



University of Geneva

Faculty of Science & CUI

Zahra Jaleh, Seyedvahid Mousavinezhad



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About Cheesy Math



01

01 Cheesy Math I

Objective

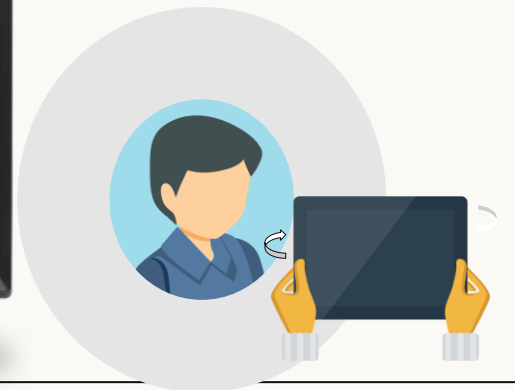
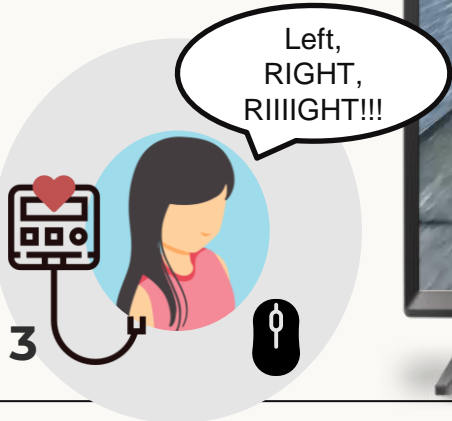
- The project aims to assess how the quality of human performance in solving easy math problems differs when individuals focus solely on math puzzles versus when playing a video game.

Game

- For this purpose, we've created a runner game with two-player control. In the game, they collect cheese and solve math puzzles.

01 Cheesy Math II

Game Play



01 Cheesy Math III

Updates I

Professor Chanel

- When Mousy approaches the right and left boundaries too closely, players hear different alarms. It helps the second player better control the character.

```
if ((accelerationX < -0.1f) || (Input.GetKey(KeyCode.LeftArrow))){  
    // Move Left if the device is tilted to the left  
    if (this.gameObject.transform.position.x > PlayerBoundary.leftBoundry)  
    {  
        transform.Translate(Vector3.left * Time.deltaTime * moveSideSpeed);  
        if (this.gameObject.transform.position.x < PlayerBoundary.leftBoundry + boundryTreshold){  
            // Play sound to inform that Player approach to the left boundry  
            leftCrashFX.Play();  
        }else{  
            leftCrashFX.Stop();  
            rightCrashFX.Stop();  
        }  
    }  
}
```

01 Cheesy Math IV

Updates II

Professor Moccozet

- Count the number of speed changes during the game for each participant.

```
if fastValueOld != fastValue:
    time_save = datetime.datetime.now() - start_game
    result.append({'id': it, 'time': int(time_save.total_seconds()), 'HR mean': HR_mean, 'fast value': fastValue})
    result_df = pd.DataFrame(result)
    result_df.to_csv(result_path, index=False)
    it += 1
```

| | A | B | C | D |
|----|----|------|---------|------------|
| 1 | id | time | HR mean | fast value |
| 2 | 1 | 30 | 85.02 | 1 |
| 3 | 2 | 61 | 95.3 | 0 |
| 4 | 3 | 112 | 85.41 | 1 |
| 5 | 4 | 122 | 92.64 | 0 |
| 6 | 5 | 133 | 80.92 | 1 |
| 7 | 6 | 153 | 88.14 | 0 |
| 8 | 7 | 164 | 84.64 | 1 |
| 9 | 8 | 235 | 90.12 | 0 |
| 10 | 9 | 245 | 84.79 | 1 |
| 11 | 10 | 255 | 85.93 | 0 |

Research Question



02

02 Research Question I

How does playing video games affect human performance in solving easy math problems?

- Before the game, one player answers 10 math questions in 1 minute (Six seconds per question).
- During the game, they respond to similar questions.
- Measure the differences in their math-solving performance.

02 Research Question II

What about the noisy data?

- A supervisor notes player one's answers while they guide player two.
- It helps to reveal interaction errors.

02 Research Question II

Hypothesis

- An underlying assumption in our research is that the player's math-solving performance during the game would likely be less accurate compared to when they were not playing.
- This hypothesis is rooted in the notion that the act of gaming introduces multitasking and distractions that could affect performance.

