Motivation, Control and Hearing Loss-Related Fatigue

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Hearing Loss, Listening Effort and Fatigue

• Listening IS exhausting!!!
  – Post on hearingaidforums.com

• “…since I lost most of my hearing…, I've had periodic bouts of tiredness that are deeper and of a different quality than I ever experienced before.”
  – Copithorne, 2006

• “I go to bed most nights with nothing left. It takes so much energy to participate in conversations all day, that I’m often asleep within minutes.”
  – Blog post http://hearingelmo.wordpress.com
Fatigue - More than effort and task difficulty

High effort/difficulty ≠ always lead to fatigue
Fatigue - More than effort and task difficulty

- Risk for fatigue increases in:
  - Mentally/physically challenging conditions
    - Requires effortful control to attain/maintain performance
    - Maintaining “acceptable” performance is difficult or not possible
  - Low control conditions
    - Timed or scheduled tasks with limited flexibility
    - Limited ability to modify the task characteristics
  - Important conditions
    - High motivation
    - Negative consequences for poor performance

Hockey & Earle (2006); Boksem & Tops (2008); Ackerman (2011); Hockey (2013); Earle & Hockey (2015).
A motivational control theory of cognitive fatigue (Hockey, 2013)

• Fatigue is an emotional response serving an adaptive, goal-directed, function
  – forces us to evaluate current goal-directed behaviors in terms of an effort/reward balance

• Fatigue is a “protective” mechanism to help us decide if the effort applied towards a goal is worth the reward.

A motivational control theory of cognitive fatigue (Hockey, 2013)

- **Goal:** Successful Communication
  - Successful communication with minimal effort
  - Unsuccessful communication with allocated effort
    - Evaluate effort/reward ratio
      - Low reward/benefit
        - Maintain effort: No change in performance
        - Reduce effort: Disengage
      - High reward/benefit
        - Increase effort: Successful communication with allocated effort
        - Increase effort: Unsuccessful communication with allocated effort

A simple block diagram interpretation of Hockey’s (2013) model
A motivational control theory of cognitive fatigue (Hockey, 2013)

A simple block diagram interpretation of Hockey’s (2013) model

Fatigue development is minimal

Fatigue develops/increases

- Evaluate effort/reward ratio

- A continuum

- Fatigue development is minimal

- Low reward/benefit
  - Maintain effort: No change in performance
  - Reduce effort: Disengage
  - Variable effort: Change goal

- High reward/benefit
  - Increase effort: Successful communication with allocated effort
  - Increase effort: Unsuccessful communication with allocated effort

- Successful communication with minimal effort
- Unsuccessful communication with allocated effort
Model Predictions-

- Speech processing-related fatigue should be associated with task difficulty and hearing loss
  - Conditions where speech understanding is more difficult & effortful should be more fatiguing

- Degree of hearing loss would be associated with perceived effort and speech processing-related fatigue
  - More hearing loss -> more difficulties -> more effort -> more fatigue
Assessing speech-processing related fatigue in the laboratory

1. Does task difficulty or hearing loss modulate effort and speech-processing related fatigue?
2. Does degree of hearing loss modulate effort and speech-processing related fatigue?
PARTICIPANTS AND PROCEDURES
Participants

- Young normal hearing adults (N = 50)
  - Mean age = 24 years
    - range 18-32 years

- Older adults with hearing loss (N=31)
  - Mean age = 71 years
    - range 63-79 years
  - Mean PTA = 35.6 dB
    - range 25-53 dB
  - All hearing aid users
  - All tested unaided
“Listening IS exhausting!!”

What Color was Charlie?

Ready Charlie go to Blue 1 now   Ready Eagle go to Green 4 now
“Listening IS exhausting!!”

What CallSign was One?

Speech Fatigue Task (SFT)

Ready Charlie go to Blue 1 now ➔ Ready Eagle go to Green 4 now
"Listening IS exhausting!!"

Speech Fatigue Task (SFT)

What Number was Green?

Call Signs
- Arrow
- Baron
- Charlie
- Eagle
- Hopper
- Laker
- Ringo
- Tiger

Color
- Blue
- Green
- Red
- White

Number
1 2 3 4 5 6 7 8

Ready Charlie go to Blue 1 now  ➡️  Ready Eagle go to Green 4 now
“Listening IS exhausting!!”
Task Parameters and Test Conditions

• Speech Task:
  • Duration: 50-60 minutes (340 stimuli)
  • Speech presented free field (60 dBA)
    – Mixed with a cafeteria babble
  • 4 SNRs- Participants did an “easy” and “hard” SNR. Specific SNR’s varied b/w groups (G1, G2)
    – Young NH: G1: Quiet & -4; G2: -2 & -6 dB SNRs
    – Older HI: G1: +2 & -2; G2: 0 & -4 dB SNRs

– Visual “Alerts” occur on 30% of trials
  • Random occurrence but distributed evenly
    – half during the first 170 trials and half during the 2nd 170 trials
Subjective Measures of Effort and Fatigue

• Rating Scale of Mental Effort (RSME; Zijlstra, 1993)
  – Visual analogue scale, rate effort from “absolutely no effort” to > “Extreme effort”
    • Numeric range of 0-150
  – S’s rate “…effort it took you to finish the task.”

