EXPLORING THE RELATIONSHIP BETWEEN INDOOR CONDITIONS, EXTERNAL STIMULI, AND PHYSIOLOGICAL STATE

Ryan Clark

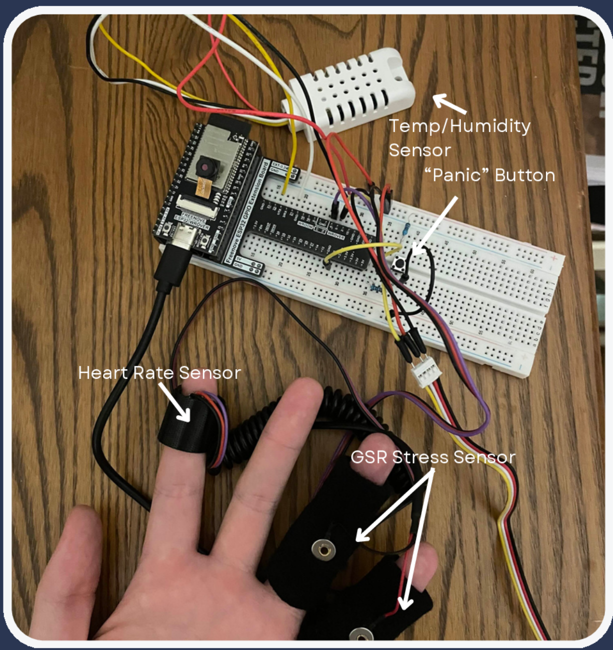
EXECUTIVE SUMMARY

This project explores the relationship between different indoor conditions, including external stimuli, and physiological state. The physiological variables measured here are heart rate (BPM) and the resistance measurements provided by a galvanic skin response (GSR) sensor to gauge stress levels. Temperature and humidity were measured to get a sense of indoor conditions.

The impetus for this project was to better understand indoor conditions and how they might affect our mental state, especially as these conditions change.

Old buildings with poor ventilation, which are quite common in New York City, may be more variable in temperature and therefore subjecting their residents/visitors to more fluctuations in their physical state.

The project generally found surprisingly little relationship between stress levels and heart rate. It also found little variation in temperature, though humidity did change drastically due to some precipitation occurring during data collection.



INTRODUCTION

The project was inspired by the concept of a heat index - what if this heat index concept could be applied to indoor space to help us understand what conditions could cause harm to our physiological or mental state? This could include risks of distraction, irritability, or health risks.

Initially, this idea was to be applied in a classroom setting. It may have been an ideal setting due to the existence of many GSAPP spaces lacking central air, and the possibility of body heat generated by students creating more temperature/humidity variability.

NWS Heat Index — Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution · Extreme Caution · Danger · Extreme Danger

RELATIONSHIP TO THE URBAN CONTEXT

Understanding indoor space is vital to understanding urban life. According to the New York City Department of Health, the average person spends about 90% of their time indoors.

While much of urban planning/design focuses on the public realm, the conditions of indoor space must be further studied to understand the relationships between indoor space and health.

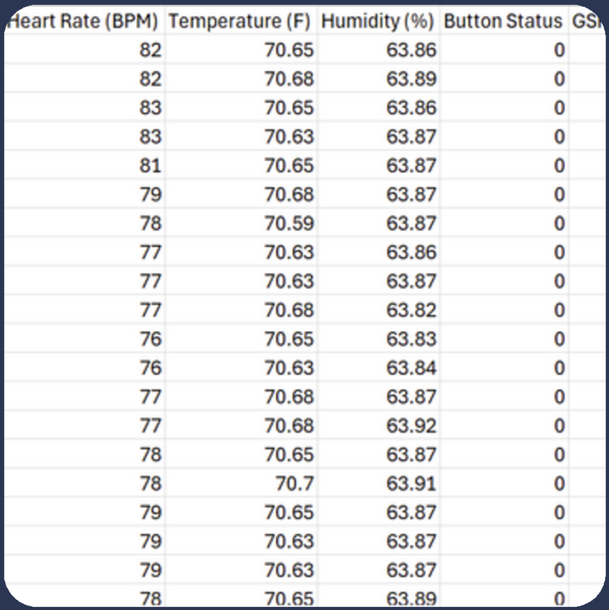
Issues of indoor heat and temperature variability, particularly in older buildings lacking air conditioning, are becoming more of a concern as climate change threatens hotter and hotter summers.

