American Journal
of Speech-Language
Pathology

Computer and internet interventions to optimise listening and learning for people with hearing loss: accessibility, use and adherence

SCHOLARONE™
Manuscripts

1 **Computer and internet interventions to optimise listening and learning for people with**
2 **hearing loss: accessibility, use and adherence**

3 Melanie Ferguson PhD[1], Helen Henshaw PhD[2]

4

5 [1]NIHR Nottingham Hearing Biomedical Research Unit, Nottingham University Hospitals
6 NHS Trust, Nottingham UK
7 [2]NIHR Nottingham Hearing Biomedical Research Unit, Otology and Hearing Research
8 Group, Division on Clinical Neuroscience, University of Nottingham UK
9

10 Corresponding author:
11 Melanie Ferguson
12 NIHR Nottingham Hearing Biomedical Research Unit
13 113 The Ropewalk
14 Nottingham, UK
15 NG1 5DU
16

17 Tel: (+44)115 8232619
18 Fax: (+44)115 8232615
19

20 Email: melanie.ferguson@nottingham.ac.uk
21

22 .

23

24 **Abstract**

25 Purpose: To examine accessibility, use and adherence to computerised and online

26 interventions for people with hearing loss.

27 Method: Four intervention studies of people with hearing loss were examined: two auditory

28 training studies, one working memory training study, and one study of multimedia

29 educational support.

30 Results: A small proportion (~15%) of participants had never used a computer, which may be

31 a barrier to the accessibility of computer and internet-based interventions. Computer

32 competence was not a factor in intervention use or adherence. Computer skills and internet

33 access influenced participant preference for the delivery method of the multimedia

34 educational support programme.

35 Conclusions: It is important to be aware of current barriers to computer and internet-delivered

36 interventions for people with hearing loss. However, there is a clear need to develop and

37 future-proof hearing-related applications for online delivery.

38

Introduction

There is an ever increasing use of personal computers and the internet to provide healthcare

and health-related information (Brouwer et al., 2011), and hearing healthcare is no exception.

Telehealth applications in audiology, or tele-audiology, include hearing screening (Smits,

Merkus, & Houtgast, 2006; Swanepoel, Myburgh, Howe, Mahomed, & Eikelboom, 2014),

diagnosis (Krumm, Ribera, & Klich, 2007), and interventions such as auditory training

(Ferguson, Henshaw, Clark, & Moore, 2014; Sweetow & Henderson Sabes, 2006),

counselling (Laplante-Lévesque, Pichora-Fuller, & Gagné, 2006; Lundberg, Andersson, &

Lunner, 2011) and patient education (Ferguson, Brandreth, Leighton, Brassington, &

Wharrad, In Review; Thorén, Öberg, Wänström, Andersson, & Lunner, 2013). Advantages of

tele-audiology include improved time-, clinical- and cost-effectiveness, and increased

accessibility to healthcare (Fabry, 2010), with the added advantage of being delivered

remotely in patients' homes (Ferguson et al., 2014; Henshaw & Ferguson, 2013). A

systematic review of peer-reviewed articles concluded that tele-audiology provided the

potential to extend services beyond the audiology clinic, in particular to under-served

communities and those with poor accessibility to audiology services (Swanepoel & Hall,

2010).

Typically, discussions on accessibility of hearing healthcare and the benefits of tele-

audiology focus on remote and rural communities in underdeveloped and developing

countries, as well as those countries with large geographic distances, such as Australia.

However, issues accessing hearing services are not limited to these countries, they are also

relevant to smaller, developed countries, such as the UK (Ferguson, 2012). Firstly, it is

estimated that only one in three people in the UK who would benefit from a hearing aid have

one (AoHL, 2014). Secondly, many hearing aid users have significant hearing difficulties for

at least ten years before they receive hearing aids (Davis, Smith, Ferguson, Stephens, &

64   Gianopoulos, 2007). Thirdly, there is a failure of family doctors to refer those in the pre-

65   typical hearing aid age group to audiology services. Just under half (47%) of those with a

66   significant hearing loss in the 55-74 year age group who went to their general practitioner

67   with complaints of hearing loss failed to get an onward referral to audiology services (Davis,

68   et al., 2007). Finally, two-thirds of the 10 million people with hearing loss in the UK are over

69   the age of 65 years. Tele-audiology can only be effective if it is accessible, used and adhered

70   to by the target population.