Emotional Model



03

04 Emotional Model I

Flow

- Change the speed of the character based on the changes in heart rate.
- In different levels of difficulty, the HR will change, with higher HR as the difficulty increases. *

04 Emotional Model II

Flow

- Before the game, we set a baseline heart rate (HR) for player one by calculating the mean.
- During the game, we dynamically adjust the character's speed based on their heart rate mean fluctuations.

```
# ECG signal processing using biosppy library and extract Heart Rate  
HR = ecg.ecg(signal=ECG_list, sampling_rate=1000., show=False)["heart_rate"]  
  
# Compute HR mean for each window  
HR_mean = np.round(np.mean(HR), 2)
```

04 Emotional Model III

For each window size of 10 seconds:

- If the player's Mean of HR dropped below the baseline, indicating a decrease in arousal or engagement
 - **Increase the character's speed**
- If the HR exceeded the baseline, indicating heightened arousal
 - **Decrease the character's speed**

```
if HR_mean < baseline and fastValue == 0:  
    fastValue = 1  
    print("go faster")  
  
if HR_mean > baseline:  
    fastValue = 0  
    print("go slower")
```

04 Problem Fixed

HR label

ECG label

OpenSignals Saved Data

```
# OpenSignals Text File Format. Version 1
# {"00:21:06:BE:15:D9": {"position": 0, "device": "bitalino_rev", "device name":
"00:21:06:BE:15:D9", "device connection": "BTH00:21:06:BE:15:D9", "sampling rate": 1000,
"resolution": [4, 1, 1, 1, 1, 10, 10, 10, 10, 6, 6], "firmware version": 1282, "comments":
"", "keywords": "", "mode": 0, "sync interval": 2, "date": "2023-8-17", "time":
"10:37:31.126", "channels": [1, 2, 3, 4, 5, 6], "sensor": ["RAW", "HR", "RAW", "RAW", "RAW",
"RAW"], "label": ["A1", "A2", "A3", "A4", "A5", "A6"], "column": ["nSeq", "I1", "I2", "O1",
"O2", "A1", "A2", "A3", "A4", "A5", "A6"], "special": [{}, {}, {}, {}, {}, {}], "digital
IO": [0, 0, 1, 1]}}
# EndOfHeader
0 0 0 0 0 0 606 0 0 0 0
1 0 0 0 0 0 613 0 0 0 0
2 0 0 0 0 1 615 0 0 0 0
3 0 0 0 0 0 614 0 0 0 0
4 0 0 0 0 0 595 0 0 0 0
5 0 0 0 0 0 576 0 0 0 0
6 0 0 0 0 0 548 0 0 0 0
7 0 0 0 0 0 507 0 0 0 0
8 0 0 0 0 0 472 0 0 0 0
9 0 0 0 0 0 445 0 0 0 0
```

```
# OpenSignals Text File Format. Version 1
# {"00:21:06:BE:15:D9": {"position": 0, "device": "bitalino_rev", "device name":
"00:21:06:BE:15:D9", "device connection": "BTH00:21:06:BE:15:D9", "sampling rate": 1000,
"resolution": [4, 1, 1, 1, 1, 10, 10, 10, 10, 6, 6], "firmware version": 1282, "comments":
"", "keywords": "", "mode": 0, "sync interval": 2, "date": "2023-8-17", "time":
"10:54:35.279", "channels": [1, 2, 3, 4, 5, 6], "sensor": ["RAW", "ECGBIT", "RAW", "RAW",
"RAW", "RAW"], "label": ["A1", "A2", "A3", "A4", "A5", "A6"], "column": ["nSeq", "I1", "I2",
"O1", "O2", "A1", "A2", "A3", "A4", "A5", "A6"], "special": [{}, {}, {}, {}, {}, {}],
"digital IO": [0, 0, 1, 1]}}
# EndOfHeader
0 0 0 0 0 0 501 0 0 0 0
1 0 0 0 0 0 504 0 0 0 0
2 0 0 0 0 0 507 0 0 0 0
3 0 0 0 0 0 508 0 0 0 0
4 0 0 0 0 1 511 0 0 0 0
5 0 0 0 0 0 511 0 0 0 0
6 0 0 0 0 0 510 0 0 0 0
7 0 0 0 0 0 510 0 0 0 0
8 0 0 0 0 0 509 0 0 0 0
9 0 0 0 0 0 508 0 0 0 0
10 0 0 0 0 0 508 0 0 0 0
```

