Listening effort and fatigue
What are we measuring?

Dr Piers Dawes
“I went to a great conference today. It was riveting and I was hooked on pretty much every word. And then I got home and collapsed on the sofa. I’m not just tired, I’m shattered. I’ve had to turn my ears off to rest in silence and my eyes are burning...When I was younger, I was a little embarrassed to be so tired all the time. I would force myself to go out and be busy...all I wanted to do was crawl under the sofa and nap...”

Adult with hearing loss (Bess & Hornsby, 2014)
# Audiolological measures

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audiogram</td>
<td>Hearing sensitivity; fit hearing aid to compensate for loss of audibility</td>
</tr>
<tr>
<td>Speech recognition tests</td>
<td>Accuracy of speech recognition</td>
</tr>
<tr>
<td>Hearing questionnaires</td>
<td>Hearing disability &amp; hearing aid benefit</td>
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<tr>
<td>Listening effort / fatigue?</td>
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Optimal fit (based on audiogram) and good speech recognition

But listening may still be challenging and tiring.
Definitions

• **Listening effort** refers to the mental exertion required to attend to and understand an auditory message.

• **Listening-related fatigue** refers to extreme tiredness resulting from effortful listening.

Summary so far...

• Effort/fatigue possibly an important (unmeasured) aspect of hearing disability

• The mental effort required to listen detracts from other tasks (e.g. comprehension)

• Measures of effort/fatigue could optimise interventions/technology that reduce effort/fatigue, individualise treatment
Measures of effort

1. Self-report
2. Behavioural
3. Physiological
1. Self-report

NASA task load index (Hart & Staveland)
- multidi-dimensional effort; 6 work-load related factors based on a model of workload
- mental, physical, temporal, performance, effort, frustration

How hard did you have to work to accomplish your level of performance?

[Scale from Very Low to Very High]
Do you have to concentrate very much when listening to someone or something?

Can you easily ignore other sounds when trying to listen to something?

Do you have to put in a lot of effort to hear what is being said in conversation with others?

• New & experienced HA users
• Rate SSQ ‘difference’ over 3 months

# 1. Self-report

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheap, quick, easy to administer</td>
<td>Relies on good introspection (cognitively impaired, or children)</td>
</tr>
<tr>
<td>No special equipment required</td>
<td>Subjective; one person finds ‘effortful’ may not equate with another person’s idea of ‘effort’</td>
</tr>
<tr>
<td>No particular expertise required to administer or interpret</td>
<td>No validated self-report measures about hearing fatigue/effort</td>
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<tr>
<td></td>
<td>Sensitivity (?)</td>
</tr>
<tr>
<td></td>
<td>Influenced by task accuracy(?)</td>
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</tbody>
</table>
2. Behavioral

• Single or dual-task paradigm

Single: respond to target word/sentence
Time taken to respond = effort

Early studies: Downs (1982), Gatehouse & Gordon (1990)
Single task

• Digit triplet test “The digits, three, one, nine”

1. Identification: identify the final digit in a triplet

2. Arithmetic: calculate the sum of the initial and the final digits in a triplet

• Answers:

Identification: 6, 3, 5

Arithmetic: 7, 9, 5
*Recognition accuracy > 80%
# Single task

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast processing rate might be important</td>
<td>Not clear that increased effort = slower responses</td>
</tr>
<tr>
<td>Use equipment available in audiology clinics</td>
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- **Advantages**: Fast processing rate might be important. Use equipment available in audiology clinics.
- **Disadvantages**: Not clear that increased effort = slower responses.
Dual-task

Primary speech recognition task
Secondary task; memory or reaction time

- Limited capacity of cognitive resource
- Two tasks compete for resources

→ As one task becomes more taxing, resource capacity is exceeded and performance on the secondary task worsens
Dual Task

Primary: Repeat sentences in noise, eg “The boat slid on the smooth rocks”

Secondary: Visual reaction time

Draw arrows on your note pad:
• Numbers (1-9) on either left or right of the screen

• Press the arrow that points toward the even number and away from the odd number
• Repeat target sentences

• Respond to numbers as fast as possible
• Young NH subjects, Simulated effect of NR
• At low SNR (-6 dB), no positive effect of NR on speech, but better performance on secondary tasks

## Dual task

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face validity – like real life multi-tasking</td>
<td>Assumes i) all cognitive capacity taken by both tasks ii) all remaining</td>
</tr>
<tr>
<td></td>
<td>resources devoted to the second task, with first task as priority</td>
</tr>
<tr>
<td>Use equipment available in audiology clinics</td>
<td>Multi task or task switching?</td>
</tr>
</tbody>
</table>
3. Physiological

- Measures of brain activity or nervous system arousal linked to task difficulty
- fMRI, EEG, skin conductance, heart rate, muscle tension, pupil size, hormone levels (cortisol)
Pupil size

Pupil *dilation* reflects listening effort - **larger** task-evoked pupil size in more challenging listening conditions
## 3. Physiological

<table>
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<th>Advantages</th>
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</thead>
<tbody>
<tr>
<td>Objective measure</td>
<td>Age differences in physiology</td>
</tr>
<tr>
<td>Could be sensitive (?) to differences between listening conditions and individuals</td>
<td>Sensitive to stress/emotion</td>
</tr>
<tr>
<td></td>
<td>Need special expensive equipment</td>
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<tr>
<td></td>
<td>Need expertise in analysis and interpretation</td>
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<td></td>
<td>Need controlled conditions</td>
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</table>
Measures of effort

1. Self-report
2. Behavioural
3. Physiological
Unanswered questions

• How important is ‘effort’?

• Is fatigue more important than effort? How does effort relate to fatigue?

• Measures do not always agree with each other. Which are the most reliable and valid measures?

• Which measures are applicable in research vs clinical settings?

Clinical applications, Future

• Additional outcome measure
• Individualise treatment, choose features
• New treatments; e.g. Cognitively controlled hearing aid
Clinical Applications, Now

Questionnaire

e.g. SSQ effort-related questions
or general effort/fatigue one (NASA TLX, or Fatigue Assessment Scale)

Workshop on listening effort and fatigue

- BSA special interest group for cognition in hearing
- University of Manchester
- April 2015 (date TBC)
- Limited places

Contact Ronan McGarrigle for details
ronan.mcgarrigle@manchester.ac.uk
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* School of Psychological Sciences, the University of Manchester, UK
† Central Manchester University Hospitals NHS Foundation Trust, Manchester Academic Health Science Centre, Manchester, UK
‡ Communication Sciences Research Center, Cincinnati Children ’ s Hospital Medical Center, Cincinnati, Ohio, USA, § MRC Institute of Hearing Research, Nottingham, UK

Piers.dawes@manchester.ac.uk