

ENGR-E599

Final Project: “Analyzing physiological signals to identify potential indicators of deception during a polygraph test.”

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1. Background

The purpose of this project is to use physiological data to detect deception in a polygraph set up. Various physiological signals like ECG, Respiration, EDA are recorded and are used to identify the deceptive blocks vs non-deceptive blocks. From an evolutionary standpoint, the idea is that when a subject lies, they experience an increase in heart rate, EDA (Electro dermal activity) and respiration when compared to when they answer normal questions. Below is a detailed explanation on how these physiological factors get affected when a person lies,

- **Heart rate:** Lying is associated with increase in heart rate, as the subject experiences ‘flight or fight’ response when they prepare themselves to deal with stressful situations. In addition, heart rate is more likely to increase when person lies about a negative event than when they are lying about positive event.
- **Electro dermal activity (EDA):** Elevated EDA-levels during lying and the intention to lie are indicators for increased arousal and are caused by stress and cognitive load.
- **Respiration:** People breathe in faster when they are lying than when they’re telling the truth, as the brain needs to increase its oxygen levels taken from the environment to supplement this.

2. Approach

Below are the steps involved in this analysis,

1. **Data collection and augmentation:** The physiological signal data is extracted for each subject and the model is iterated through all these files to extract the features. The resting period (first 30 seconds) data from each block is excluded from the analysis.
2. **Data processing:** Neurokit2 package in python is used to pre-process the data. This package provides convenience function that automatically processes to clean the ECG, EDA, and Respiration signal data to remove the noises and any artifacts. In addition to this, butter worth filter is applied on respiration data to filter out frequencies in the range of 0.1 to 0.5Hz.

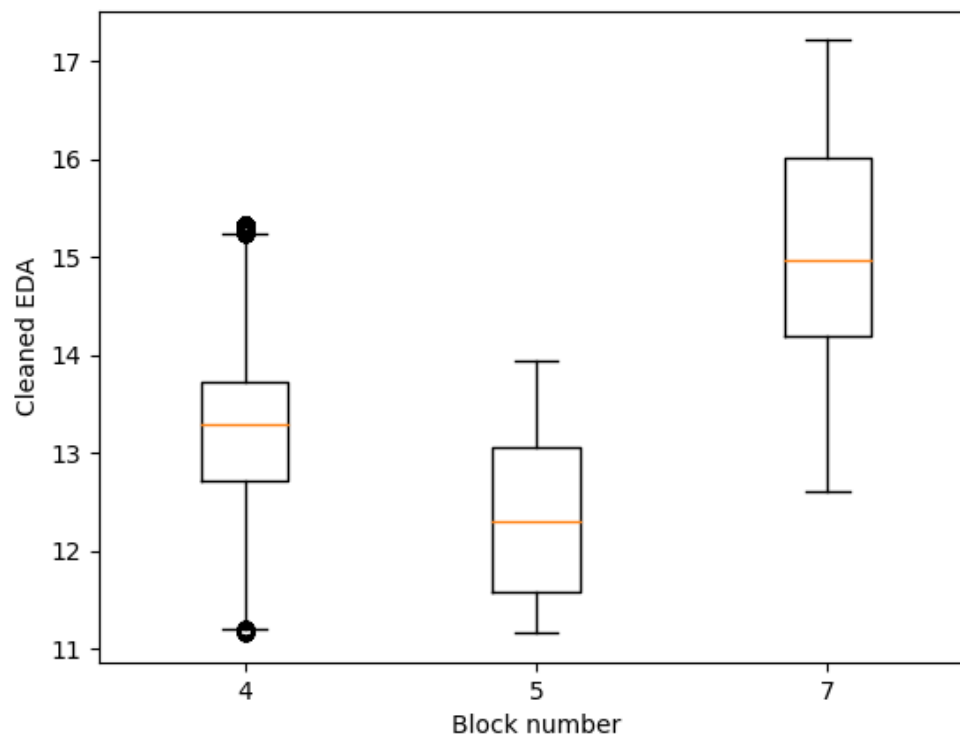
3. **Feature extraction:** Multiple features are derived from the physiological signals mentioned above,
 - **ECG:** IBI feature is extracted from ECG data.
 - **EDA:** Mean EDA, Mean Phasic EDA and mean skin conductance peak amplitude features are extracted from EDA data
 - **RSP:** respiration rate and IE ratio features are extracted from RSP data.
4. **Repeated measures ANOVA:** Finally, the repeated measures ANOVA model is run on the finally obtained feature data.

The above features are extracted for each block for all subjects and stored in a data frame. Multiple ANOVA test are run by taking a subset of blocks and for each of these features to see which combination yield significant results. I considered one of blocks 3 or 4 and 6 or 7 and block 5 as the baseline for the ANOVA experimentation.

