DS-4101 Human-Technology Interaction

Cognitive Load detection & Stress Reduction using Game Notifications

A Healthier Alternative to Social Media Breaks for Students

16th December, 2024

By Team Cognitune

Agenda Overview

01 Problem Statement

02 Literature Survey

03 Experiment Protocol

04 Analysis & Findings

05 Challenges & Limitations

06 Impact

Problem Statement

Many students, including those at our university, take breaks during study sessions to maintain focus and productivity. However, these breaks can often become counterproductive when students engage in activities like scrolling through social media platforms such as Instagram or YouTube. These platforms offer highly engaging, algorithm-driven content, like reels or shorts, which are designed to capture and hold attention for long periods.

Extended Breaks

Social media is designed to keep users scrolling, often leading to prolonged breaks where students lose track of time.

Post-Break Distraction

After using social media, students often find themselves distracted when they try to return to their studies. This is because social media content stimulates parts of the brain that make it harder to refocus on academic tasks.

Why is this a problem?

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1. Reduced Productivity

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2. Mental Fatigue & Stress

Why is this a problem?

1. Reduced Productivity
2. Mental Fatigue & Stress
3. A Common Experience

Practical Applications

Enhanced Study Techniques

Our project can help students adopt stress-reducing games during study breaks to enhance cognitive recovery, minimize distractions, and boost academic performance, complementing techniques like the Pomodoro Method.

Workplace Productivity Solutions

Our solution could be integrated into corporate wellness programs and to improve productivity and reduce burnout through stress-reducing games during breaks.

Therapeutic Settings

Cognitive-behavioral therapists or psychologists could recommend specific stress-reducing games as part of therapeutic interventions for students or individuals dealing with high stress or cognitive overload.

Game Design and Development

Insights from our research could inspire game developers to design new games specifically tailored for break-time stress relief.

Literature Survey

Heart rate response to cognitive load as a marker of depression and increased anxiety

Evgeniia I. Alshanskaia[1*†], Natalia A. Zhozhikashvili[2†], Irina S. Polikanova[3] and Olga V. Martynova[3,4,5]

Frontiers

AIM: To examine HR and HRV responses to cognitive load and their association with anxiety and depression traits.

METHODOLOGY: HR and HRV were recorded via ECG and PPG during a 1-back cognitive task with varying difficulty levels in 90 participants.

CONCLUSION: HR increased with task difficulty, showing sensitivity to cognitive load, and was higher in individuals with anxiety and depression traits.

source

How do students engage with computer-based assessments: impact of study breaks on intertemporal engagement and pass rates

Quan Nguyen[1] · Sam Thorne[2] · Bart Rienties[1]

Behaviormetrika - SpringerLink

AIM: To investigate the effect of study breaks and exam preparation weeks on students' engagement and module pass rates in a computer-based assessment environment.

METHODOLOGY: The study involved using a mixed-effect logistic regression model, the study analyzed data from 123,916 students across 205 modules and examined their engagement patterns over time using virtual learning environment (VLE) logs.

CONCLUSION: Study breaks positively impacted the odds of passing, with additional study breaks increasing pass rates by 28%.

source

The Effect of Reels on Attention among Young and Middle-Aged Adults

Annesha Das[1]*, Ms. Hrithika Mishra[2]

The International Journal of Indian Psychology

AIM: To investigate how short-form videos, like Instagram Reels, impact the attention and cognitive load of young and middle-aged adults.

METHODOLOGY: The study analyzed 30 papers and used surveys and questionnaires to compare the effects of reels on attention span, distraction, and cognitive load between young and middle-aged participants.

CONCLUSION: The study found that short-form videos significantly increase cognitive overload and distraction, especially in young individuals, while middle-aged adults exhibit better attention control, albeit still impacted by extended exposure to reels

source

Neurobiological Link between Stress and Gaming: A Scoping Review

by Grace Y. Wang [1,2,*], Dovile Simkute [3] and Inga Griskova-Bulanova [3]

MDPI - Journal of Clinical Medicine

AIM: To explore the neurobiological relationship between video gaming and stress, examining how gaming influences physiological stress responses, particularly in the context of gaming addiction.

METHODOLOGY: A scoping review of 11 studies published between 2012 and 2022, analyzing neurobiological methods such as EEG, heart rate, and cortisol levels to understand gaming's impact on stress responses.

CONCLUSION: Gaming can stimulate stress-like physiological responses, with these effects influenced by the individual's biological profile, gaming history, and content. While casual gaming may reduce stress, certain game types (e.g., competitive) may increase stress markers like cortisol and blood pressure

source

Stress-Reducing Effects of Playing a Casual Video Game among Undergraduate Students

Veeral Desai [1,2] · Arnav Gupta [3] · Lucas Andersen [4] · Bailey Ronnestrand [4] · Michael Wong [1,4,5]

Brazilian Society of Psychology

AIM: To compare the effectiveness of playing a casual video game (Flower) versus participating in a mindfulness meditation session for reducing stress among undergraduate students.