Transferred Data

```
Heart Rate = [4.0, 0.0, 132.39999389648438, 0.0, 0.0, 0.0, 0.0]
Heart Rate = [5.0, 1.0, 132.0, 0.0, 0.0, 0.0, 0.0]
Heart Rate = [6.0, 0.0, 132.0, 0.0, 0.0, 0.0, 0.0]
Heart Rate = [7.0, 0.0, 132.1999969482422, 0.0, 0.0, 0.0, 0.0]
Heart Rate = [8.0, 0.0, 133.1999969482422, 0.0, 0.0, 0.0, 0.0]
Heart Rate = [9.0, 0.0, 134.1999969482422, 0.0, 0.0, 0.0, 0.0]
Heart Rate = [10.0, 0.0, 134.39999389648438, 0.0, 0.0, 0.0, 0.0]
Heart Rate = [11.0, 0.0, 134.6999969482422, 0.0, 0.0, 0.0, 0.0]
Heart Rate = [12.0, 0.0, 135.1999969482422, 0.0, 0.0, 0.0, 0.0]
Heart Rate = [13.0, 1.0, 135.1999969482422, 0.0, 0.0, 0.0, 0.0]
Heart Rate = [14.0, 0.0, 134.6999969482422, 0.0, 0.0, 0.0, 0.0]
Heart Rate = [15.0, 0.0, 134.6999969482422, 0.0, 0.0, 0.0, 0.0]
```

```
ECG = [12.0, 0.0, 0.0032999999821186066, 0.0, 0.0, 0.0, 0.0]
ECG = [13.0, 0.0, 0.00389999998942017555, 0.0, 0.0, 0.0, 0.0]
ECG = [14.0, 0.0, 0.0032999999821186066, 0.0, 0.0, 0.0, 0.0]
ECG = [15.0, 1.0, 0.002799999990016222, 0.0, 0.0, 0.0, 0.0]
ECG = [0.0, 0.0, 0.00170000000225380063, 0.0, 0.0, 0.0, 0.0]
ECG = [1.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0]
ECG = [2.0, 0.0, -0.002199999988079071, 0.0, 0.0, 0.0, 0.0]
ECG = [3.0, 0.0, -0.0032999999821186066, 0.0, 0.0, 0.0, 0.0]
ECG = [4.0, 0.0, -0.00389999998942017555, 0.0, 0.0, 0.0, 0.0]
ECG = [5.0, 0.0, -0.0049999999888241291, 0.0, 0.0, 0.0, 0.0]
ECG = [6.0, 0.0, -0.007199999876320362, 0.0, 0.0, 0.0, 0.0]
ECG = [7.0, 1.0, -0.008899999782443047, 0.0, 0.0, 0.0, 0.0]
```


04 Problem Fixed

The screenshot displays the bitoline software interface. On the left, a list of six channels is shown, each labeled 'RAW' and 'A1' through 'A6'. The main configuration panel for the 'bitoline' device shows the MAC and NAME as '00:21:06:BE:15:D9'. A blue bar indicates the device is 'ENABLED'. The 'SAMPLING RATE' is set to '1000 Hz'. Below this, there are sections for 'CHANNELS' (represented by six blue dots), 'DIGITAL' (two radio buttons), and 'TRIGGER' (one radio button). On the right, a 'FILE OPTIONS' panel is visible, featuring tabs for 'FILE OPTIONS', 'SAVE LOCATIONS', 'AUTO START', 'DEVICE CONFIGURATION', and 'INTEGRATION'. Under 'FILE OPTIONS', there are three options: 'TCP-IP' (unchecked), 'Lab Streaming Layer' (checked), and 'CONTINUOUS MODE' (unchecked). Each option has a brief description of its function.

DEVICE bitoline

MAC 00:21:06:BE:15:D9

NAME 00:21:06:BE:15:D9

ENABLED

SAMPLING RATE 1000 Hz

CHANNELS

DIGITAL

TRIGGER

FILE OPTIONS **SAVE LOCATIONS** **AUTO START** **DEVICE CONFIGURATION** **INTEGRATION**

☐ TCP-IP
Turning on this option will allow you to send data over TCP-IP.

☒ Lab Streaming Layer
Turning on this option will allow you to send data over lab streaming layer.

☐ CONTINUOUS MODE
When this option is turned on, whenever the connection to a device is lost, the software will automatically try to reconnect and resume data acquisition.

04 Emotional Model IV

Biosppy

```
# ECG signal processing using biosppy library and extract Heart Rate
HR = ecg.ecg(signal=ECG_list, sampling_rate=1000., show=False)["heart_rate"]
```

```
# Compute HR mean for each window
HR_mean = np.round(np.mean(HR), 2)
```

