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Listening effort and fatigue: are we talking about the same thing?

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Introduction

Listening effort refers to the exertion of mental power required to attend to and understand an auditory message. *Listening-related fatigue* refers to a feeling of tiredness/lack of energy following effortful listening.

Hearing-impaired individuals commonly report listening-related fatigue which negatively affects their daily life.

An objective measure of listening effort may be useful for audiologists assessing a patient's hearing disability.

So, what is the problem?

There is ambiguity in the literature regarding what we mean when we discuss listening effort/fatigue.

A variety of subjective (e.g., self-report scales/questionnaires), behavioural (e.g., response time/dual-task measures) and psychophysiological (e.g., pupillometry, skin conductance, EEG) techniques have been used to measure both listening effort and fatigue.

However, each technique appears to be indexing disparate phenomena:

- **Subjective:** The perceived experience of listening effort/fatigue
- **Behavioural:** The presumed behavioural consequence of listening effort/fatigue
- **Psychophysiological:** The physiological mechanisms that underpin listening effort/fatigue

For example, studies have shown no relation between:

- Subjective and behavioural measures (Larsby et al. 2005)
- Subjective and psychophysiological measures (Zekveld et al. 2011)

We present a set of terminology to:

- Highlight the disparate nature of each measure
- Address some of the ambiguity in the literature
- Help avoid misleading comparisons when discussing the literature

Proposed terminology

Perceived listening effort

To denote subjective measures of listening effort as indexed using self-rating scales/questionnaires.

Perceived listening fatigue

To denote subjective measures of listening-induced fatigue as indexed using self-rating scales/questionnaires.

Auditory processing efficiency

To denote correct response latency in single-task listening paradigm (faster responses = greater auditory processing efficiency).

Auditory processing cost

To denote response decrement on a secondary task (in a dual-task paradigm) with speech processing as a primary task.

Cognitive listening fatigue

To denote general performance decline (RT or accuracy) from the beginning to the end of a listening task.

Physiological cost of listening

To denote changes in physiological state as a function of changes in listening task demand.

See 'Table 1' for example of how the proposed terminology can be applied to previous literature.

Publication	Method used	Terminology used	Suggested (new) terminology
Subjective measures			
Luts et al. (2010)	13-point effort scale during listening task	Listening effort	*Perceived listening effort*
Kramer et al. (2006)	Open-ended questionnaire: 'Reason for sick-leave'	Mental distress	*Perceived listening fatigue*
Behavioural measures			
Gatehouse & Gordon (1990)	Single-task: Speech RT	Ease of Listening	*Auditory processing efficiency*
Sarampalis et al. (2009)	Dual-task paradigm	Listening effort	*Auditory processing cost*
Hornsby (2013)	Dual-task paradigm: secondary task RT decline across task	Mental fatigue	*Cognitive listening fatigue*
Psychophysiological measures			
Mackersie & Cones (2011)	Skin conductance, skin temperature, EMG and heart rate recordings during dichotic digits task	Listening effort	*Physiological cost of listening*
Zekveld et al. (2011)	Pupillometry during SRT task	Cognitive load	*Physiological cost of listening*
Bernarding et al. (2013)	Phase-locking of the N1 ERP component during syllable detection paradigm	Listening effort	*Physiological cost of listening*

Abbreviations: RT = Response time, EMG = Electromyography, SRT = Speech Reception Threshold, ERP = Event Related Potential.

Table 1. Examples of some key studies in the literature along with their methodology, the terminology used in each and our proposed terminology.

Conclusions

- Listening effort and fatigue measurement has been conducted using three distinct measurement techniques: Subjective, behavioural and psychophysiological.
- Each of the three techniques appear to be measuring disparate listening effort and fatigue-related phenomena.
- We set out a framework for understanding this topic and standardising the terminology used.

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