Effects of hearing impairment and hearing aid amplification on listening effort – a systematic review

Authors

Barbara Ohlenforst[1,4]
Adriana A. Zekveld[1,2,3]
Elise P. Jansma[6]
Yang Wang[1,4]
Graham Naylor[7]
Artur Lorens[8]
Thomas Lunner[3,4,5]
Sophia E. Kramer[1]

Contact

Barbara Ohlenforst
baoh@eriksholm.com

Background

Hearing impairment negatively affects speech perception and may increase listening effort, especially under adverse conditions such as in the presence of background noise. Previous research showed that hearing-aid amplification improves speech perception performance. However, it is still not clear how hearing-impairment and hearing-aid amplification affect effort during speech perception. This systematic review addressed the following research questions:

Q1: Is speech comprehension more effortful for hearing-impaired than for normal-hearing listeners?

Q2: Can hearing aid amplification reduce listening effort during speech comprehension?

Method

Inclusion criteria and search:

The Population, Intervention, Control, Outcomes and Study design (PICOS)[9] strategy was used to create inclusion criteria for relevance. To be included in the review, studies had to meet the following selection criteria of:

- experimental work on hearing impairment OR
- hearing aid technologies AND
- listening effort OR
- fatigue during speech perception
- published in peer reviewed journals in English language

The methods applied in those articles were categorized into subjective, behavioral and physiological assessment of listening effort. For each study, the statistical analysis addressing research question Q1 and/or Q2 was extracted.

Analysis:

The statistical results from each included study were categorized according to Q1 and Q2 as 'more effort' (+), 'equal effort' (=) or 'less effort' (-). The total number of signs were counted and a one-sided (directional) Sign-test and the standard binomial test were used to calculate significance (Tables 1, 2) for each outcome on Q1 and Q2.

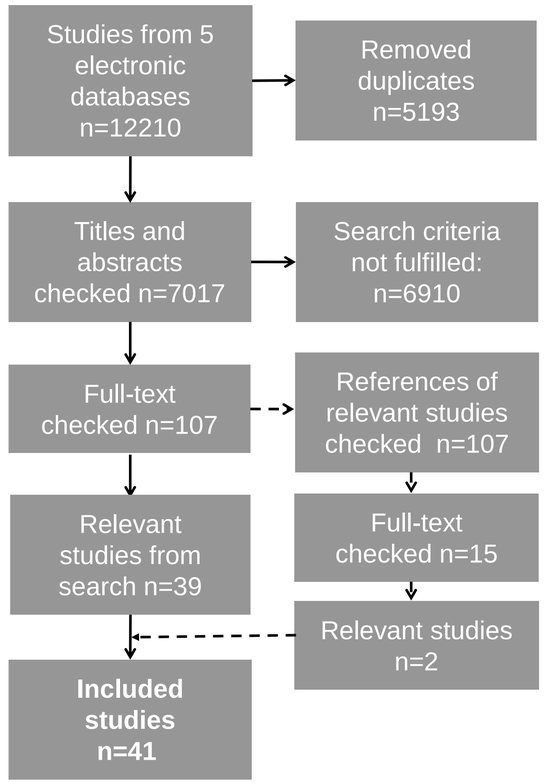
Quality of evidence rating:

For the articles identified as relevant, a quality rating, based on the GRADE[10] guidelines was carried out to judge the reliability and confidence of the estimated effects for Q1 and Q2 (Tables 1, 2). Quality of evidence was rated as high, moderate, low or very low, depending on whether the level of quality criteria was undetected, serious, not serious or very serious for limitations, inconsistency, indirectness, imprecision and publication bias for each outcome.

Results of the search

Our search revealed 41 relevant articles, published from inception to August 2014.

The most common reasons for exclusion were that direct measures of listening effort were not applied, hearing aid amplification was not provided or studies focused on the treatment of diseases and neither of the two research questions was answered.



Analysis and quality of evidence

Q1: Is speech comprehension more effortful for hearing-impaired than for normal-hearing listeners?

Outcomes	Level of limitation	Level of inconsistency	Level of indirectness	Level of imprecision	Publication bias	No. of subjects (studies)	p-value (Sign-test) LE: NH<HI	Quality: GRADE
Subjective: visual-analogue scale	Serious	Serious	Serious	Serious	undetected	479(7)	p = 0.219	Very low
Behavioral: dual-task paradigm	Serious	Serious	Serious	Serious	undetected	334(8)	p = 0.196	Very low
Behavioral:reaction time measures	Serious	Not serious	Not serious	Serious	undetected	10(1)	p = 0.125	Low
Physiological: pupil measure	Serious	Serious	Serious	Serious	undetected	130(2)	p = 0.250	Very low
Physiological: EEG	Serious	Not serious	Not serious	Serious	undetected	84(3)	p = 0.027	Low

Table 1: GRADE quality of evidence rating for outcomes on Q1.

Q2: Can hearing-aid amplification reduce listening effort during speech comprehension?

Outcomes	Level of limitation	Level of inconsistency	Level of indirectness	Level of imprecision	Publication bias	No. of subjects (studies)	p-value (Sign-test) LE: HA<none	Quality GRADE
Subjective: visual-analogue scale	Serious	Serious	Serious	Serious	undetected	546 (15)	p = 0.074	Very low
Subjective: questionnaire	Serious	Serious	Serious	Serious	undetected	659 (4)	p = 0.273	Very low
Behavioral: dual-task paradigm	Serious	Serious	Serious	Serious	undetected	292 (10)	p = 0.196	Very low
Behavioral:reaction time measure	Serious	Serious	Serious	Serious	undetected	82 (3)	p = 0.062	Very low

Table 2: GRADE quality of evidence rating for outcomes on Q2.

Conclusion

Q1: Evidence relating to Q1 was provided by 21 studies that reported 41 relevant findings. Our interpretation of the scientific evidence within this review is, that only physiological measurement methods showed significantly more listening effort during speech comprehension due to hearing impairment.

Q2: In 27 studies, evidence relating to Q2 was provided by 56 findings. There was no significant finding suggesting that hearing-aid amplification can help to decrease listening effort during speech comprehension.

The quality of evidence on both research questions (Q1 and Q2) was low or very low, according to the GRADE Working Group guidelines[10]. Studies of high quality are highly needed in the future to provide consistent and reliable findings.

The results of this review underline the need for a conceptual framework for listening effort, to specify which stages of cognitive processing are addressed by which type of assessment method.

Affiliation: [1]Section Ear & Hearing, Dept. of Otolaryngology-Head and Neck Surgery, VU University Medical Center and EMGO Institute for Health Care Research, Amsterdam, The Netherlands; [2]Department of Behavioral Sciences and Learning, Linköping University, Linköping, Sweden; [3]Linnaeus Centre HEAD, The Swedish Institute for Disability Research, Linköping and Örebro Universities, Linköping, Sweden; [4]Eriksholm Research Centre, Oticon A/S, Snekkersten, Denmark; [5]Department of Clinical and Experimental Medicine, Linköping University, Sweden; [6]Medical Library, VU University Amsterdam, Amsterdam, the Netherlands; [7]MRC/CSO Institute of Hearing Research, Scottish Section, Glasgow, United Kingdom[8]Institute of Physiology and Pathology of Hearing, International Center of Hearing and Speech, Warsaw, Poland

References: [9]Armstrong EC, (1999); [10] Guyatt et al. (2011);

LISTEN607373

Institute of Physiology and Pathology of Hearing

European Commission

VUmc VU University Medical Center Amsterdam

EriksholmResearchCentre PART OF OTICON