PROJECT SETTING/ INTERACTIONS

Data collection took place in an apartment without air conditioning, though with a central steam heating system (this was not active during any of the readings).

Data collection was performed in the same spot for each reading around the same time (~8pm).

Direct interactions did not occur as this was a solitary effort, though certain “feedback loops” did exist. For example, I could choose to view the data output in real time, which may have affected the readings in some way.



Heart Rate (BPM)	Temperature (F)	Humidity (%)	Button Status	GS
82	70.65	63.86	0	
82	70.68	63.89	0	
83	70.65	63.86	0	
83	70.63	63.87	0	
81	70.65	63.87	0	
79	70.68	63.87	0	
78	70.59	63.87	0	
77	70.63	63.86	0	
77	70.63	63.87	0	
77	70.68	63.82	0	
76	70.65	63.83	0	
76	70.63	63.84	0	
77	70.68	63.87	0	
77	70.68	63.92	0	
78	70.65	63.87	0	
78	70.7	63.91	0	
79	70.65	63.87	0	
79	70.63	63.87	0	
79	70.63	63.87	0	
78	70.65	63.89	0	

TECHNOLOGIES USED

A single sensor was used to measure both temperature and humidity. A pulse sensor was used, with code to calibrate the sensor and calculate BPM.

A galvanic skin response sensor was used, and its data was cleaned such that its lowest reading was reduced to zero and each other reading was also reduced by the same amount.

All data was collected roughly every second during readings, which generally lasted about 5-10 minutes. An ESP-32 WROVER module was used to run the Arduino code and interpret data from each of the sensors.

