive training, and motivational engagement. These interventions aim to improve auditory function, activity, participation, and quality of life for adults with hearing loss. Self-management and behavior change is core to all these interventions to promote patient-centered approaches. The consistent use of appropriate outcomes to assess benefits of adult aural rehabilitation is paramount for high-quality research. There has been publication of increasingly higher quality of evidence to support adult aural rehabilitation interventions, and a greater use of theory underpinning the research (see Table 4). Finally, the technological advances over the last decade see the interventions

Table 4 Evidence and Underlying Theory Supporting the Effectiveness of Four Adult Aural Rehabilitation Processes

Process	Evidence			
	High-quality research		Underpinned by theory	
	Y/N	Evidence	Y/N	Theory
Sensory management: hearing aids and alternative devices	Y	Hearing aids: Cochrane review of RCTs[28] Alternative devices: systematic review[46]	Y	WHO ICF framework
Instruction: knowledge and skill	Y	Cochrane review of self-management options[35] RCT of effectiveness of C2Hear[15]	Y	Learning theory COM-B system
Perceptual training: auditory and cognitive training	Y	Systematic review of computerized auditory training studies[68] RCT of phoneme discrimination training[74]	Y	Neuroplasticity
Counseling: motivational engagement	?Y	Feasibility study with intervention and control groups[88]	Y	Transtheoretical model

described here, which are increasingly being delivered through a range of online and smartphone technologies, as providing opportunities for greater self-managment of hearing loss. With the rapid rate of developments in technology providing novel opportunities within hearing science and adult aural rehabilitation, we ask what will the next decade bring?

CONFLICTS OF INTEREST AND SOURCE OF FUNDING

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