Biking vs. Button Pressing: A Naturalistic Approach to Effort-Based Decision-Making

Vivek Anand[1], Dongyeun Kim[1], Camilla May[1], Zeke Gleichgerrcht[2], Neal Laxpati[2], Chris Rozell[1] & Sankar Alagapan[1]

[1]Georgia Institute of Technology [2]Emory University

Motivation

Effort-based decision-making (EBDM) paradigms objectively quantify motivation by measuring how individuals weigh effort costs against rewards, providing insights beyond subjective reports [1]. Traditional button-press tasks [2-3], lack ecological validity and do not capture sustained, whole-body effort typical of real-world behavior. Our preliminary results analyzing high resolution SEEG recordings show that under-the-desk biking, a more naturalistic effort, shows differential neural activations in insula during effortful activity. We hope that our eventual work will reveal neural mechanisms of motivation during naturalistic effort.

Task Design

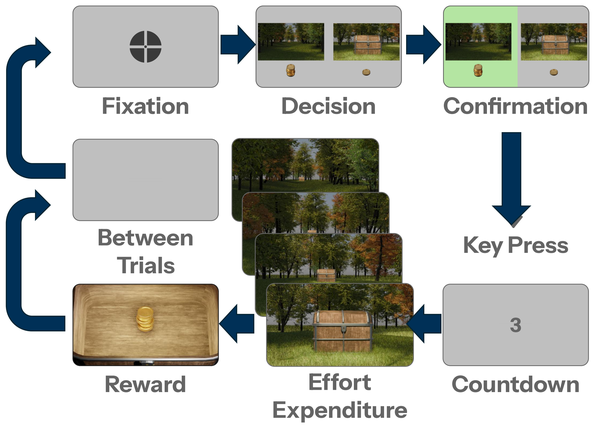


Fig 1. EBDM Task Design. Participant decides between a reference and variable effort reward pair and performs effortful task (button pressing or biking) to receive reward if successful for four blocks of six trials each.

Instrumentation

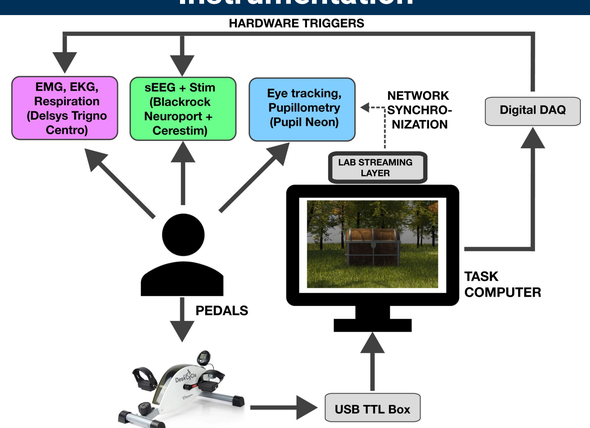
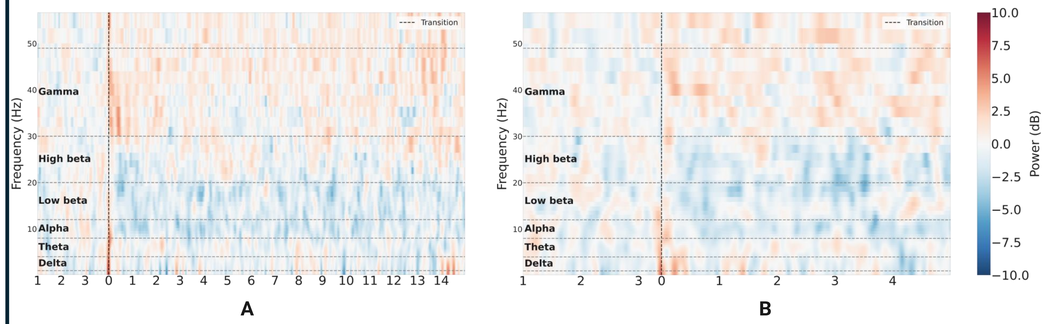


Fig 2. Instrumentation of data collection setup. Multiple modalities (eyetracking, pupillometry, EMG, SEEG, EKG) are all collected synchronously with the task.