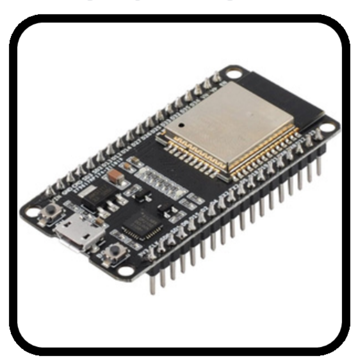
Temperature/Humidity Sensor

Pulse Sensor

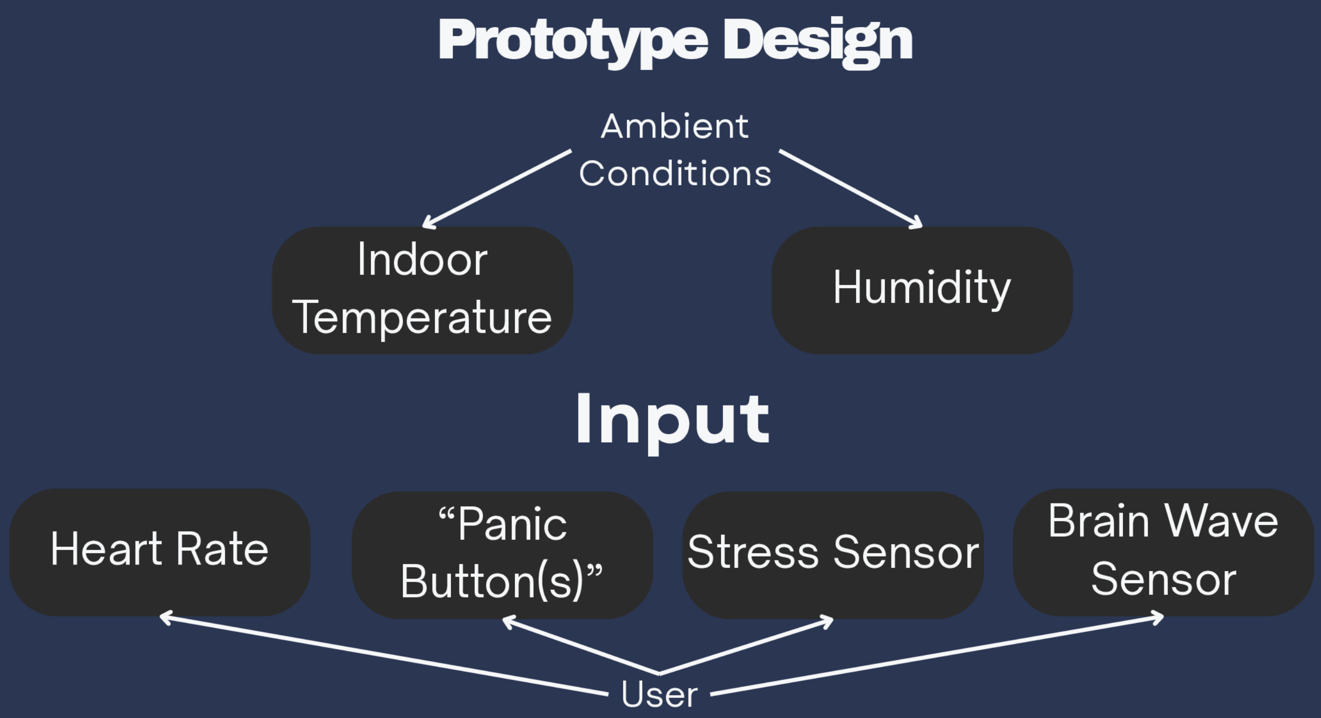
Arduino IDE

Galvanic Skin Response Sensor

ESP-32 WROVER



PILOT



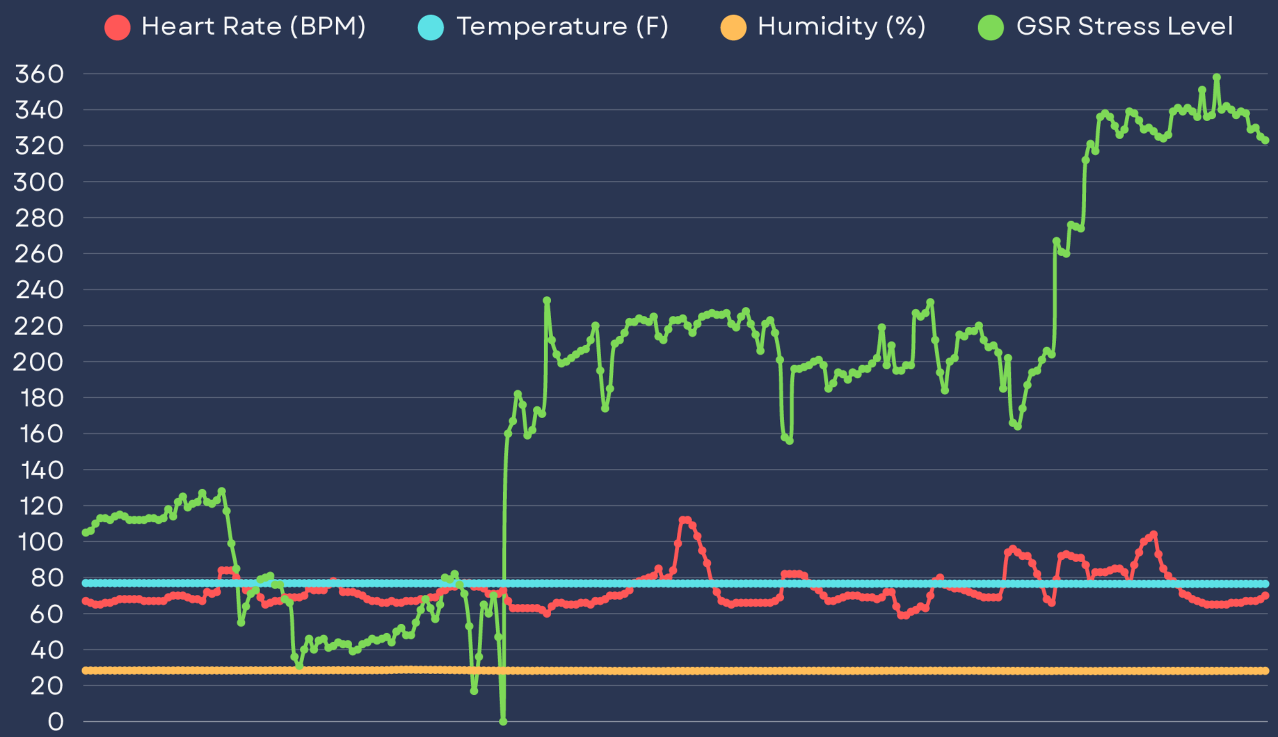
The general project design is split into two main categories: ambient conditions and user input. Ambient conditions consist of temperature (measured in degrees Fahrenheit) and humidity (measured as a percentage).