METHODOLOGY: The study involved 80 undergraduate participants, randomly assigned to either a 20-minute session of the video game or a mindfulness body scan. Stress was measured both psychologically (PSM-9) and physiologically (heart rate, blood pressure) before and after the interventions.

CONCLUSION: Both interventions significantly reduced stress, though mindfulness meditation showed a greater reduction in self-perceived stress. However, casual gaming also lowered physiological stress, suggesting it can serve as an accessible and effective stress reduction tool for students

source

Analyzing Stress Responses through ECG: The Influence of Virtual Reality on Human Physiological Condition

Mehul Pandey*, Deepak Mishra†

IISST Trivandrum

AIM: To examine the potential of virtual reality (VR) environments in reducing stress, using ECG signals to analyze physiological changes in participants under different conditions (resting, stress, and post-VR exposure).

METHODOLOGY: The study involved 40 participants aged 18-25, who were exposed to three conditions: resting, stress-inducing tasks (e.g., chess, mathematical problems), and a relaxing VR environment. Heart rate variability (HRV) data were collected via ECG and analyzed using machine learning models.

CONCLUSION: The VR environment significantly improved HRV metrics, indicating a reduction in stress after VR exposure. The findings support VR's potential as an effective stress-reduction tool, though it may require integration with other interventions for more substantial stress relief

source

Methodology

Quantitative Methods

We collected and analyzed quantitative data, including heart rate (HR) and accuracy scores. This allowed us to identify trends, patterns, and relationships in participants' cognitive performance before and after the break.

Qualitative Methods

We gathered qualitative data through surveys to understand participants' perceived effects of the break activities on their stress and focus levels.

Our Hypothesis

H0 (Null Hypothesis):

There will be no significant change in cognitive load after playing a stress-relieving game during breaks.

H1 (Alternate Hypothesis):

Playing a stress-relieving game during breaks leads to a noticeable decrease in cognitive load compared to using social media.

Experimental Protocol

Experimental Protocols

Baseline Stabilisation

Cognitive Task

Break

Repeat Cognitive Task

Survey

Baseline Stabilisation

- **Objective:**
  - Establish a baseline for participant vitals to compare against post-task data
- **Procedures:**
  - Measure HR
- **Duration:** 30s – 1 minute
- **Purpose:**
  - To ensure any physiological or cognitive changes are attributable to the intervention

Consent

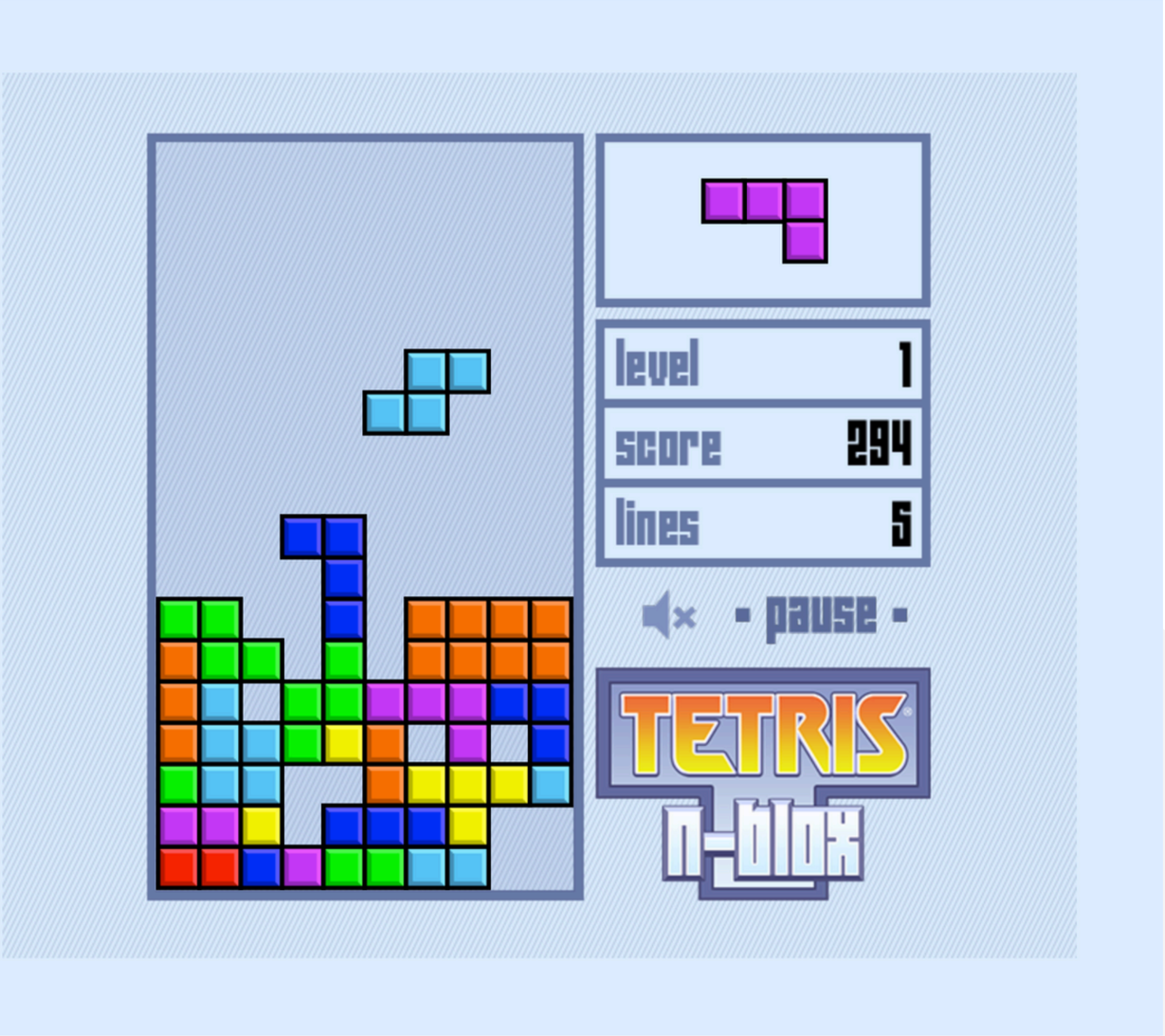
- **Description:**
  - Participants provided informed consent to participate in the study
- **Procedures:**
  - Consent Form
- **Duration:** 30s – 1 minute
- **Purpose:**
  - To ensure participants understood the study procedures and voluntarily agreed to take part

