MECHANICAL ENGINEERING
TEXAS A&M UNIVERSITY

ECEN 689: Neuro-electronics:
Term Project

Stress, music, and task performance: *To assess the interplay between auditory stimuli, cognitive stressors, and visuospatial task performance*

Thursday, 29th Nov. 2018
ZACH 260
2.20 - 3.35 PM

Team #4
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Outline

1. **Introduction:** Motivation, development, and challenges
2. **Objectives:** Goals, and hypotheses
3. **Background:** Current state-of-the-art, and methods
4. **Methods:** Approach, experimental study, and limitations
5. **Results:** Post-processing, analysis, and takeaways
6. **What's next:** future work, improvements, and a discussion
7. **Impact**

Motivation

Why: The brain/ cognition

- Complex
- We don’t understand it (sufficiently)
- The ability to multi-task/ task-precedence selection is fascinating
- This is a **Neuro**-electronics course

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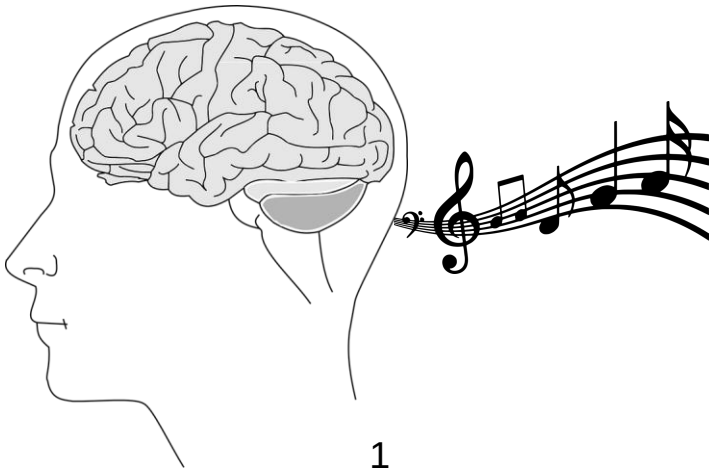
[1] Image/s borrowed from wikimedia commons, free for non-commercial reuse

Motivation

Why: Auditory Stimuli

- Accessible
- Permits necessary variations
- Interested in therapeutic attributes of music
- Passionate about music/ musical instruments



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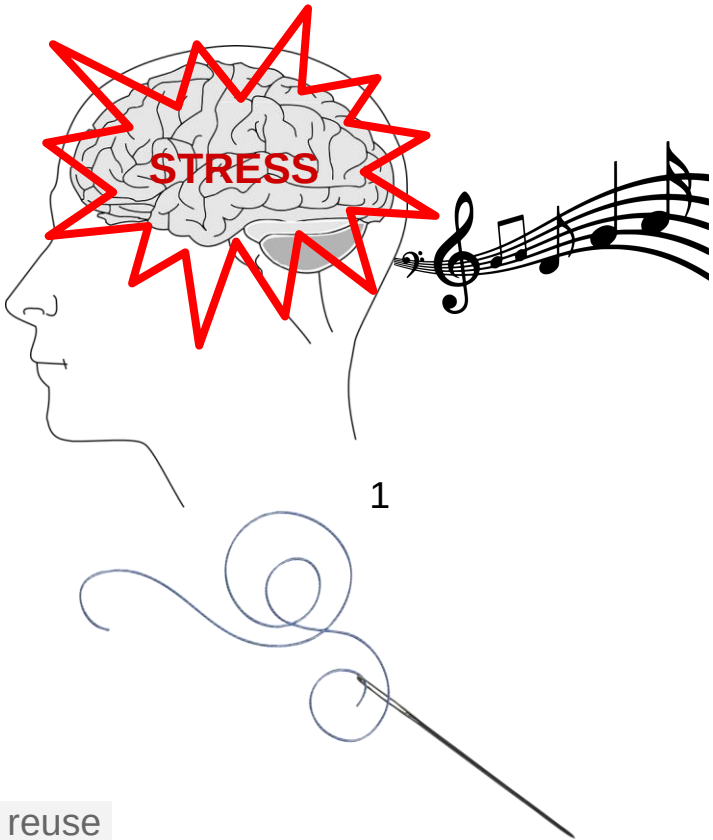
Motivation