1. R-Peak Detection

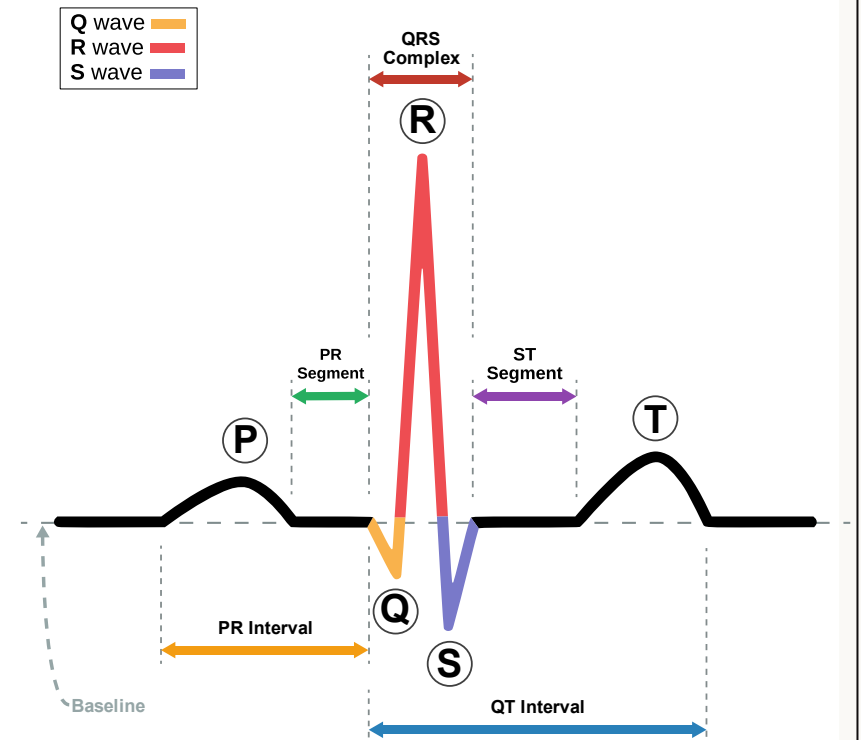
- Pan-Tompkins QRS detection algorithm

2. Calculate RR Intervals

- Time intervals between 2 successive R-Peaks

3. Calculate Heart Rate

- Heart Rate (BPM) = $\frac{60 \times 1000}{\text{Average RR Interval (ms)}}$



Modalities

Inputs & Outputs



04

04 Modalities I

Inputs

1. **Movement (Smartphone accelerometer)**
 - Move Mousy left and right
2. **Touch (Laptop touchpad)**
 - Jump
3. **Heart Rate (Bitalino + OpenSignal)**
 - Mousy's speed Adjustment

04 Modalities II

Outputs

1. Sound (Speaker)

- Correct and Wrong answer
- Running close to the boundaries
- Crashes

2. Display (Monitor)

- The number of collected cheeses
- Correctness of answers

3. Vibration in Mobile version (Smartphone Sensor)

- In case of crashes into obstacles

Tools & Applications



05

05 Tools & Apps I

Unity3D(v2021.3.9f1)

- It's a powerful cross-platform game engine for creating video games, VR, and AR apps. Equipped with many tools, a user-friendly interface, and a strong C# scripting API.

Visual Studio Code

- A streamlined code editor with support for development operations like debugging, task running, and version control. (C# and Python)

05 Tools & Apps II

Bitalino and OpenSignal

- Bitalino is a device used for heart rate acquisition. Open Signal is its corresponding app designed to collect and transfer data to other applications.

Unity Remote

- Unity Remote is a downloadable app that sends live inputs from Android and iOS devices to Unity projects.

05 Tools & Apps III

Unity Asset Store & Mixamo

- Unity Asset Store is a Unity Technologies online marketplace for developers to discover digital assets like 3D models, 2D textures, animations, audio, and more for their game projects.

Adobe Photoshop & Premier Pro

- Apps for editing photos, videos, and sound used to create game logos and loop music.