Cognitive Task: Pre-Break

- **Task Description:**
  - Participants solved 5 logical reasoning & 5 arithmetic questions
- **Duration:** 5 minutes
- **Rationale:**
  - Tasks are designed to simulate real study conditions and induce a cognitive load
- **Objective:**
  - Assess initial cognitive performance and physiological responses

Break Session

- **Activity Options:**
  - Play a stress-reducing game (Tetris) OR browse social media
- **Duration:** 2 minutes (including the logistical measures).
- **Purpose:**
  - Explore the impact of different types of short breaks on cognitive and physiological recovery.
- **Objective:**
  - Determine which activity offers better stress relief and cognitive recovery.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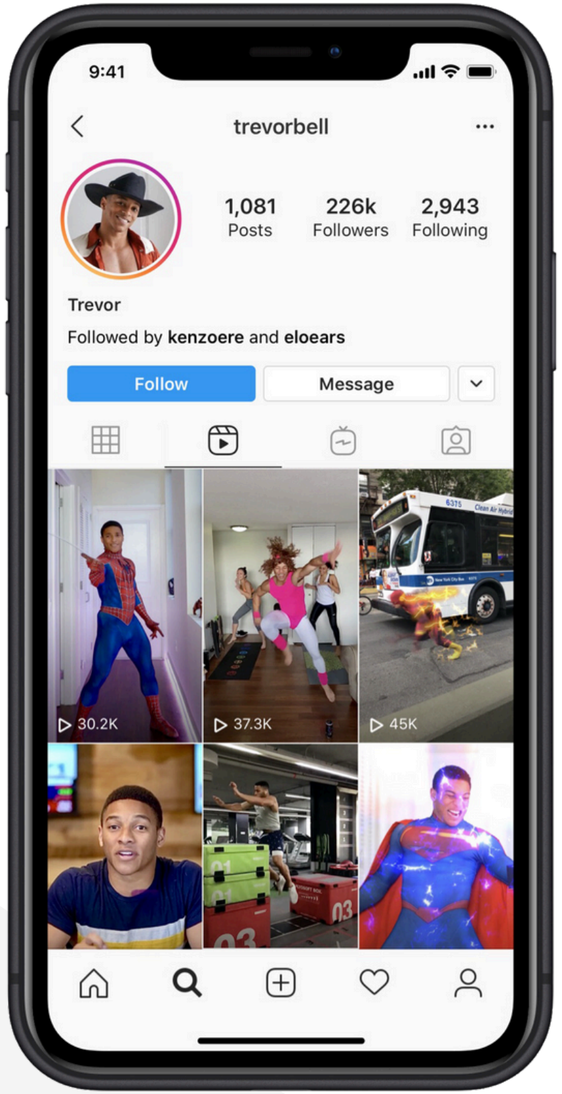
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2,943
Following
Trevor
Followed by kenzoere and eloears
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Message
30.2K
37.3K
45K

Cognitive Task: Pre-Break

- **Task Description:**
  - Participants solved 5 logical reasoning & 5 arithmetic questions (different questions)
- **Duration:** 5 minutes.
- **Rationale:**
  - Tasks are designed to simulate real study conditions and induce a cognitive load.
- **Objective:**
  - Assess initial cognitive performance and physiological responses.