Why: Stress

- Stressors are a plenty
- “Stressed” almost a daily state of mind [1]
- Relief is subjective, and nuanced [2,3]
- Our understanding of the brain’s response is still nascent [4,5]



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[Fig-1] Robot-assisted surgery,[Fig-2] Graduate school, [Fig-3] Needle threading

Motivation

- **Opportunity:** 1) apply, 2) implement, and 3) explore a potential research problem
- Combine this with some common interests: **math, gaming, and music***
- Develop a simple framework and test hypotheses
- Verify the validity of existing results/ contribute to the body of literature

*+ A love for dogs

Objectives

- **Build a simple user-interface:**
  - Model it around existing games (flappy bird)
  - Introduce a cognitive stressor (math task)
  - Provide auditory stimuli (music)
  - Assess user performance (game score)
- Test a set of **hypotheses:**
  - **Desired/undesired** auditory stimuli can **enhance/deter** response respectively (interference): *Prior research indicates that music of any kind is detrimental to given task.*
  - **Tempo** of auditory stimuli may improve performance on the motor task, only if their frequency (image update rate, and audio beats-per-minute) is matched: *Earlier works seem to indicate that the temporal attributes of visual and auditory stimuli do not exhibit significant correlation.*
  - **Cognitive stressors** limit task performance, but are overcome with time (learning effect): Although it is a known fact that stress limits our abilities, the effect of learning (and stress) is not addressed well, additional the role of feedback in this context is not explored sufficiently too.
- **Identify correlations** (if any) between auditory stimuli, visuospatial tasks, cognitive load, and discuss implications

Current literature

The effect of music/noise

- Music can be as distracting as noise [6,7]
- Current research indicates that performance measures agree with the following trend (w/background audio) [7]: **Silence>Music>Noise**