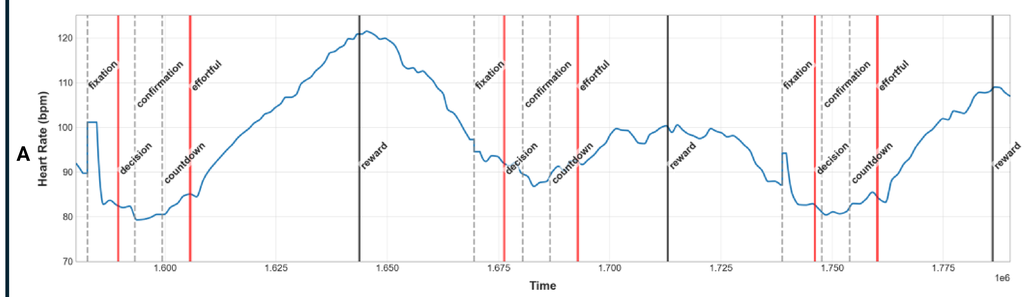
Biking vs Button Pressing Differentially Modulates Brain Oscillations



__Reduction__ in __alpha__ and __low beta; Increase__ in __high gamma__ during the effortful phase.
__Reduction__ in __high beta__ for button pressing but __not__ biking

Fig 3. Baseline Corrected and Averaged Spectrograms for Right Middle Insula. A) Under the desk Biking B) Button Pressing (Current Standard in EBDM tasks)

Biking Modulates Heart Rate



Heart rate __increases__ during the effortful phase for biking but __not__ button pressing.
Heart rate __decreases__ after effortful phase.

Fig 4. Heart rate over multiple trials. A) Under the desk Biking B) Button Pressing

Electrode Placement

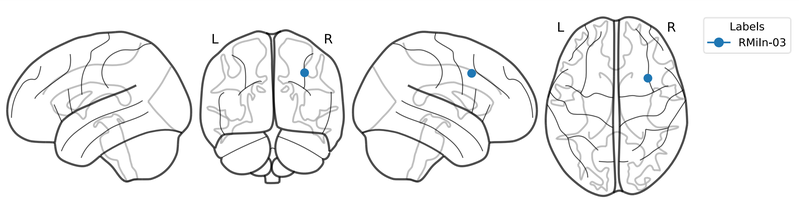
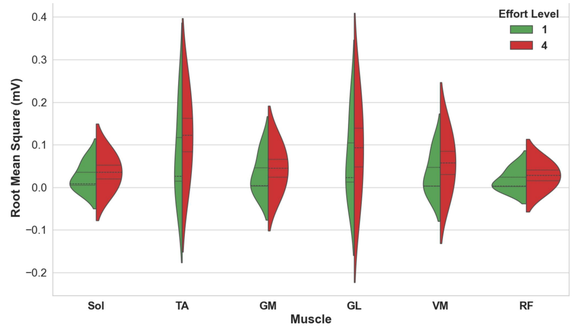


Fig 5. Electrode Location of the Right Middle Insula (Lead RMiIn3)

Biking Differentially Modulates Muscle Activity



Increased effort level during the biking task is associated with __greater EMG activation__ (RMS) across all six recorded leg muscles

Fig 6. Muscle Activations Between Low and High Effort Trials. Muscles: Soleus, Tibialis Anterior, Gastrocnemius Medialis, Gastrocnemius Lateralis, Vastus Medialis, Rectus Femoris

Conclusion

Task specific differences for effortful tasks can significantly bias decisions chosen [4], a result we see too. Therefore, there is a need to employ *naturalistic tasks* which better approximate real-life situations to avoid task biases. Specifically, we find that

1. **The Right Middle Insula differentially modulates for button pressing versus biking** during the effortful phase for the high beta bands and has been implicated in playing key role in physical and cognitive effort. [5-6]
2. **Effort levels differentially modulate muscle activations.**

Future work will explore:

- **Neural correlates of choice behavior during physical exertion:** we will identify neural and auxiliary correlates of decision variables involved in decision making tasks
- **Auxiliary predictors of neural signals:** we will build models to use auxiliary signals to predict neural activity in decision relevant regions.

References

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