71   In the case of existing hearing aid users, it is important to be mindful of the skill set required

72   to access personal computers (PCs), the internet, and mobile technologies without which

73   access to tele-audiology solutions can be limited. We carried out a study of 50-74 year olds

74   (n=1298) and showed significant effects of age, gender and socioeconomic status (SES) on

75   PC and internet use, with poorer use seen in older people, women, and those with lower SES

76   (Henshaw, Clark, Kang, & Ferguson, 2012). PC and internet use in the youngest group (50-

77   54 years) was 85% and 36% respectively but was significantly lower in the oldest group (70-

78   74 years) at 36% and 17%. These differences were consistent with other reports (Seybert &

79   Lööf, 2010; Thoren, Öberg, Wänström, Andersson, & Lunner, 2013). Current data on internet

80   use shows a year-on-year increase in 55-74 year olds (2010 =61%, 2012 = 70%, 2014 =

81   78%), suggesting teleaudiology will become more prevalent in this age group (UNECE,

82   2015) over the coming years.

83   There has been little published on the effect of hearing loss on PC and internet use in older

84   adults. In our study of PC and internet use (Henshaw et al., 2012), use was greater for those

85   aged 63-74 years with slight hearing difficulties than those reporting no difficulties, although

86   those with moderate hearing difficulties showed less use. This suggests that potential uses of

87   tele-audiology in this age group, including early intervention such as auditory training,

88 provision of education and support, and hearing screening, may be best served for those with

89 milder hearing losses prior to obtaining hearing aids.

90 The main aim of this investigation was to examine accessibility, use and adherence with three

91 different home-delivered interventions in older adults with hearing loss who had a broad

92 range of computer skills.

Methods

94 Four studies are presented and assessed: two adaptive computerised auditory training with a

95 control period (AT); computerised working memory training (WMT) with two arms,

96 adaptive training and an active control (i.e. span stimuli were fixed at three items);

97 multimedia educational support (MES) using reusable learning objects (RLOs), which are

98 chunks of interactive multimedia learning, containing highly visual components to illustrate

99 concepts and processes, in this case hearing aids and communication strategies (Windle &

100 Wharrad, 2010). In addition, preference for the delivery mode of the MES is reported.

101 Outline details of the studies and participants included in this investigation are shown in

102 Table 1. Participants were recruited and took part in in only one study. The studies and the

103 results are described in more detail elsewhere (AT1, Ferguson et al., 2014; AT2, Henshaw &

104 Ferguson, 2014; WMT, Henshaw & Ferguson, 2013; MES, Ferguson et al., in review). Three

105 studies (AT1, AT2, MES) showed positive results, with at least moderate effect sizes. The

106 WMT results are currently unpublished.

107 Computer skills were rated by participants on a validated three-category scale (Never used a

108 computer, Beginner or Competent, see Henshaw et al., 2012). The percentage of participants

109 in each category provides a measure of accessibility in terms of PC skills (Table 1). For the

110 auditory training studies, the training program was demonstrated to the participants on a

111 laptop, which was then loaned for use at home. Use was reported as the mean training

5

112 duration in minutes. Adherence was reported as percentage of total requested time on task

113 achieved, which was 360 and 210 minutes for AT1 and AT2 respectively. The working

114 memory training program was delivered online. Use was reported as the number of sessions

115 completed (35-45 minutes each), and adherence was reported as the percentage of

116 participants who completed all 25 sessions as requested. For all training intervention studies,

117 participants received a weekly telephone call from a researcher to monitor technical and

118 procedural issues. For the education study, participants were offered the choice of delivery

119 based on accessibility in their homes (DVD for TV or PC, or via the internet). Participants

120 were requested to watch each of the seven RLOs, and use was measured as the mean number

121 of RLOs watched. Adherence was the percentage who attended the six-week evaluation

122 session and watched all seven RLOs at least once.

123 **Results**

124 Accessibility, use and adherence results are shown in Table 1.

125 *Auditory training.* There was a broadly similar mix of computer skills across both studies,

126 with the Never category having the fewest participants (~15%). There was no significant

127 difference in use across categories (p > .05), suggesting that PC competence did not influence

128 the use of auditory training. Adherence was generally high, with no drop-outs for either

129 study. Adherence was similar for all categories in AT1 and not significant (p>.05).

130 *Working memory training.* All users were required to have internet access at home in order to

131 participate in the study, so by definition this intervention was not accessible to those without

132 internet access. There were twice as many Competent users as Beginners. Use was similar for

133 each category. Adherence was lower in the Competent users, but this was not significant (p >

134 .05). There were however more drop outs for adaptive training (n=4) than for active-control

6

135   training (n=1), which may reflect the highly challenging nature of this type of training

136   intervention. Further examination of the effects of motivations and gameplay are required.