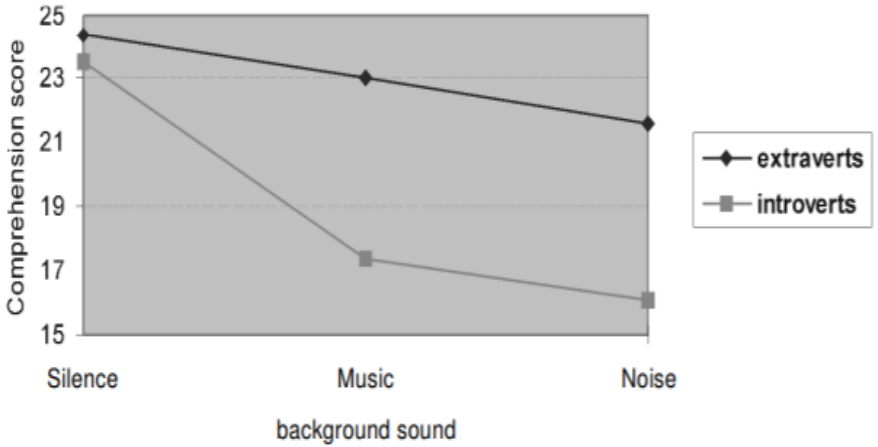


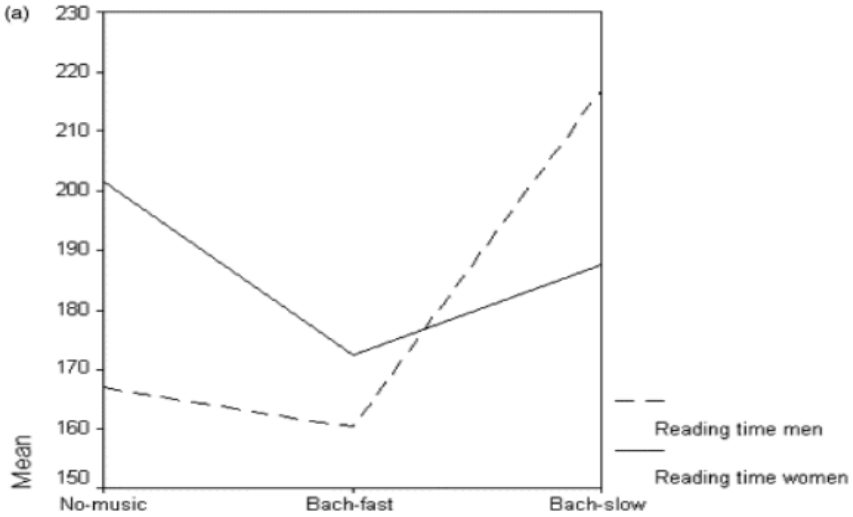
Figure 1. Mean scores of introvert's and extravert's performance on a reading comprehension task, in the presence of background music, noise and silence.

[Fig-4] Plot is borrowed without permission from [7]

Current literature

Effect of Tempo:

- Subjects in slow-music conditions performed slowly when compared to subjects in fast-music conditions [8]
- Different tempo music activates people to different degrees. Slow music may produce a relaxed feeling [8]

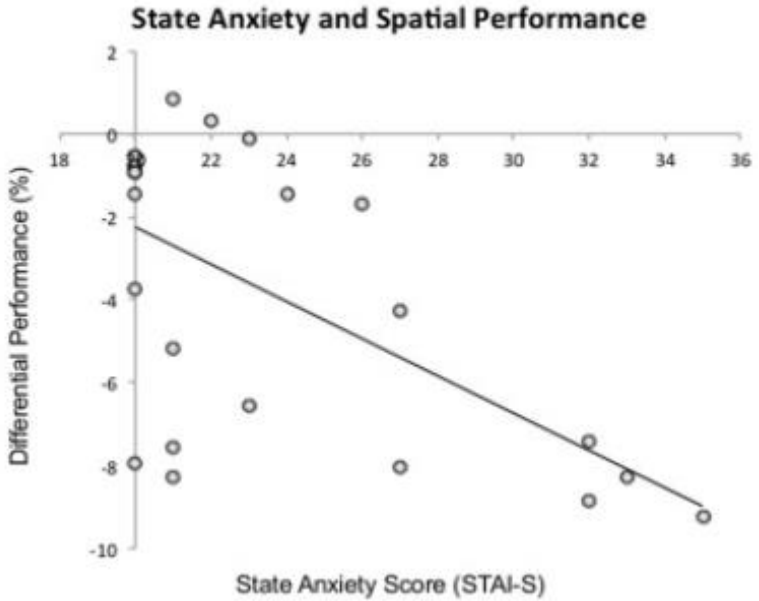


[Fig-5] Plot is borrowed without permission from [8]

Current literature

Effect of stressors:

- Results predicted that anxiety is negatively correlated with the spatial working memory performance [9]
- Spatial working memory is more susceptible to anxiety related disruption than verbal working memory [9]



[Fig-6] Plot is borrowed without permission from [9]

Current literature

Tasks (user performance)

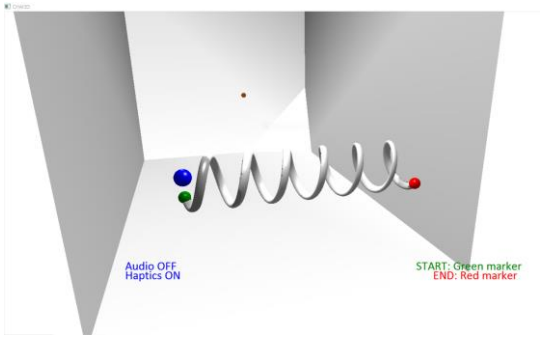
- Reading comprehension [7]
- Memorizing a prose [7]
- Spatial tasks [9]