User Test



06

06 User Test I

Participants

- 3 men and 3 women as player 1
- 6 adults with gaming experience

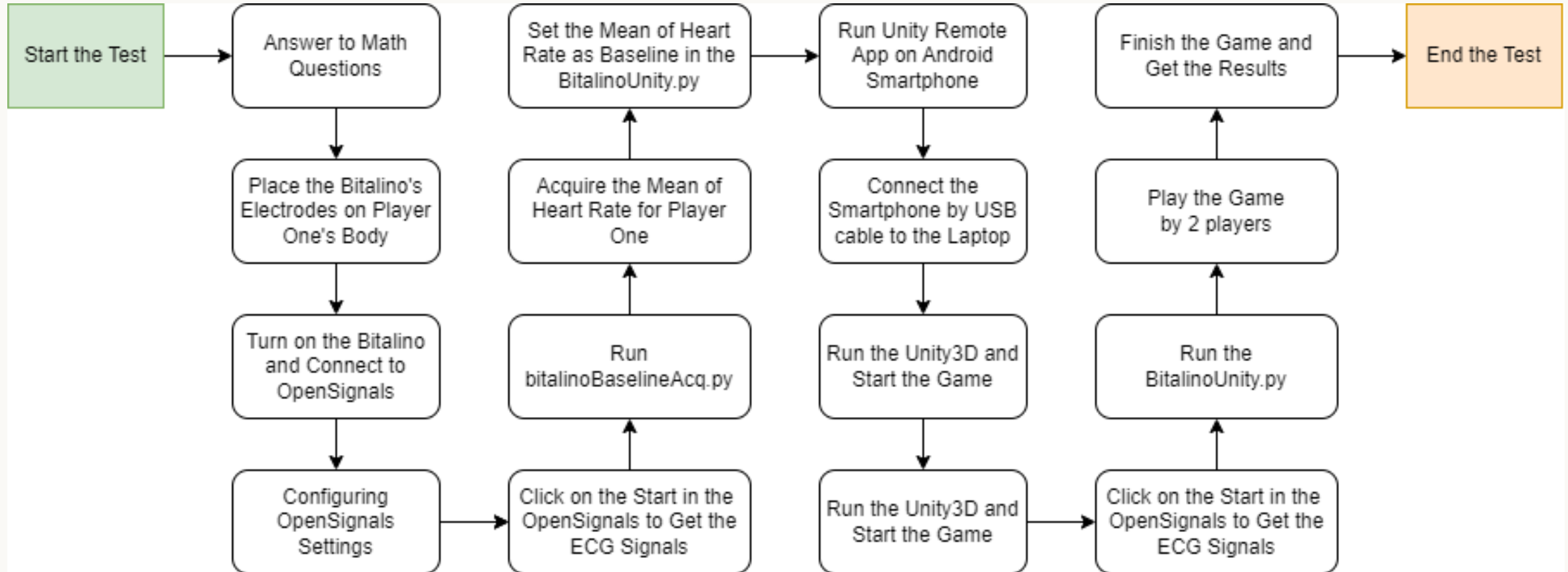


06 User Test II

User Test Process Diagram



06 User Test III



06 User Test IV

Results

Men's Performance

| Participant ID | Baseline of HR | Performance Before the Game | | Performance During the Game | | Supervisor Observations | | Error | Collected Cheeses | Number of Speed Changes |