In each reading other than the "baseline" (see next page), a different external stimulus is present in order to observe any differences in data output.

Unfortunately, I was unable to collect data from the brain wave sensor.

PILOT RESULTS

“Baseline” Reading



Taken over the course of ~5 mins - no external stimuli

Avg Humidity: **28%**

Avg heart rate: **73 BPM**

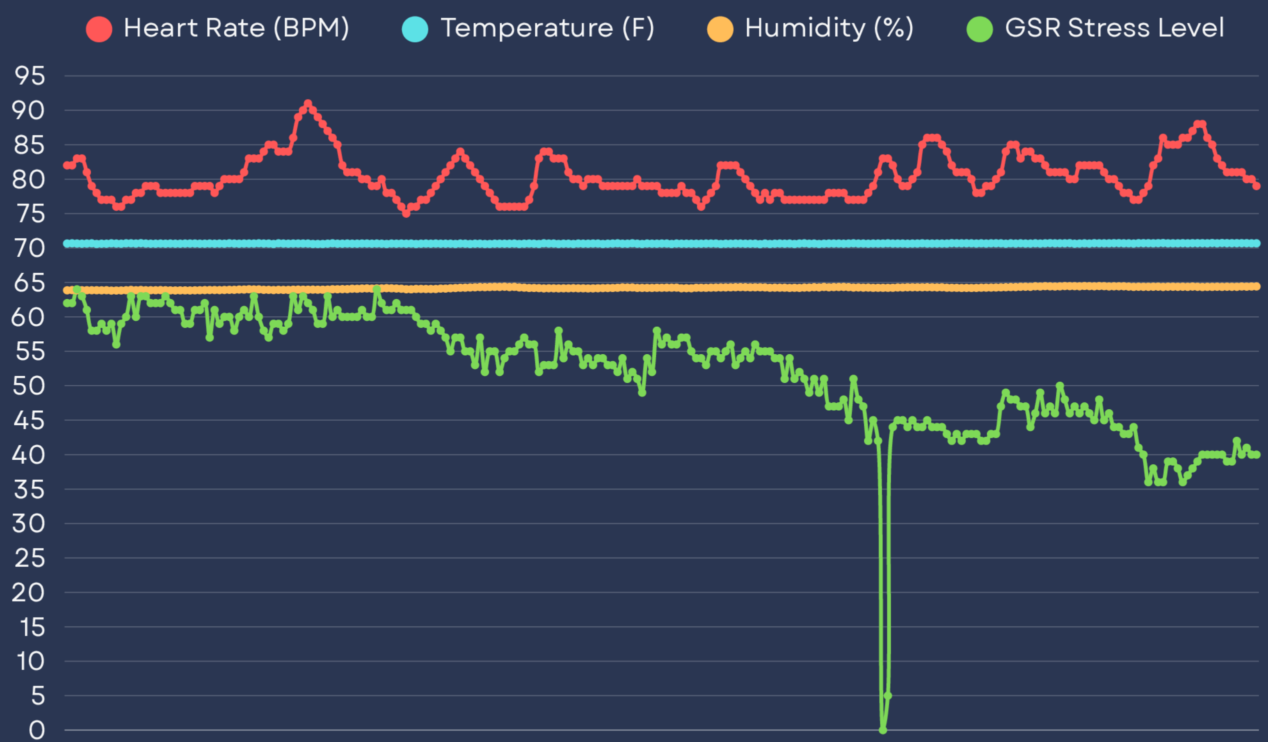
Avg Stress Level: **180**

Avg Temp: **77° F**

Button Pressed: **Never**

PILOT RESULTS

While Reading a Book



Taken over the course of ~5 mins

Avg Humidity: **64%**

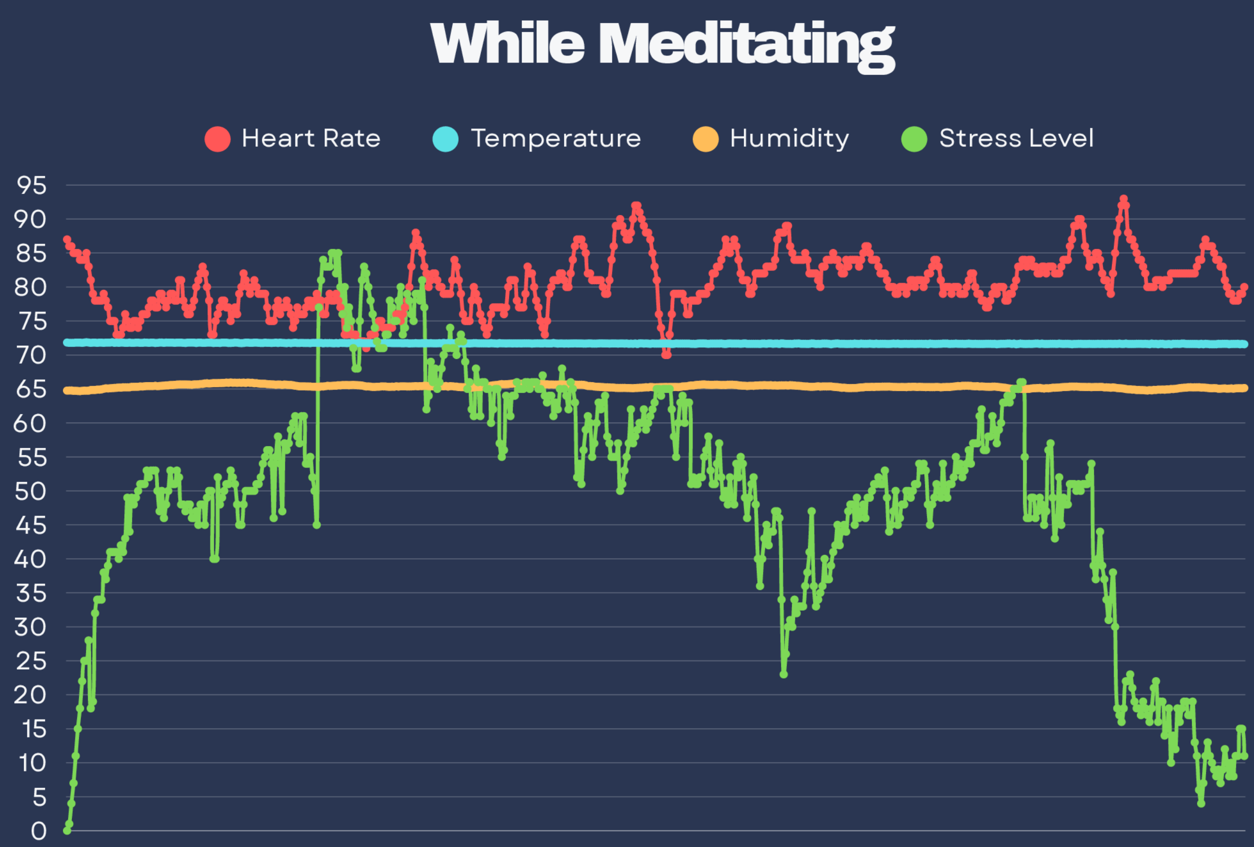
Avg heart rate: **80 BPM**

Avg Stress Level: **52**

Avg Temp: **71° F**

Button Pressed: **Never**

PILOT RESULTS



Taken over the course of ~10 mins

Avg Humidity: **64%**

Avg heart rate: **80 BPM**

Avg Stress Level: **52**

Avg Temp: **71° F**

Button Pressed: **Never**

CONCLUSIONS/URBAN INTERACTIONS

Based on the readings, it didn't seem that heart rate correlated much with stress levels. This may have to do with the unpredictability of GSR sensors.

During the "baseline" reading, stress levels increased over time, possibly due to discomfort caused by the sensors themselves and a lack of distraction from said discomfort.

Interestingly, the button was never pressed. This may have to do with the fact that none of the data collection scenarios were particularly stress-inducing. It is also possible that other test subjects may have reacted differently in those scenarios and pressed the button more often.

Stress levels were the most variable out of any other piece of data, with readings varying widely. Temperature and humidity did vary between readings but held relatively steady over the course of each reading.

Deploying this prototype more widely could have fascinating results. It would be especially interesting to look at indoor conditions during extreme summer heat, which would likely induce more interaction with the button, higher heart rates, and more stress. Testing the prototype on people of different ages and in different buildings could be a point of further research.