Post-Experiment Survey

- **Survey Content:**
  - Collect feedback on task difficulty, stress levels, and the perceived effectiveness of break activities.
- **Duration:** 30s - 1 minute.
- **Purpose:**
  - Collect subjective/qualitative data to complement physiological and performance metrics.
- **Objective:**
  - Enhance understanding of the interventions' impact from the participants' perspectives.

Post-Experiment Survey

Thank you for participating in our study and contributing to the data collection process. Your input is invaluable in helping us understand how different activities impact stress and focus during study sessions.

We kindly request you to take a moment to complete this short survey. It will only take 1-2 minutes and will provide us with important insights to complement our findings. Your responses are greatly appreciated!

1. **What activity were you asked to do during the break?** *

- ◯ I played a game (e.g., Tetris)
- ◯ I scrolled social media (e.g., reels)

4. **How relaxing was the break activity?** *

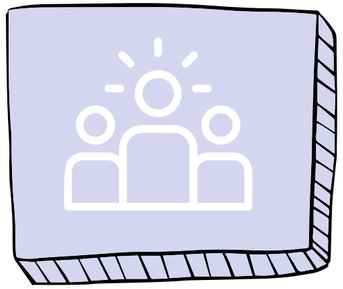
	Not at all relaxing	Slightly relaxing	Moderately relaxing	Very relaxing	Extremely relaxing
	◯	◯	◯	◯	◯

Website Demo

https://dakshinator.github.io/HTI-Exp/

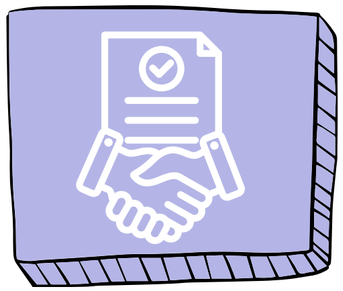
Analysis & Findings

Experiment DETAILS



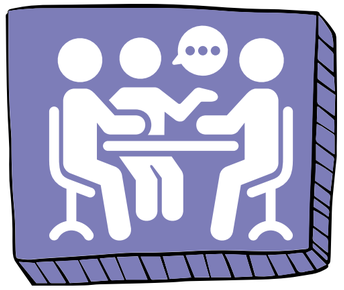
01. Participants

Participants: 33 undergraduate students, randomized into control and treatment groups.



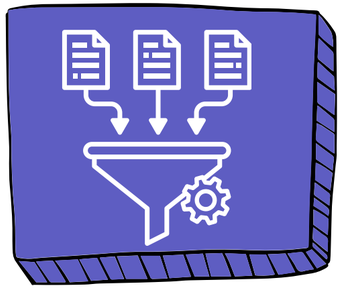
02. Consent

- **Details:** Informed participants of study purpose, data collection, and usage.
- **Process:** Consent form signed by participants before starting the experiment.



03. Groups

- **Control Group:** Used social media during the break.
- **Treatment Group:** Played a game (Tetris) during the break to reduce cognitive load.
- Both groups did the **same cognitive tasks.**



04. Data Collecion

Objective Data:

- HR (hrband smartwatch),
- Section-wise accuracy scores

Subjective Data:

- Stress & Performance Perception through Survey Form

Data Description

Data Source	Type	Description
Sensor Data	Quantitative (HR)	Data on heart rate collected during tasks
Task Performance Data	Quantitative (Accuracy)	Accuracy scores achieved during cognitive tasks
Survey Data	Qualitative (Survey - Likert)	Participant responses on stress, relaxation, and performance

Data Preprocessing

Original Dataset

- 15 columns (e.g., timestamp, speed, sleep_class, hr, etc.