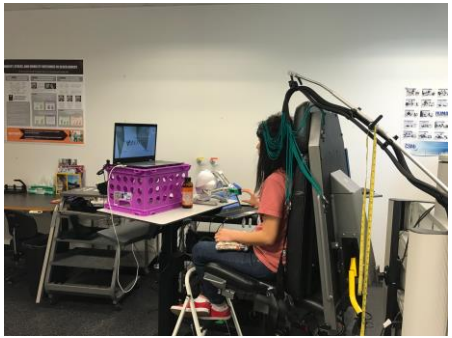
Auditory stimuli

- UK Garage style music [7]
- Office noise [7]

Stress induction

- Threat of shock to induce sustained anxiety [9]
- Public speaking and mental arithmetic [10]



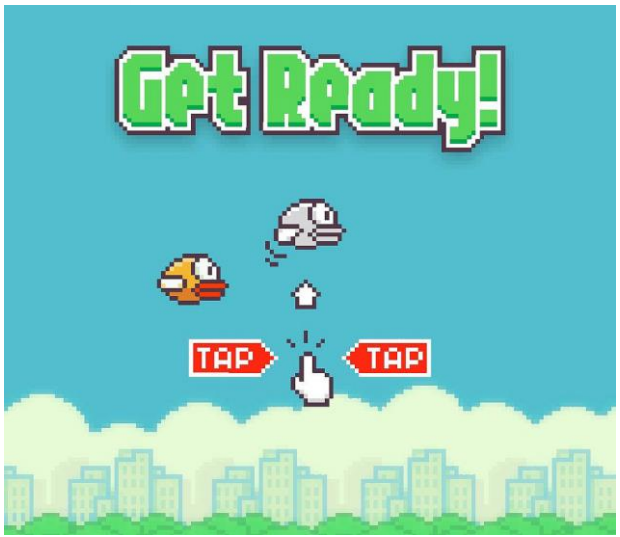


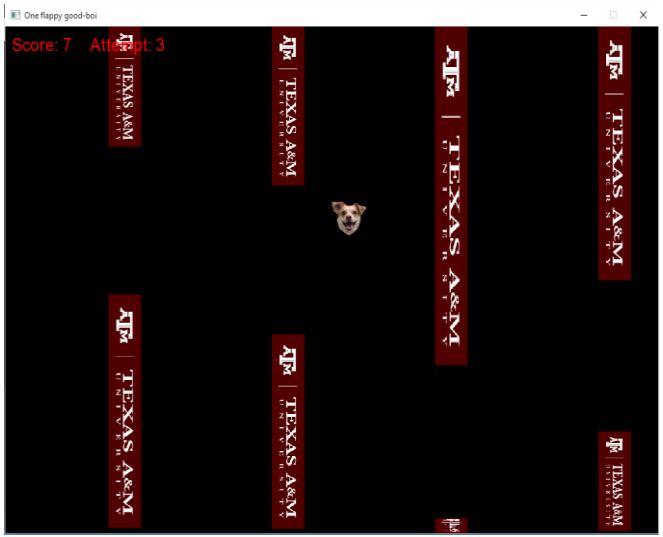
[Fig-7],[Fig-8] courtesy of the BioRobotics Laboratory, TAMU, MEEN

Methods

The interface: A simple side-scroller game **"***One flappy good boi***"**

- **Platform:** Built on C++ w/SFML [11]
- Inspired by Flappy Bird (Dong Nguyen, dotGears)
- Hit spacebar to control dog sprite, avoid obstacles