|----------------|----------------|-----------------------------|-------|-----------------------------|-------|-------------------------|-------|-------|-------------------|-------------------------|
| | | Correct | Wrong | Correct | Wrong | Correct | Wrong | | | |
| MP1 | 79.46 | 10 | 0 | 5 | 5 | 5 | 5 | 0 | 53 | 12 |
| MP2 | 85.74 | 10 | 0 | 6 | 4 | 8 | 2 | 2 | 44 | 10 |
| MP3 | 75.55 | 9 | 1 | 4 | 6 | 5 | 5 | 1 | 65 | 10 |

06 User Test V

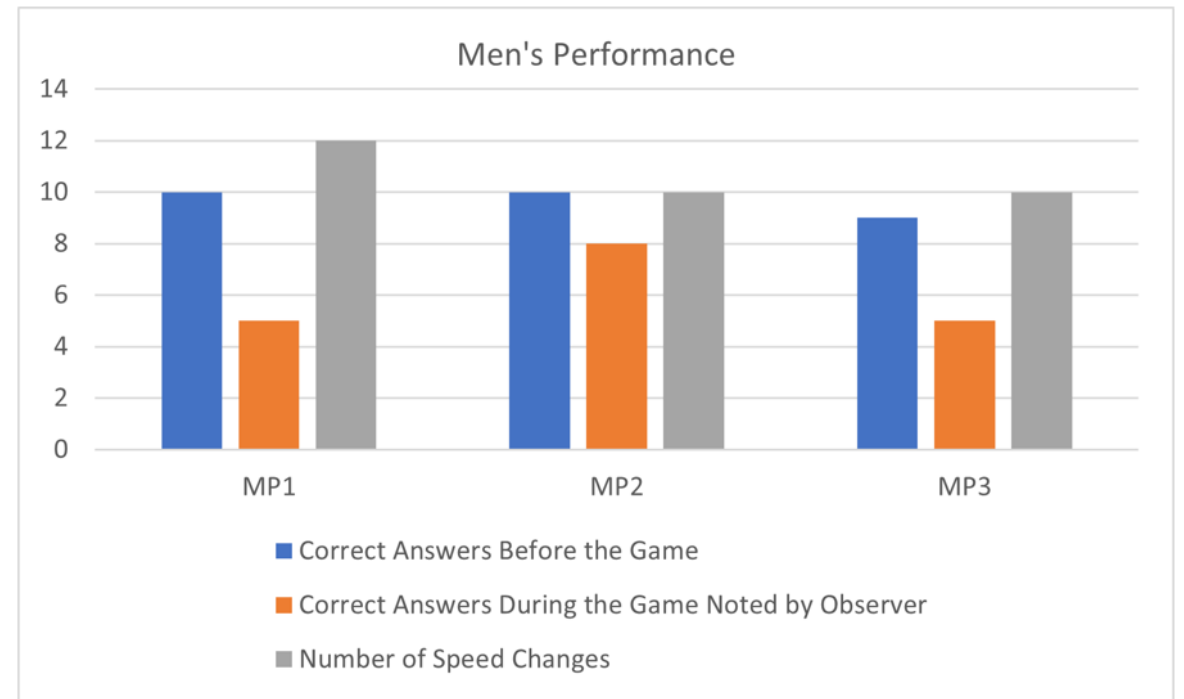
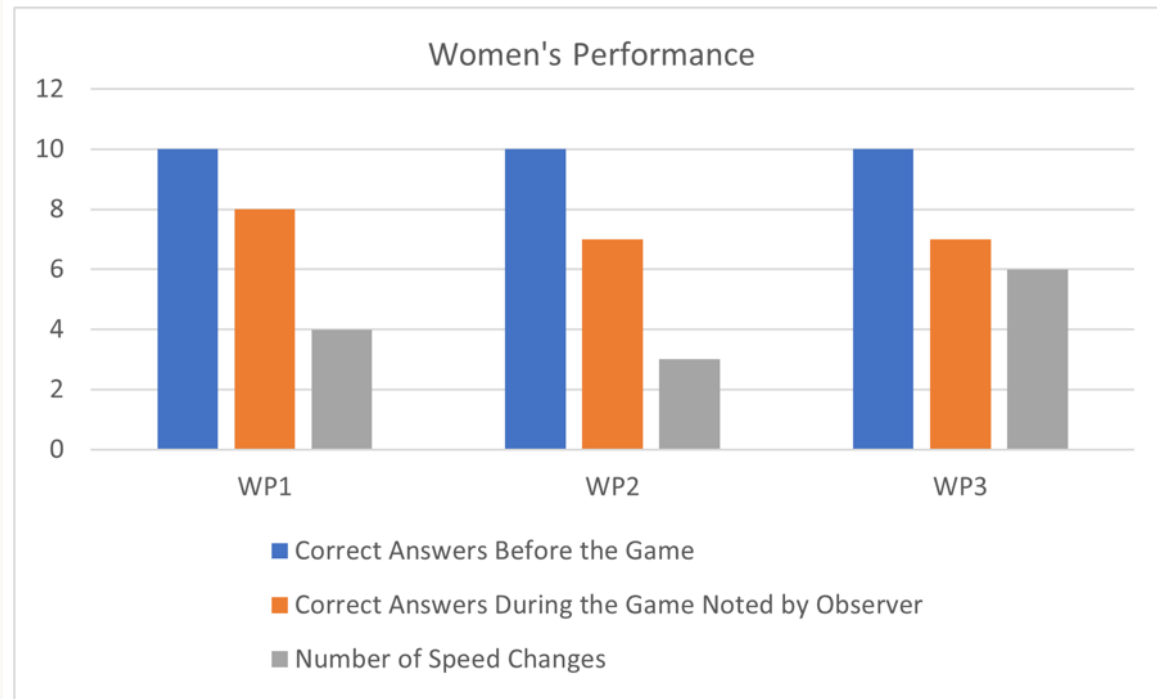
Results