Column Selection

- Retained only timestamp and hr as relevant features

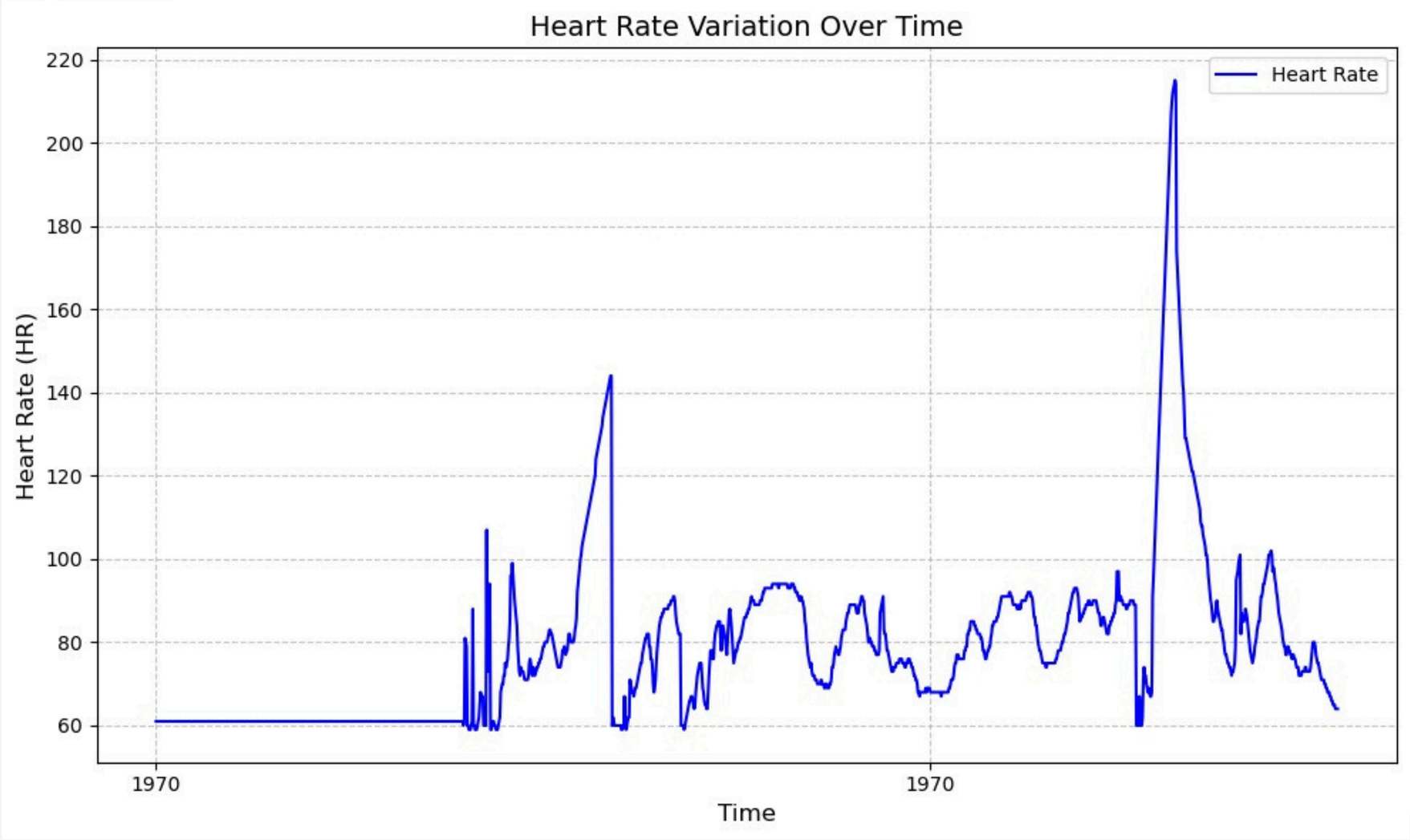
Unit Encoding

- Timestamp units were ambiguous hence Encoded time-based units:
  - 1, 2, 3, 4, ..., n for each timestamp