[Fig-9] Flappy Bird homescreen

Methods

The interface: A simple side-scroller game **“***One flappy good boi”*

- **Primary task (A):** Avoid obstacles, maximize score
- **Secondary task (B):** Perform math w/**A**
- **Score:** every *flap* counts, math a bonus on task **B**

Methods

The experiments: Interplay b/w stress, audio stimuli, and the primary task

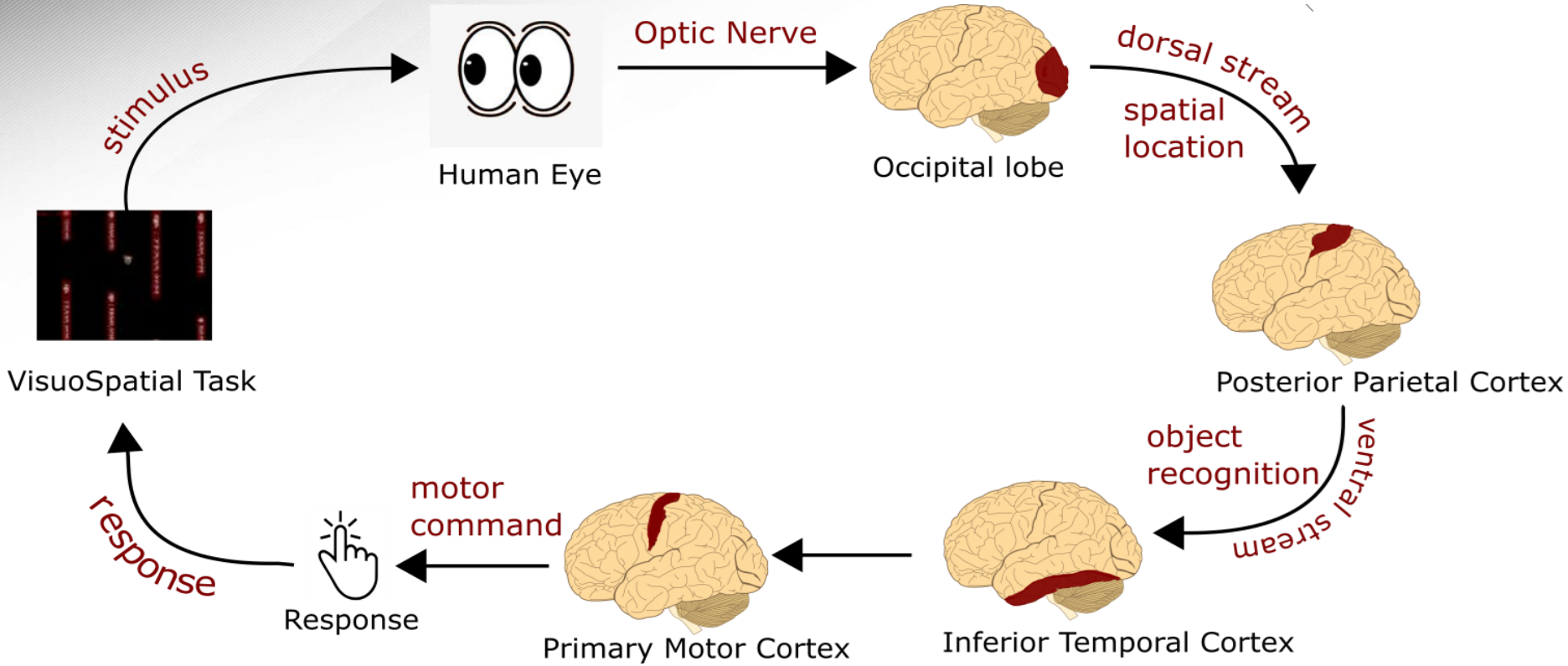
- **Music (binary):** Preferred/ undesired, ***a subjective choice***
- **Math:** Randomized three number (*0-15*) addition task
- **FileIO:** Store user score data: flap, and math for postproc
- **Modes:** Task A only, the **baseline**, common to all studies