137   *Multimedia educational support.* The Never category had the smallest number of

138   participants, similar to the auditory training studies. However, there were twice as many

139   Competent users than Beginners, not seen in the auditory training studies. This may be

140   because the MES study was carried out a few years later and so reflects the trend of increased

141   PC and internet use over time (see UNECE, 2015). Despite a range of delivery modes, 21%

142   of the patients were excluded from participating in the study because they did not have access

143   to a DVD player, PC or internet. Use of the MES was greatest in the Never category, which

144   watched more RLOs than the Beginners or Competent users, although this difference was not

145   statistically significant (p > .05). Eight people watched 21+ RLOs (i.e. each RLO more than

146   three times), and when they were excluded the mean number of RLOs watched was 9.7, 10.0

147   and 10.8 for Never, Beginner and Competent respectively. Adherence was very high, with no

148   effect of PC skill. For choice of delivery, not surprisingly, all the Never category chose DVD

149   for TV, as did most of the Beginners, with only a low number (11%) opting for internet

150   delivery. The majority of Competent users (60%) opted for internet delivery, with three-

151   quarters choosing a PC-based option. Even so, a quarter of Competent users chose DVD for

152   TV, although the reasons for this are not known.

153   **Discussion and Conclusion**

154   We have examined accessibility, use and adherence to three types of interventions for people

155   with hearing loss who have a range of computer skills. Accessibility is an inherent barrier to

156   interventions if either the person does not have either access to the hardware (e.g. DVD

157   player, PC or internet) or have the skills to use it. However, only a relatively small proportion

158   of the participants (~15%) had never used a computer. As our study participants were on

159   average younger than the typical first-time hearing aid user (74 years, Davis et al, 2007),

160   accessibility is likely to be lower in a typical (older) UK hearing aid clinic sample.

161   Nevertheless, access to IT and mobile technologies for the over-55s is increasing, and will

162   continue to increase over the coming years (Deloitte, 2014). There was no evidence that PC

163   skill was a factor in either use or adherence with these interventions. It is possible that other

164   factors, such as individuals' extrinsic and intrinsic motivations to use these interventions, are

165   influential (Henshaw, McCormack, & Ferguson, In press). In conclusion, the potential for

166   online applications to reach many people with hearing loss who cannot or will not access

167   conventional audiology services is substantial. Although there are currently some barriers to

168   internet access for a proportion of people with hearing loss, there is a clear need to develop

169   and future-proof internet-delivered applications.

170   **Acknowledgments**

Table 1. Study and participant characteristics. Percentage, mean use and mean adherence of three categories of computer skills (Never, Beginner, Competent). BEA= better ear average, HA = hearing aid, RLOs = reusable learning objects, TV=television, PC-personal computer, Web=internet

	Auditory training 1			Auditory training 2			Working memory training			Multimedia educational support					
Study type	RCT			Repeated measures			RCT			RCT					
Intervention	Phoneme discrimination in quiet			Phoneme discrimination in noise			Verbal and Visuospatial working memory and storage tasks			Reusable learning objects					
Intervention duration	360 minutes (6 hours) across 4 weeks			210 minutes (3.5 hours) across 1 week			25 sessions (approx.. 16.5 hours) across 5 weeks			7 RLOs = 58.7 minutes across 6 weeks					
n participants (n females)	44 (15)			30 (10)			57 (30)			100 (41)					
Participants (source of recruitment)	Non-HA users (general practitioner)			Existing HA users (volunteer database)			Existing HA users (volunteer database)			First-time HA users (audiology service)					
Age mean(SD), range in years	65.3 (5.7), 53-74			67.4 (7.1), 50-74			64.0 (6.0), 50-74			68.8 (9.2), 42-87					
Mean $BEA_{0.5-4kHz}$ (SD) dB HL	32.5 (6.0)			43.8 (13.4)			42.6 (13.88)			35.8 (9.0)					
Data collection period	2009- 2011			2011-2012			2012-2014			2012-2013					
	%	Use (mins)	Adherence (%)	%	Use (mins)	Adherence (%)	%	Use (sessions)	Adherence (%)	%	Choice of delivery (%)			Use (RLO's watched)	Adherence (%)
											TV	PC	Web		
Never	15.9	379	105%	13.3	193	92	0	-	-	16.2	100	0	0	17.3	100
Beginner	45.5	378	105%	40.0	193	92	33.3	25.0	100	27.2	62	27	11	12.4	95
Competent	38.6	380	106%	46.7	203	97	66.7	23.3	87	56.6	24	16	60	11.9	96

References

Action on Hearing Loss. (2014). Statistics about Deafness and Hearing. Retrieved 26th
November 2014. http://www.actiononhearingloss.org.uk/your-hearing/about-
deafness-and-hearing-loss/statistics.aspx.

