Validity of Automated Audiometry- Application for Telehealth

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1. Dept of Communication Pathology, UP
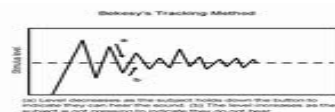2. Ear Science Institute Australia & University of Western Australia

A long history

- Dates back to **1947** when first reported by Georg von Békésy.

First type:
- **Method of adjustment**

  Automatically increased and decreased based on response button.
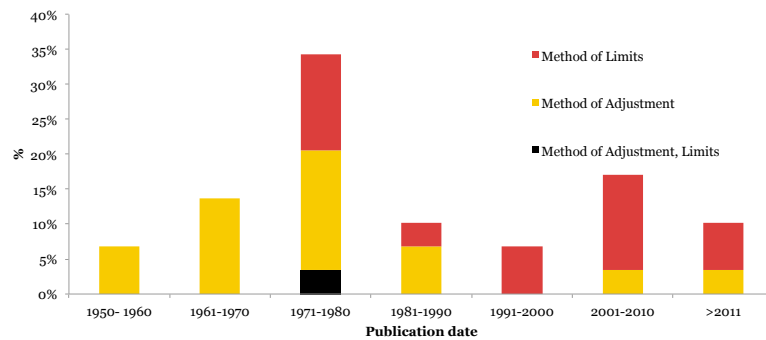
Later developments:
- **Method of limits**

  Automatically adjusts intensity up or down depending on response or lack of response. Programmed according to conventional manual audiometry procedures (typically versions of the Hughson and Westlake threshold seeking method).

  Georg von

  (Hughson & Westlake, 1944).

Automated audiometry over 10 decades (1956-2011)

Distribution of reports in systematic review (n=29), date of publication and type of automated audiometry (method of limits, method of adjustment, method of limits and method of adjustment)

Addressing the need?

Hearing loss	Health care professionals

Hearing loss

- **Most prevalent** disabling condition.
- Affecting **10%** of the population to a mild or greater degree.
- **1 of only 4** of nonfatal conditions among the **20** leading causes of global burden of disease
- **278** million people worldwide with bilateral moderate-to-profound hearing impairments.
- **80%** of individuals live in developing countries.

Health care professionals

- **Small number** of health care professionals globally are **inadequate** to meet the global need of health care services
- Developing countries rely on external **technical** and **financial** support.

(WHO, 2010; Swanepoel et al, 2010; Fagan & Jacobs, 2009; Goulios & Patuzzi, 2008)

Automated audiometry: a solution?

Main aim of study:

- The aim of the study was to **systematically review** and quantify the validity, as measured by reliability (test-retest) and accuracy, of *automated audiometry* (AA) compared to **manual audiometry** (MA) in published literature.

Sub-aims

- **Test-retest reliability** of AA compared to the gold standard of MA for AC and BC testing.

- **Accuracy** of AA compared to the gold standard of MA for AC and BC testing.

- To conduct a **meta-analysis** in order to combine and quantify results obtained for accuracy and test-retest reliability of AA compared to MA for AC and BC testing.

2 phases

Systematic literature review-

➢ Find as many **primary studies** relating to the research question using an unbiased search strategy,