1 Stress
- Task A+B
- Tasks A+B w/good music
- Tasks A+B w/bad music

2 Audio Stimulus
- Task A w/good music
- Task A w/bad music

2.1 Tempo
- Task A w/>800 bpm (EDM)
- Task A w/ slow jazz

Brain response



Current study

The experiments: A break down of the steps involved

- **Participants:** Our team, in compliance with TAMU IRB guidelines
- **Audio source:** Over the ear headphones and YouTube/ Spotify
- **Stages:**

Familiarization

- **25** attempts, to understand control, math task, and gameplay
- Participants respond to subjective queries about frame of mind, opinions on the task, etc.

Experimentation

- Counterbalanced experiments i.e. the order was randomized, to reduce any learning
- **25** attempts for each mode along with a **60** second break in between modes to alleviate fatigue

Post Processing

- Scores obtained in a CSV file, and normalized (feature scaling), by individual
- Combined data presented in the form of bar graphs for each experiment group

Current Study

The experiments: A break down of the steps involved

- **Participants:** Our team, in compliance with TAMU IRB guidelines
- **Audio source:** Over the ear headphones and YouTube/ Spotify
- **Stages:**

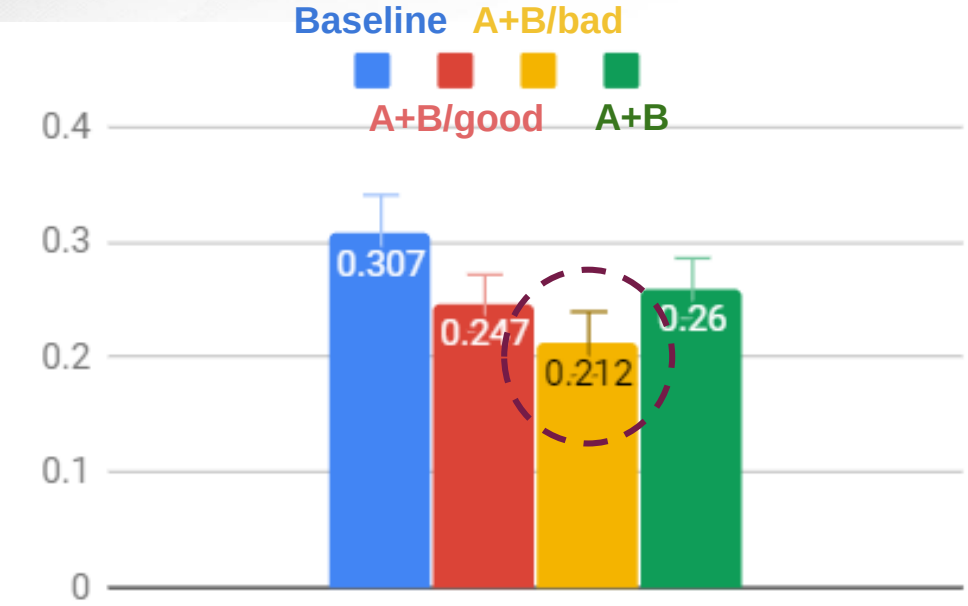
Limitations:

- Subjective measures not quantified
- Access to the right tools/ instruments (to measure perceptual load/ physiological load)
- Design of experiments
- Bias/ poor hypotheses
- Sampling errors: non-random/ quantity
- **TIME**