Brouwer, W., Kroeze, W., Crutzen, R., de Nooijer, J., de Vries, N. K., Brug, J., & Oenema,
A. (2011). Which intervention characteristics are related to more exposure to internet-
delivered healthy lifestyle promotion interventions? A systematic review. *Journal of
Medical Internet Research, 13*(1), e22.

Davis, A., Smith, P., Ferguson, M., Stephens, D., & Gianopoulos, I. (2007). Acceptability,
benefit and costs of early screening for hearing disability: a study of potential
screening tests and models. *Health Technology Assessment, 11*(42), 1-294.

Deloitte. (2014). The smartphone generation gap: over 55? There's no app for that. Retrieved
10th December 2014, from
http://www2.deloitte.com/content/dam/Deloitte/global/Documents/Technology-
Media-Telecommunications/gx-tmt-2014prediction-smartphone.pdf

Fabry, D. (2010). Applications of telehealth for hearing care. *Audiology Today, Sep*, 18-25.

Ferguson, M. (2012). Delivery of hearing healthcare and education using the internet. *ENT
and Audiology News, 21*(3), 68-69.

Ferguson, M., Brandreth, M., Leighton, P., Brassington, W., & Wharrad, H. (in review). A
randomised controlled trial to evaluate the benefits of a multimedia educational
programme for first-time hearing aid users. *Ear and Hearing*.

Ferguson, M. A., Henshaw, H., Clark, D. P., & Moore, D. R. (2014). Benefits of phoneme
discrimination training in a randomized controlled trial of 50-to 74-year-olds with
mild hearing loss. *Ear and Hearing, 35*, e11-e121.

Henshaw, H., Clark, D., Kang, S., & Ferguson, M. (2012). Computer skills and internet use in adults aged 50-74 years: influence of hearing difficulties. *Journal of Medical Internet Research, 14*(4), e113.

Henshaw, H., & Ferguson, M. (2013). Working memory training for adult hearing aid users: study protocol for a double-blind randomized active controlled trial. *Trials, 14*(417), 1-10.

Henshaw, H., McCormack, A., & Ferguson, M. A. (In press). Intrinsic and extrinsic motivation drives computer-based auditory training uptake, engagement, and adherence for people with hearing loss. *Frontiers in Auditory Cognitive Neuroscience*.

Krumm, M., Ribera, J., & Klich, R. (2007). Providing basic hearing tests using remote computing technology. *Journal of Telemedicine and Telecare, 13*(8), 406-410.

Laplante-Lévesque, A., Pichora-Fuller, M. K., & Gagné, J.-P. (2006). Providing an internet-based audiological counselling programme to new hearing aid users: A qualitative study. *International Journal of Audiology, 45*(12), 697-706.

Lundberg, M., Andersson, G., & Lunner, T. (2011). A randomized, controlled trial of the short-term effects of complementing an educational program for hearing aid users with telephone consultations. *Journal of the American Academy of Audiology, 22*(10), 654-662.

Seybert, H., & Lööf, A. (2010). Internet usage in 2010 - households and individuals. *Data in Focus, 50*, 2010.

Smits, C., Merkus, P., & Houtgast, T. (2006). How we do it: The Dutch functional hearing–screening tests by telephone and internet. *Clinical Otolaryngology, 31*(5), 436-440.

Swanepoel, D. W., & Hall, J. W. (2010). A systematic review of telehealth applications in audiology. *Telemedicine Journal and e-Health, 16*(2), 181-200.

Swanepoel, D. W., Myburgh, H. C., Howe, D. M., Mahomed, F., & Eikelboom, R. H. (2014).

Smartphone hearing screening with integrated quality control and data management.

International Journal of Audiology, Early Online, 1-9.

Sweetow, R. W., & Henderson Sabes, J. (2006). The need for and development of an

adaptive listening and communication enhancement (LACETM) program. *Journal of

the American Academy of Audiology, 17*(8), 538-558.

Thorén, E. S., Öberg, M., Wänström, G., Andersson, G., & Lunner, T. (2013). Internet access

and use in adults with hearing loss. *Journal of Medical Internet Research, 15*(5), e91.

Thorén, E. S., Öberg, M., Wänström, G., Andersson, G., & Lunner, T. (2013). A randomized

controlled trial evaluating the effects of online rehabilitative intervention for adult

hearing-aid users. *International Journal of Audiology*, *53(7),* 452-461.

UNECE (United Economic Commission for Europe) Statistical Database: Percentage of

populaiton using internet by age, sex, variable, countyr and year.

http://w3.unece.org/pxweb/dialog/Saveshow.asp?lang=1. Accessed 1st April 2015.