Women's Performance

| Participant ID | Baseline of HR | Performance Before the Game | | Performance During the Game | | Supervisor Observations | | Error | Collected Cheeses | Number of Speed Changes |
|----------------|----------------|-----------------------------|-------|-----------------------------|-------|-------------------------|-------|-------|-------------------|-------------------------|
| | | Correct | Wrong | Correct | Wrong | Correct | Wrong | | | |
| WP1 | 75.76 | 10 | 0 | 8 | 2 | 8 | 2 | 0 | 47 | 4 |
| WP2 | 87.33 | 10 | 0 | 9 | 1 | 7 | 3 | 2 | 12 | 3 |
| WP3 | 85.72 | 10 | 0 | 8 | 2 | 7 | 3 | 1 | 19 | 6 |

06 User Test VI

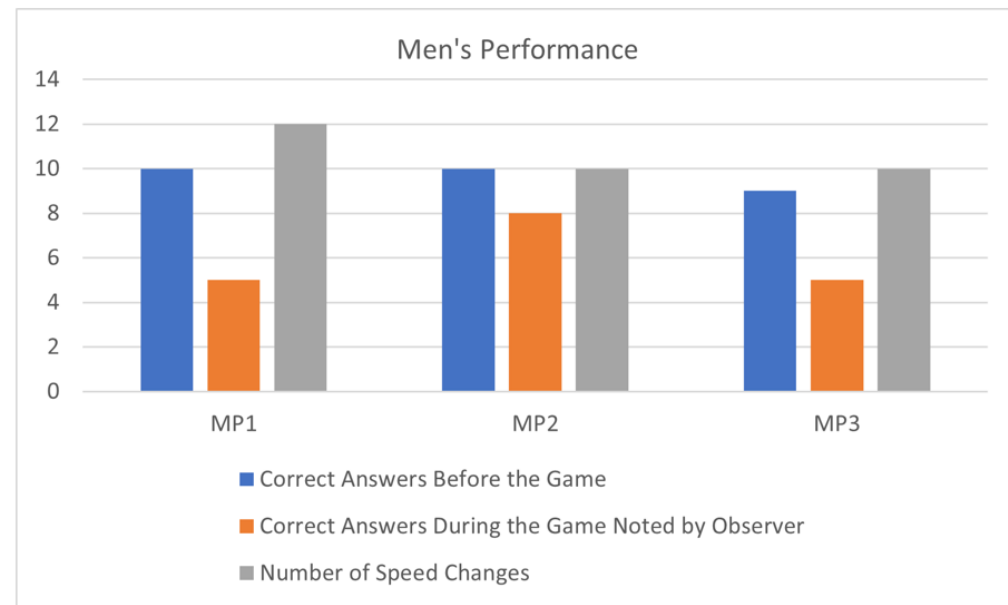
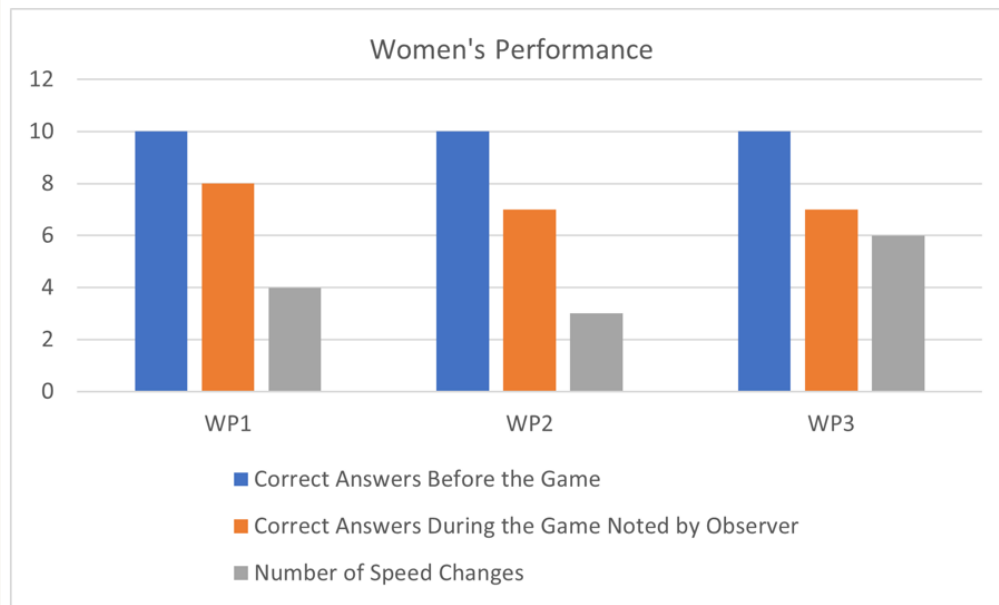
Results



Observations I

Participants exhibited a considerable drop in in-game performance compared to their performance before starting the game.

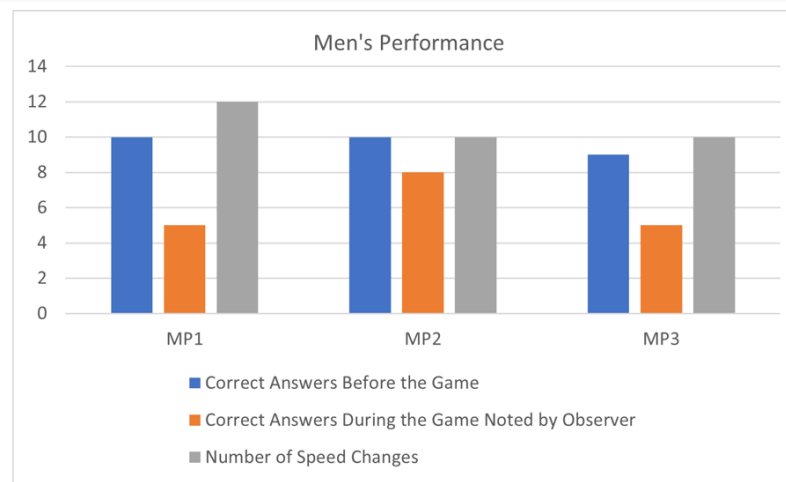
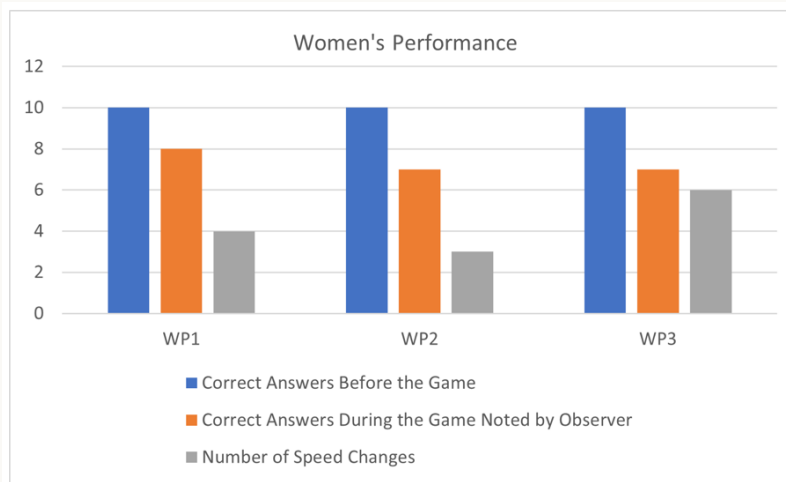
- The effects of factors that cause distraction in the game for players
- The impact of multitasking during gameplay



Observations II

The Heart Rate fluctuation was less among female participants compared to male participants.