➢ identify **gaps** regarding AA in current research,

➢ suggest **areas for further investigation** and

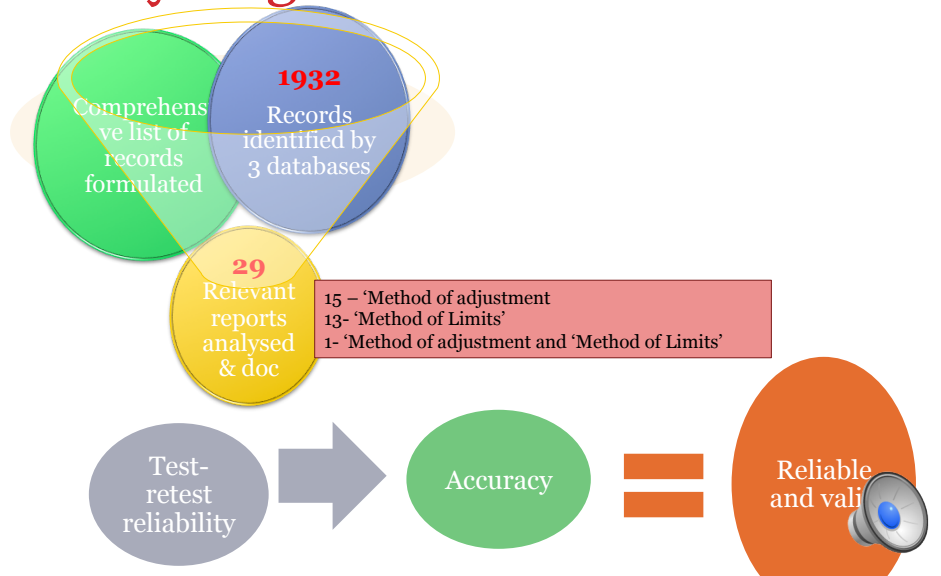➢ provide a framework/background to appropriately position **new research activities.**

Meta-analysis-

➢ Allows the researcher to make the best use of information gathered during the systematic review by **increasing** the value of the analyses,

➢ **combine** and **quantify** the results of individual reports resulting in an overall assessment of **test-retest reliability** and **accuracy**.

➢ Achieved by determining **weighted averages** of average differences (real and absolute) **across studies**.

➢ Comparing of **test-retest reliability** of MA to AA, comparing test-retest reliability differences to **average differences** obtained between MA and AA.

Study design and method

1932 Records identified by 3 databases

Comprehensive list of records formulated

29 Relevant reports analysed & doc

15 – 'Method of adjustment
13- 'Method of Limits'
1- 'Method of adjustment and 'Method of Limits'

Test-retest reliability → Accuracy = Reliable and vali

Recap

reCap

- Method of adjustment
- Method of limits
- Systematic literature review
- Meta-analysis

Test-retest reliability

- **Test-retest reliability** - repeatability of a technique allowing a comparison of techniques to determine which is more precise.

- **11** of the **29 reports** presented data on test-retest reliability (4- 'method of limits', 7- 'method of adjust').

Type of hearing	Normal hearing	Hearing loss	*Both	Not indicated
AC testing	2	3	1	4
AC and BC testing	-	-	-	1

- **No** data was reported on **children**.
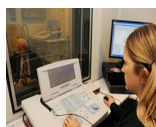
Results

Frequencies (Hz)	.125	.25	.5	1	2	3	4	6	8	All
MANUAL THRESHOLD AUDIOMETRY										
Average differences and standard deviations										
Air conduction automated threshold audiometry (3 reports)										
Average difference	-	-	2.3	2.1	1.5	2.0	-0.4	-1.7	-	1.3
SD	-	-	6.7	4.8	5.0	4.7	6.9	7.6	-	6.1
Absolute average differences and standard deviations										
Air conduction automated threshold audiometry (2 reports)										
Absolute average difference	4.8	3.4	2.9	3.2	2.7	-	2.8	-	3.0	3.2
SD	5	3.7	3.7	3.4	3.6	-	3.5	-	4.3	3.9
AUTOMATED THRESHOLD AUDIOMETRY										
Average differences and standard deviations										
Air conduction automated threshold audiometry (3 reports)										
Average difference	-	-	0.3	-1.1	0.0	2.1	0.7	1.7	-	0.3
SD	-	-	7.1	6.8	6.4	6.2	7.1	10.4	-	6.9
Absolute average differences and standard deviations										
Air conduction automated threshold audiometry (2 reports)										
Absolute average difference	4.9	3.4	2.9	2.6	2.6	-	2.3	-	2.0	2.9
SD	4.8	3.5	3.6	3.2	4.1	-	3.0	-	3.2	3.8

Meta-analysis weighted average test-retest reliability differences for manual and automated audiometry

Meta-analysis test-retest difference

- AA compared to MA, demonstrated **no statistically significant difference** (Summary Data ANOVA; p>0.01).

- Recent report on MA obtained absolute average test-retests differences **(3.6 dB, 3.9 SD)** that were in line with the meta-analysis results **(2.9 dB, 3.8 SD).**

- Test-retest reliability for AA was indicated to be **within typical variability** compared to test-retest reliability for MA.