• Fatigue and vigor subscales of the Profile of Mood States (POMS; McNair, et al., 1971)
  – 15 items, describes “how you feel RIGHT NOW.”
Behavioral Measure of Fatigue

- Psychomotor Vigilance Task (PVT; Dinges & Powell, 1985) to assess sustained attention
  - Simple 10 minute visual vigilance task sensitive to fatigue related changes in attention
  - Completed before 1\textsuperscript{st} POMS and after 2\textsuperscript{nd} POMS
  - Fatigue quantified as a “decrement” in response times to visual marker (ability to maintain attention)
Study Procedures

- PVT
- POMS
- Speech Fatigue Task
- POMS
- PVT
- RSME
Results

Does task difficulty or HL modulate fatigue?
Does task difficulty or HL modulate fatigue? *Performance effects*

- Monotonic changes in performance with SNR for NH and HI groups

![Graph showing SFT Accuracy (in %) vs SNR (in dB) for NH and HI groups. Error bars = 1 St. Error]
Does task difficulty or HL modulate fatigue? *Subjective fatigue*

- Task is fatiguing for both groups
  - More so for older HI group (p<0.05)
- But unaffected by task difficulty (SNR)
  - And no SNR x time/group interactions (all p>0.05)
Does task difficulty or HL modulate fatigue? *Behavioral fatigue*

- Significant effect of time and group (older HI are slower)
  - But no effect of SNR ($p>0.05$)
  - And no interactions bw SNR, time or group (all $p>0.05$)
Does task difficulty or HL modulate effort?
Associations Between **Performance (SNR)** and Mental Effort

- Performance changes with SNR for NH and HI groups

**SNR (in dB)**
-6 -4 -2 0 2 Quiet

**SFT Accuracy (in %)**
- 40
- 50
- 60
- 70
- 80
- 90
- 100

**Error bars = 1 St. Error**

**Mean data**

![Graph showing SFT accuracy vs SNR (in dB) for NH and HI groups with error bars indicating standard error.](image-url)
Associations Between Performance (SNR) and **Mental Effort**

- But effort changes with SNR only for NH
Associations Between Performance (SNR) and Mental Effort

- Weak (NH) or no (HI) association between task difficulty (SNR) and perceived effort on the task
Results

Associations between Degree of Hearing Loss, Effort and Fatigue
Association Between 1) PTA & effort and 2) PTA & fatigability

- Weak association bw PTA and mental effort on task (RSME)
- No association bw PTA and change in POMS fatigue scores
- As PTA increases fatigability and effort decrease
In contrast, **strong association** between fatigability and perceived effort on the task

- Esp. in HI

**Associations Between Fatigability and Mental Effort**

Individual NH data

-6 dB SNR

-4 dB SNR

-2 dB SNR

Quiet

Individual HI data

-4 dB SNR

-2 dB SNR

0 dB SNR

+2 dB SNR

$r = 0.38$

$p < 0.001$

$r = 0.55$

$p < 0.001$
Sustained speech processing can lead to subjective and behavioral fatigue

1. Does task difficulty or HL modulate speech-processing related fatigue?
   - **Task difficulty:** No!
   - No relationship between SNR or individual performance on fatigability
   - **Hearing Loss:** Partly-
     - Subjective fatigue (POMS) was larger for older HI
       - No bw group difference in behavioral (PVT) fatigue

Task difficulty & HL may have effects here
Sustained speech processing can lead to subjective and behavioral fatigue—Why?

2. Does degree of HL modulate speech-processing related fatigue?
   - **No**: PTA was not associated with variations in effort or fatigue
   - Neither speech understanding ability OR degree of HL were strongly related to speech processing-related fatigue
Sustained speech processing can lead to subjective and behavioral fatigue—Why?

- Perceived effort (RSME rating) was the strongest predictor of speech processing-related fatigue
  - Esp. for our participants with hearing loss
  - But perceived effort was NOT strongly related to SNR, performance, or degree of hearing loss
Sustained speech processing can lead to subjective and behavioral fatigue—Why?

- Perceived effort (RSME rating) was the strongest predictor of speech processing-related fatigue
  - Especially for our participants with hearing loss
  - But perceived effort was NOT strongly related to SNR, performance, or degree of hearing loss

- Other individual factors must play a dominant role
  - E.g., motivation, expectations, personality…
A motivational control theory of cognitive fatigue (Hockey, 2013)

Goal: Successful Communication

- Successful communication with minimal effort
- Unsuccessful communication with allocated effort

Evaluate effort/reward ratio

Low reward/benefit
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High reward/benefit
- Increase effort: Successful communication with allocated effort
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Other individual factors may have effects here
- motivation, expectations, personality…

A block diagram interpretation of Hockey’s (2013) model

Task difficulty & HL may have effects here

A continuum

Other individual factors may have effects here

A motivational control theory of cognitive fatigue (Hockey, 2013)
Vanderbilt Bill Wilkerson Center

Future Research
There is a lot we don’t know!

- Better understand the “fatigue experience” of persons with HL
  - Do our lab studies or generic questionnaires adequately capture the experiences of persons with HL?

- Develop/refine methods to quantify hearing loss-related stress, effort and fatigue
  - In laboratory and real world

- Characterize individual factors and physiologic mechanisms responsible for hearing loss-related fatigue

- More directly test and refine a model of hearing loss-related fatigue
  - Important for developing effective intervention strategies
Questions?

Interested in this area? Potential Post-doc position available. See me for details!