Measuring listening-related fatigue

Behavioural and physiological markers

Ronan McGarrigle¹, Piers Dawes¹, Andrew Stewart¹, Stefanie Kuchinsky²,³,⁴ & Kevin Munro¹,²

¹School of Psychological Sciences, University of Manchester, UK.
²Central Manchester University Hospitals NHS Foundation Trust, Manchester Academic Health Science Centre, Manchester, UK.
³Center for Advanced Study of Language, University of Maryland, USA.
⁴Maryland Neuroimaging Center, University of Maryland, USA.

Background

Individuals with hearing loss commonly report fatigue due to the need for sustained effortful listening in everyday situations (Bess & Hornsby, 2014).

Decreasing pupil size over time reflects a reduction in levels of autonomic arousal and has been found to relate to increased levels of reported fatigue (Hopstaken et al., 2014).

• Changes in pupil size covary with BOLD changes in locus coeruleus activity, which governs our attention-arousal system (Aston-Jones & Cohen, 2005; Murphy et al., 2014).

Increasing behavioural response times over the course of an experiment may represent a behavioural marker of mental fatigue (Hornsby, 2013).

It is not clear whether or not these objective measures are sensitive to differences in fatigue during more naturalistic listening (i.e., conditions that require sustained processing).

Research Question

Are behavioural and physiological markers of mental fatigue sensitive to differences in signal-to-noise ratio (SNR) during a narrative speech processing task?

Method

Speech-picture verification task

“Bob lives near a beautiful park and loves going for long walks there during Spring. This time he decided to bring binoculars to see if he could spot any pigeons in the trees. Fortunately, he managed to catch a glimpse of one perching in its nest.”

Participants

24 normal-hearing young adults

Listening conditions

Easy: +15 dB SNR
Hard: 8 dB SNR

Background noise

Multi-talker babble

Experiment duration

50 minutes

Trial duration

13-18 secs

Experimental Design

Blocks of Easy and Hard trials, with order counterbalanced across p’s

Analysis

• Correct responses only were analysed for pupillometry and behavioural data.

• 1 second of noise pre speech-onset used as a baseline to measure relative change in pupil size in each trial.

• Growth Curve Analysis used to capture potential curvilinear change in the pupil response.

• Response times were log-transformed to approximate a normal distribution.

Results

Pupillometry

The pupil response plotted as a function of time in the 1st (left) versus the 2nd (right) half of each listening condition block (circles = raw data, lines = cubic model fit).

• Significant condition X block ‘half’ interaction on the linear term (χ² = 3.98, p < .05). In other words, participants showed a steeper sloping pupil response for ‘hard’ versus ‘easy’ in the 2nd versus the 1st half of the block.

• LogRTs as a function of trial number across each listening condition block.

• Significant difference in overall mean logRT between conditions (χ² = 10.29, p = 0.001). However, no difference in their rate of change (linear term), χ² = 0.12, p = 0.73, or in terms of the shape of the primary (U-shaped) inflection curve (quadratic term), χ² = 1.63, p = 0.20.

Behavioural

• LogRTs as a function of trial number across each listening condition block.

• Significant difference in overall mean logRT between conditions (χ² = 10.29, p = 0.001). However, no difference in their rate of change (linear term), χ² = 0.12, p = 0.73, or in terms of the shape of the primary (U-shaped) inflection curve (quadratic term), χ² = 1.63, p = 0.20.

• Growth curve analysis revealed a significantly steeper linear decrease (i.e., slope) in pupil size over time in the hard versus the easy listening condition, which was more pronounced in the 2nd versus the 1st half of each trial block. This supports the hypothesised increase in mental fatigue over time in the more challenging (hard) listening condition.

• Behavioural (response time) measures of fatigue did not reveal any difference in the rate of change over time between listening conditions. This suggests that either:

  • Response times are not as sensitive as pupillometric measures at detecting listening-related fatigue, or
  • Pupil size is indexing a separate phenomenon

• Pupil size changes over time may represent a sensitive physiological measure of the mental fatigue associated with sustained effortful listening.

Conclusions

References


Acknowledgements: Thank you to Castang Foundation for providing funding for this PhD work.