- *Conclusion*- AC test-retest **threshold differences** for AA fall well within **current test-retest limits**.

- **BC test-retest reliability**- only one study, concluded that test-retest reliability of BC for AA was appropriate . Results correspond to manual BC test-retest reliability reported by previous studies .

(Swanepoel &Biagio, 2011; Margolis et al., 2010, Ho et al., 2009; Laukli & Fjermedal, 1

Accuracy

- **Accuracy- correspondence** of **AA** to the gold standard of conventional **MA**.

- Accuracy seen as the **difference** obtained between thresholds obtained **automatically** and those obtained **manually**.

- **All 29** reports reported on accuracy of AA (15-'method of adjust', 13- 'method of limits', 1- 'method of limits' and 'method of adjust'.

	Type of hearing	Normal hearing	Hearing loss	*Both	Not indicated
ADULT	AC testing	5	3	3	8
	AC & BC	-	3	3	1
CHILD	AC testing	1	-	1	1
	AC & BC	-	-	2	-

Results

Inter-tester differences (0.6 dB, 5.5 SD)

Frequencies (Hz)	.125	.25	.5	1	2	3	4	6	8	All
AVERAGE DIFFERENCES AND STANDARD DEVIATIONS										
Combined (10 reports)										
Average difference	-2.5	-3.5	-1.5	-1.2	-0.1	2.1	-3.6	-2.1	-5.0	0.4
SD	8.6	6.7	5.4	5.3	5.5	6.1	5.7	7.7	8.7	6.1
Method of limits (3 reports)										
Average difference	-	-0.4	-0.7	0.4	-1.3	-0.8	3.8	-1.3	-1.7	0.3
SD	-	5.1	4.4	5.3	5.8	-	4.9	-	7.0	5.5
Method of adjustment (7 reports)										
Average difference	-2.0	-2.3	0.5	0.3	2.1	1.1	0.1	-1.0	-3.1	0.8
SD	8.6	6.9	5.4	5.3	5.5	6.1	5.8	7.7	9.0	6.2
ABSOLUTE AVERAGE DIFFERENCES AND STANDARD DEVIATIONS										
Combined (4 reports)										
Absolute Average difference	4.2	3.6	3.4	3.5	3.4	-	2.9	-	3.1	4.2
SD	4.0	3.5	3.9	3.6	3.8	-	3.2	-	4.5	5.0

Weighted average differences and standard deviations between manual and automated threshold audiometry (manual minus automated)

Meta-analysis accuracy-

- Overall **average differences** between MA and AA AC audiometry (0.4 dB, 6.1 SD) **correspond** to test-retest differences for MA(1.3 dB, 6.1 SD) and AA (0.3 dB, 6.9 SD).

- **No statistically significant difference** (ANOVA; p>0.01) was evident between overall absolute differences for manual and automated audiometry (**4.2 dB, 5.0 SD**) and the test-retest absolute differences for manual (**3.2 dB, 3.9 SD**) and automated (**2.9 dB, 3.8 SD**) audiometry.

- **BC AA-** Average differences for MA and AA for BC were only reported by **9 studies**. These studies utilised various forms of analyses and as a result weighted averages for BC threshold audiometry **could not be** determined across studies.

Conclusion of study

- Automated audiometry *developed over 6 decades:* **method of adjustment** to automated audiometry incorporating conventional manual audiometry (**method of limits**).

- Current evidence demonstrate **(1) similar test-retest reliability** for automated and manual audiometry **(2)** automated thresholds **within** typical test-retest and inter-tester variability of manual thresholds.

HOWEVER, validation is still limited for

i) **automated BC** audiometry;

ii) **children** and **difficult-to-test populations**

iii) different **types** and **degrees** of hearing loss.

Application in Tele-health

- AA is **valid** and **reliable.**

- **Cost effective** and **time efficient**.

- **Increases** number of **clients** that can be served.

- Provides serves where **specialised professionals** are **limited**.

- Cases can be **uploaded** and **reviewed** by specialists in **off-site clinics**.

APPROVED

Any questions?