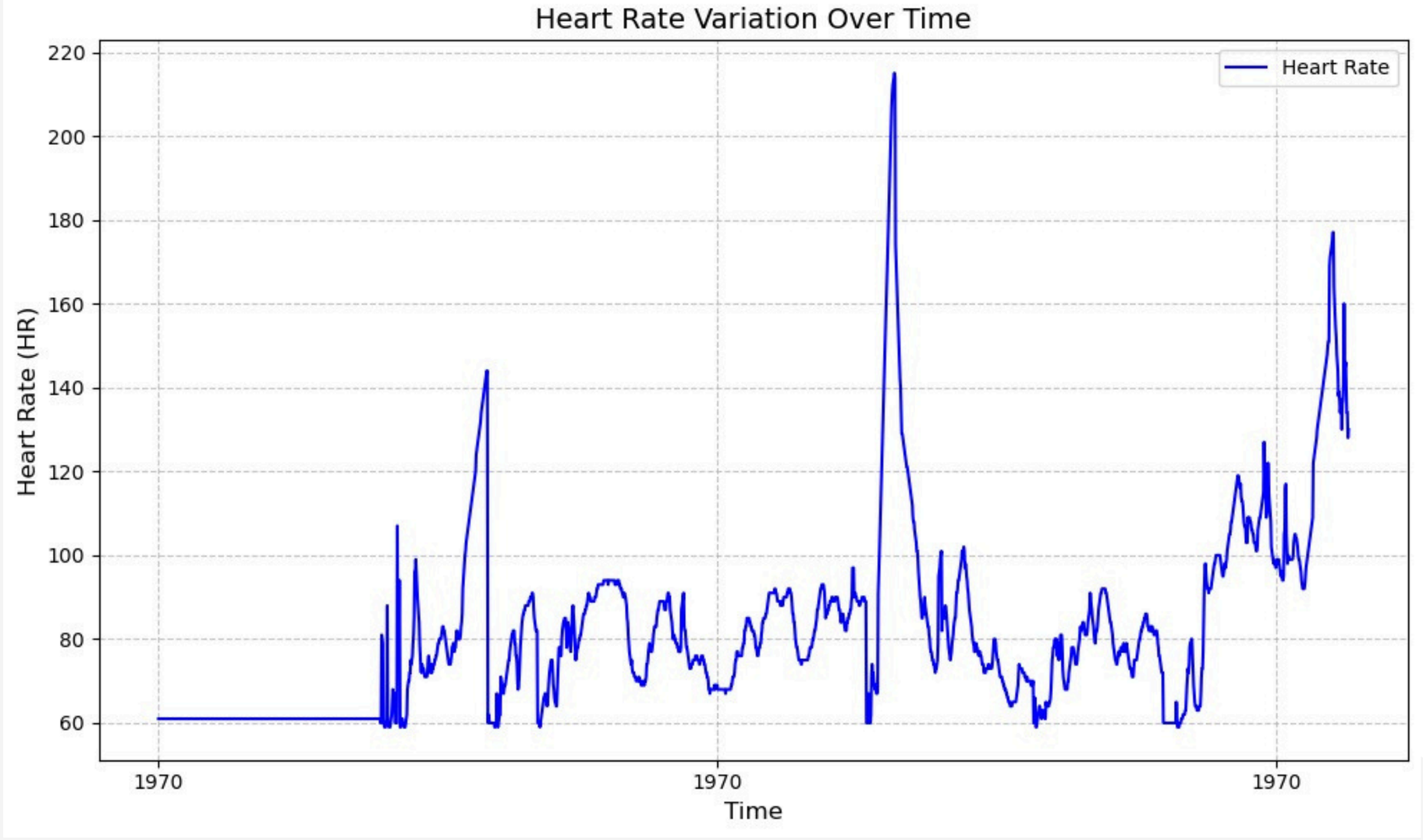
Data Cleaning

- No NaN values in hr
- Trimmed data to correct slight timing inconsistencies across participants
- Ensured uniformity for consistent analysis

Findings


Heart Rate Variation Over Time
Heart Rate
Heart Rate (HR)
220
200
180
160
140
120
100
80
60
1970
1970
Time

Findings


Heart Rate Variation Over Time
Heart Rate
Heart Rate (HR)
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200
180
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120
100
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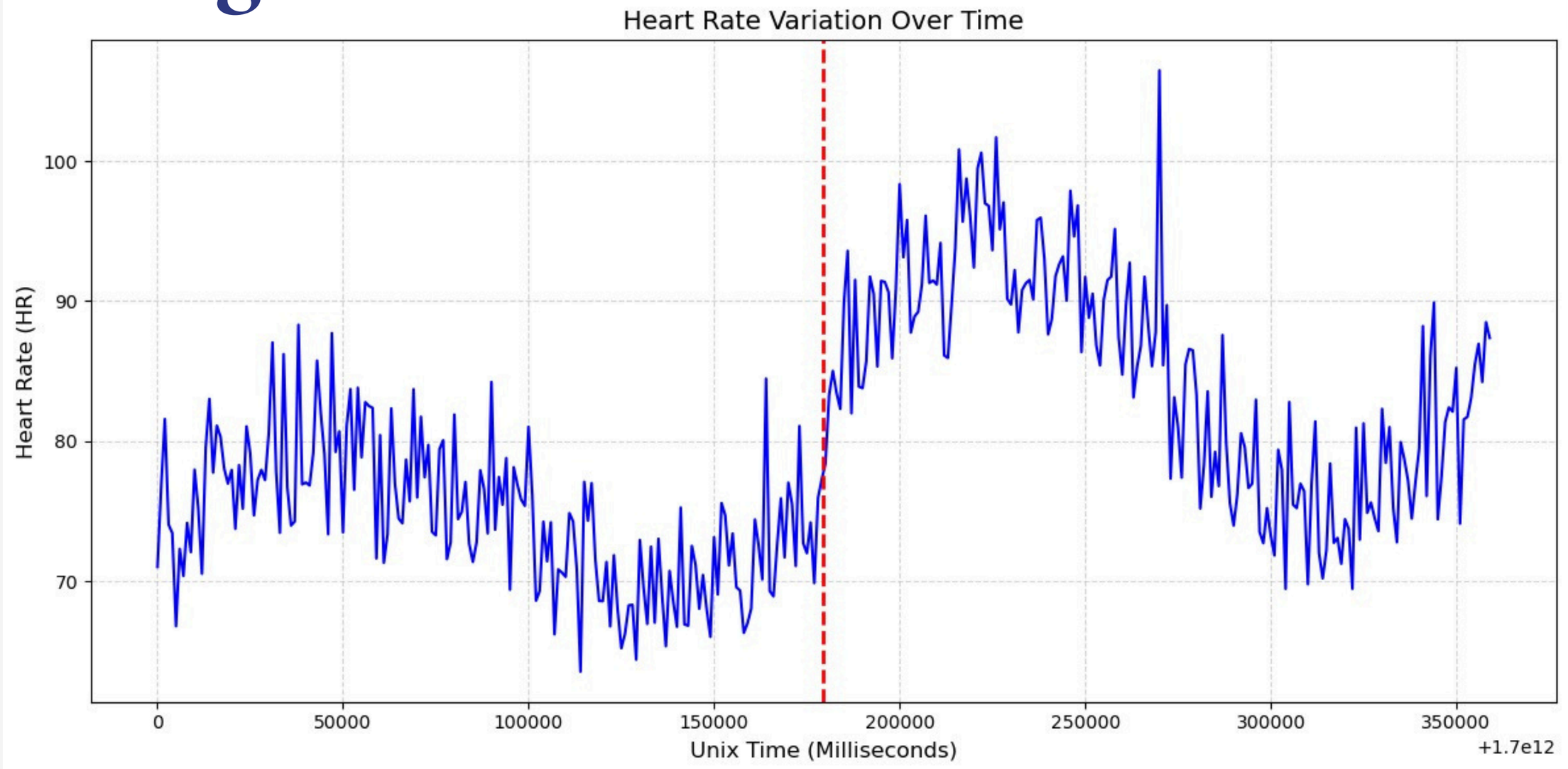
60
1970
1970
1970
Time