Results

1 Stress

- Task A+B
- Tasks A+B w/good music
- Tasks A+B w/bad music

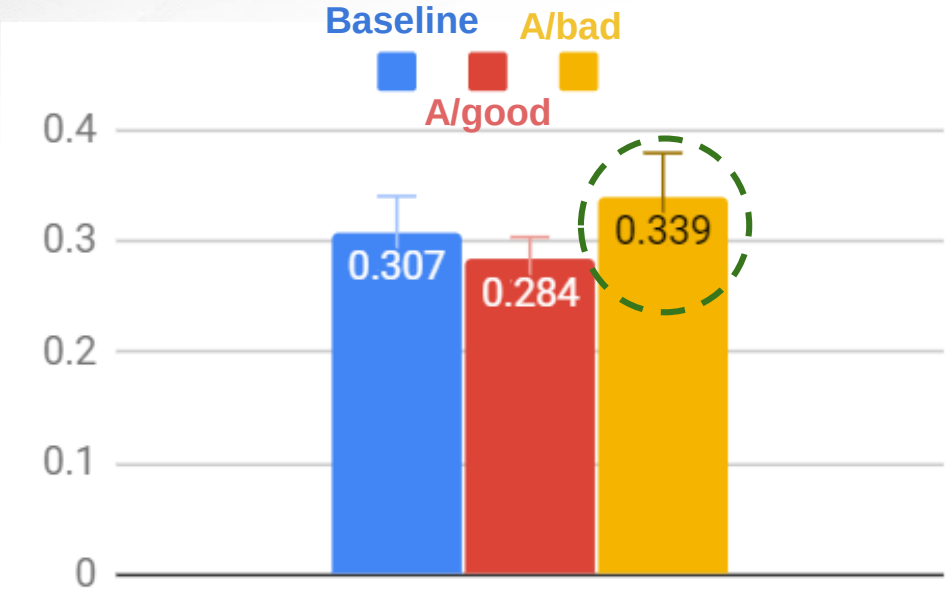


- **Cognitive stress** significantly impacts user performance
- When coupled with an undesired stimulus, user performance further reduces
- **Why:** Math and auditory stimuli demand competing pathways of activation, which affect the task

Results

2 Audio Stimulus

- Task A w/good music
- Task A w/bad music

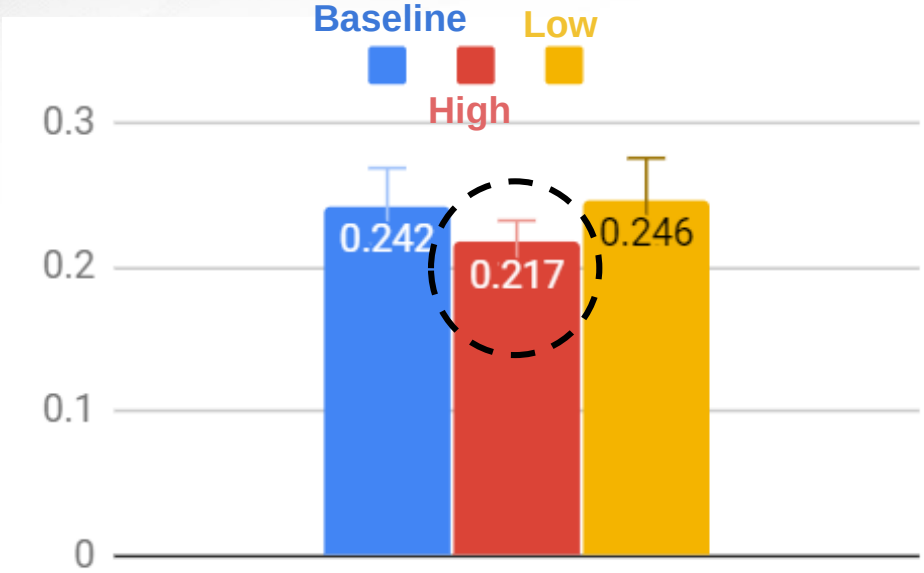


- Undesired stimulus does not hinder task performance
- Desired stimulus appears to have a negative impact
- **Why:** Desired audio stimulus is distracting, undesired/ unpleasant stimuli are easier to tune out/ ignore

Results

2.1 Tempo

- Task A w/>800 bpm (EDM)
- Task A w/ slow jazz



- Higher tempo audio negatively impacts task performance
- Lower tempo appears to have no/ negligible effect on user performance
- **Why:** Users tend to rush through a task (unforced errors), due to the higher tempo