- Female players may not take the game very seriously or their physiological system undergoes fewer changes during gameplay.
- Higher character speed variability in male players may affect their performance in answering the math questions.



Observations III

The average heart rate (HR) obtained as the baseline before the game varies among the participants.

- Individuals have distinct physiological responses.

Men's Performance

| Participant ID | Baseline of HR | Performance Before the Game | | Performance During the Game | | Supervisor Observations | | Error | Collected Cheeses | Number of Speed Changes |
|----------------|----------------|-----------------------------|-------|-----------------------------|-------|-------------------------|-------|-------|-------------------|-------------------------|
| | | Correct | Wrong | Correct | Wrong | Correct | Wrong | | | |
| MP1 | 79.46 | 10 | 0 | 5 | 5 | 5 | 5 | 0 | 53 | 12 |
| MP2 | 85.74 | 10 | 0 | 6 | 4 | 8 | 2 | 2 | 44 | 10 |
| MP3 | 75.55 | 9 | 1 | 4 | 6 | 5 | 5 | 1 | 65 | 10 |

Observations IV

The number of cheese items collected by female players was lower than that of male players.

- Female players prioritizing the solving of math questions more than collecting cheese items.

Women's Performance

| Participant ID | Baseline of HR | Performance Before the Game | | Performance During the Game | | Supervisor Observations | | Error | Collected Cheeses | Number of Speed Changes |
|----------------|----------------|-----------------------------|-------|-----------------------------|-------|-------------------------|-------|-------|-------------------|-------------------------|
| | | Correct | Wrong | Correct | Wrong | Correct | Wrong | | | |
| WP1 | 75.76 | 10 | 0 | 8 | 2 | 8 | 2 | 0 | 47 | 4 |
| WP2 | 87.33 | 10 | 0 | 9 | 1 | 7 | 3 | 2 | 12 | 3 |
| WP3 | 85.72 | 10 | 0 | 8 | 2 | 7 | 3 | 1 | 19 | 6 |

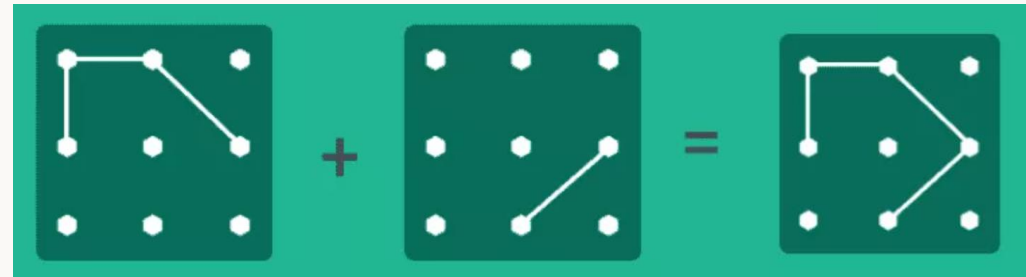
Future Work



07

07 Future Work

1. Expanding our participant pool to include a more diverse range of players.
2. Change the type of questions. For example:



3. Monitoring the heart rate of player two

References



08

08 References

1. Character and its animations:

- <https://www.mixamo.com/>
- https://www.youtube.com/watch?v=2-_V0ZuB2eA&t=354s

2. Environment:

- <https://assetstore.unity.com/packages/3d/environments/industrial/rpg-fps-game-assets-for-pc-mobile-industrial-set-v2-0-86679>
- <https://assetstore.unity.com/packages/tools/utilities/tg-utility-131460>
- <https://assetstore.unity.com/packages/3d/props/food/free-casual-food-pack-mobile-vr-85884>
- <https://assetstore.unity.com/packages/3d/environments/roadways/road-props-for-games-diffuse-map-atlas-lp-238835>
- <https://assetstore.unity.com/packages/3d/vehicles/controllable-forklift-free-80275>

3. Sound FX:

- <https://assetstore.unity.com/packages/audio/sound-fx/8-bits-elements-16848>

4. Music:

- <https://assetstore.unity.com/packages/audio/music/rock/funky-blues-rock-jam-free-118085>

5. Tools

- <https://unity.com/>
- <https://code.visualstudio.com/>
- <https://www.pluxbiosignals.com/>
- <https://assetstore.unity.com/>
- <https://docs.unity3d.com/Manual/UnityRemote5.html>
- <https://www.adobe.com/>

6. Articles

- Tian Y, Bian Y, Han P, Wang P, Gao F and Chen Y (2017) Physiological Signal Analysis for Evaluating Flow during Playing of Computer Games of Varying Difficulty. Front. Psychol. 8:1121. doi: 10.3389/fpsyg.2017.01121

THANK YOU

Does anyone have any questions?

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