Findings


Heart Rate Variation Over Time
Heart Rate (HR)
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80
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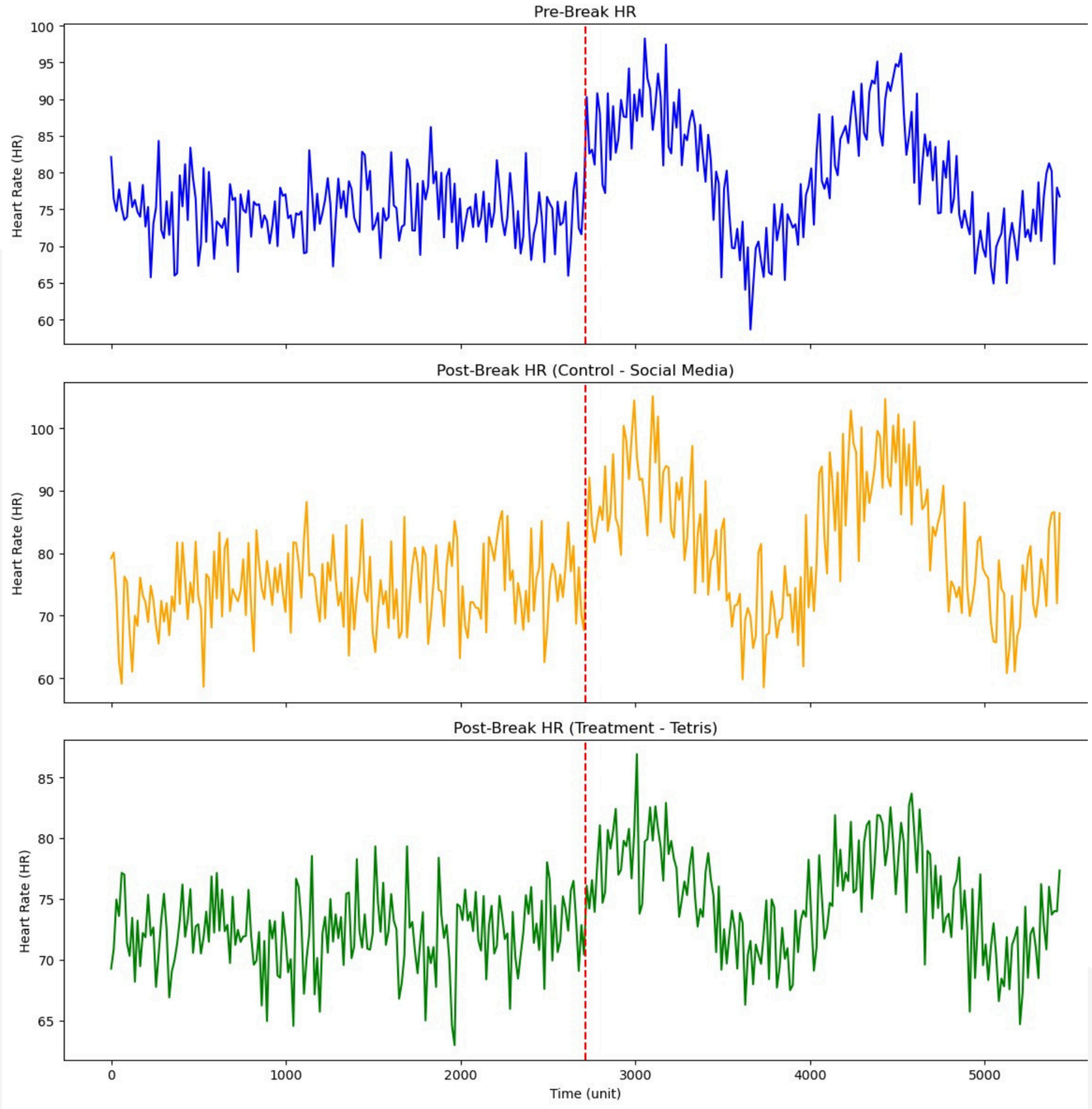
200000
250000
300000
350000
Unix Time (Milliseconds)
+1.7e12