The future

Takeaways: ..or things to focus on

1. The **coupled effect** of stress, and an undesired auditory stimulus is interesting, and it needs further research
2. Although music is distracting for the visuo-spatial task, the ability to **tune out unpleasant noise**/ stimulus should be explored
3. Investigate the role of feedback and its ability to improve user performance (over time)

Improvements: to conduct better experiments

1. **Perceptual load:** MRI, fNIRs, HR, HRV
2. **Nuanced spatial task:** 3D manipulation (physiological task)
3. **Sampling:** Include more number of participants (>3)
4. **Interface:** Bugs, better delivery for math task, etc.
5. Effective **counterbalances**, and means to alleviate **fatigue**
6. Standardized **subjective measures**: NASA TLX, etc

Impact

- Any task/problem we deal with can be discretized into the following units: ***Stimulus***, ***cognitive load***, and an ***outcome*** (our metric). Therefore, research attention on identifying correlations between the three can be useful across applications.

- The work we present in this study is synonymous to high-stress, spatial tasks that include (but are not limited to): ***Surgery, space-exploration, and precision manual-assembly***. Our findings/methods may help identify ways to improve our response under these settings.

- From our review of literature, it was evident that, although there exists a wide body of research, agreement between studies was lacking, therefore, in repeating some established techniques, we bring attention to the reproducibility, and in-turn generalization of these results.

- Continued and impactful outcomes through research in neuroscience/ neuro-electronics demand a complete functional understanding of the brain/ human behavior, a gap we hope to fulfill through research in this direction.

References

[1] Pickering, Thomas G. "Mental stress as a causal factor in the development of hypertension and cardiovascular disease." *Current hypertension reports* 3.3 (2001): 249-254.

[2] Cohen, Bethany, and J. Williamson. "Coping with stress." *Health psychology-A handbook Jossey Bass San Francisco*(1979).

[3]Tyler, Patrick, and Delia Cushway. "Stress, coping and mental well-being in hospital nurses." *Stress medicine* 8.2 (1992): 91-98.

[4] Morilak, David A., et al. "Role of brain norepinephrine in the behavioral response to stress." *Progress in Neuro-Psychopharmacology and Biological Psychiatry* 29.8 (2005): 1214-1224.

[5] Lupien, Sonia J., et al. "Effects of stress throughout the lifespan on the brain, behaviour and cognition." *Nature reviews neuroscience* 10.6 (2009): 434.

[6]Dalton, Brian H., and David G. Behm. "Effects of noise and music on human and task performance: A systematic review." *Occupational ergonomics* 7.3 (2007): 143-152.

[7]Furnham, A. and Strbac, L., 2002. Music is as distracting as noise: the differential distraction of background music and noise on the cognitive test performance of introverts and extraverts. *Ergonomics*, *45*(3), pp.203-217

[8]Kallinen, K., 2002. Reading news from a pocket computer in a distracting environment: effects of the tempo of background music. *Computers in Human Behavior*, *18*(5), pp.537-551.

[9] Vytal, K.E., Cornwell, B.R., Arkin, N.E., Letkiewicz, A.M. and Grillon, C., 2013. The complex interaction between anxiety and cognition: insight from spatial and verbal working memory. *Frontiers in Human Neuroscience*, *7*, p.93.

[10] Cebulski, S., The Effect of Stress on Visuo-Spatial Working Memory.

[11] https://www.sfml-dev.org/

Additional figure citations:

[Fig-1] https://my.clevelandclinic.org/health/treatments/16908-about-robotic-assisted-surgery

[Fig-2] https://www.pacific.edu/admission/graduate-programs.html

[Fig-3] https://www.pinterest.com/pin/134756213827344726/

[Fig-9] Flappy Bird by Dong Nguyen, dotGears inc.

That’s all folks!