Findings



No of Participants = 33

N_Control= 16

N_Treatment = 17

Findings

Accuracy Scores Table - Pre-Break and Control Group:

	Section	Pre-Break	Post-Break Control
0	Logical	2.94982	2.83421
1	Math	3.18029	2.96469

Accuracy Scores Table - Pre-Break and Treatment Group:

	Section	Pre-Break	Post-Break Treatment
0	Logical	2.94982	3.19621
1	Math	3.18029	2.76055

Quantitative Comparison

Metric	Heart Rate (HR) Data	Task Performance Scores	Key Insights
Pre-Break Trends	HR steadily increased before the break, indicating accumulated cognitive load and stress.	Logical: **2.94982** Math: **3.18029**	Increasing HR aligns with the cognitive fatigue reflected in baseline task scores.
Post-Break - Control Group	HR remained elevated and variable, showing minimal stress reduction post-social media scrolling.	Logical: **2.83421** (↓) Math: **2.96469** (↓)	Elevated HR correlates with **poorer task performance** post-break, showing limited cognitive recovery.
Post-Break - Treatment Group	HR became lower and more stable, indicating reduced stress and better physiological recovery after Tetris.	Logical: **3.19621** (↑) Math: **2.76055** (↓)	Stable HR aligns with **improved logical reasoning**. However, math scores declined, possibly due to continued fatigue.

Overall Comparison

Metric	Quantitative Findings	Qualitative Findings	Key Insights
Relaxation	Tetris resulted in lower HR and better HR stabilization, suggesting relaxation.	Tetris was rated as “Very relaxing” and “Extremely relaxing” by participants.	Physiological relaxation (HR) aligns with perceived relaxation.
Performance Perception	Logical task scores improved; social media saw a slight performance decline.	Tetris participants “Strongly agreed” on improved task performance post-break.	Perceived and actual performance improvement align for logical tasks.
Task Performance - Math	Math scores declined post-Tetris (3.18029 → 2.76055), suggesting cognitive fatigue.	Participants “Strongly agreed” that Tetris improved their performance.	Participants likely perceived their improved logical reasoning performance as an overall success while overlooking the decline in math scores due to self-satisfaction bias.

Challenges & Limitations

Hardware and Data Collection Constraints	Participant-Related Factors
Survey and Reporting Issues	External and Environmental Factors

Impact

Redefining Break Strategies:

The findings challenge the use of social media as a break activity, which, while easy, lacks measurable benefits for stress reduction or performance. In contrast, Tetris, as a simple and engaging activity, effectively reduces physiological stress and enhances logical reasoning performance.

Role of Intrinsic Motivation and Task Stress:

Real-world tasks carry intrinsic stress and pressure to perform well, which can override the restorative effects of break activities, including games. This highlights the complex interplay between mental recovery, task demands, and personal motivation in shaping post-break performance outcomes.

Exploring Other Break Activities:

While Tetris proved effective, other games or activities may perform better based on individual preferences, task types, or stress levels. Future studies can explore alternatives like mindfulness exercises or physical activities to identify optimal recovery tools for diverse needs.

Larger Workplace and Educational Impact:

In high-stress environments like workplaces, schools, or research labs, tailored break strategies can reduce burnout, boost productivity, and enhance performance. Introducing game-based breaks for logical reasoning or relaxation-focused interventions can promote sustained focus and mental recovery.

Why This Matters in the Modern World:

In a world driven by social media, FOMO, and the constant craving for instant dopamine hits, social media has become the default escape for children, young adults, and working professionals. While the need to escape life's challenges is debatable, the means of escape urgently require a transformation.

Taking up projects that seek healthier and more effective alternatives to passive scrolling is the need of the hour. These purposeful breaks can reduce stress, improve focus, and foster mental recovery, offering a scalable method to counter the adverse effects of our digital habits.

Annexure

Can HRV be calculated from simple heart rate?

In short, no.

Heart rate (HR) is measured in beats per minute. It does not require exact times – just the average of the beats in a given time period. For example, 60 beats per minute HR could mean 1 beat per second or it could mean an average of 1 beat every 0.5s, 1.5s, 0.5s, 1.5s, etc.

While heart rate focuses on the average beats per minute, **heart rate variability** (HRV) measures the specific changes in time (or variability) between successive heartbeats. The time between beats is measured in milliseconds (ms) and is called an “R-R interval” or “inter-beat interval (IBI).”

The recommended minimum number of times per second that a **heart rate variability** sensor should sample for a beat is 250. This can be referred to as 250Hz. Any monitor with a lower sample rate should not be considered HRV-accurate.

https://elitehrv.com/

Thank You!

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