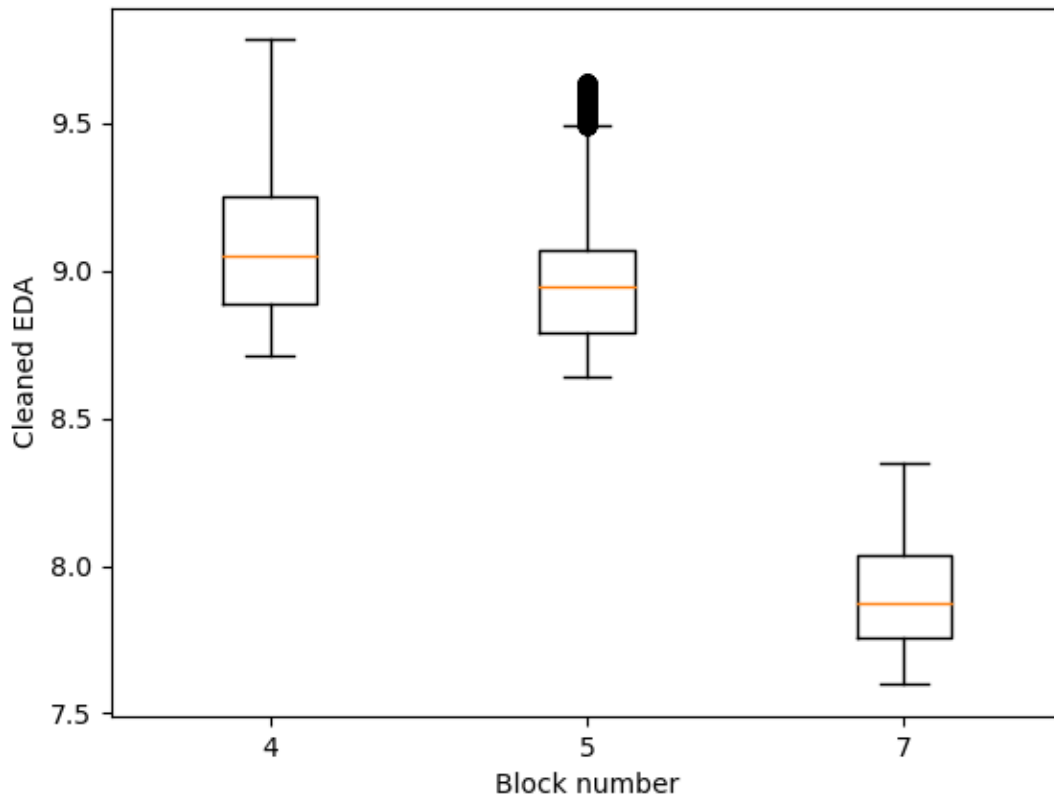
3. Results

After multiple tests, exploring all features, I found EDA feature to be the most significant. Below are a few plots showing distribution of EDA values by block,

- a. For subject 28, there is a very clear increase in EDA response in block 7 (deceptive) when compared to other blocks (non-deceptive)



- b. For subject 27, there is a very clear increase in EDA response in block 4 (deceptive) when compared to other blocks (non-deceptive)

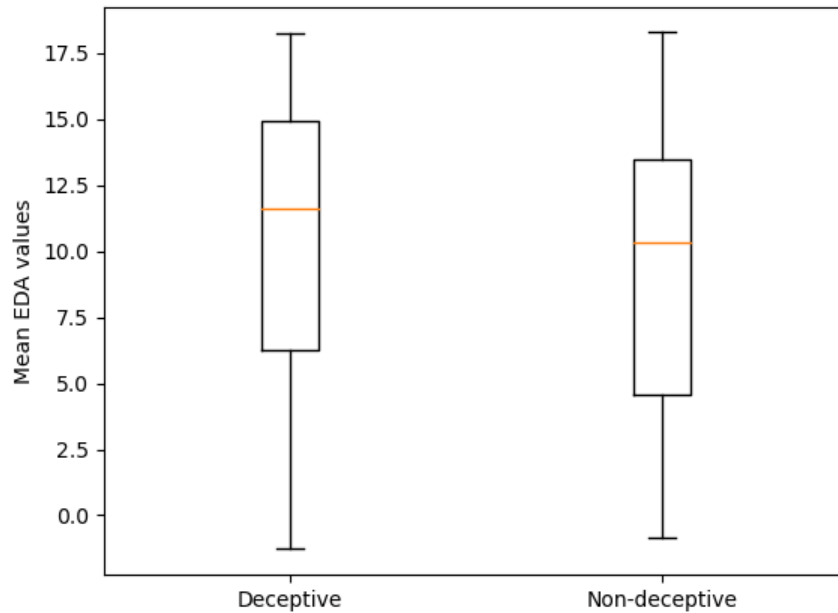


However, there were some subjects where the distinction was not so significant. The repeated measures ANOVA for blocks 4,5,7 on subjects (8 to 29) yielded a statistically significant result with $p = 0.0581$ and had the highest F-statistic, meaning there is a significant difference in means for these groups.

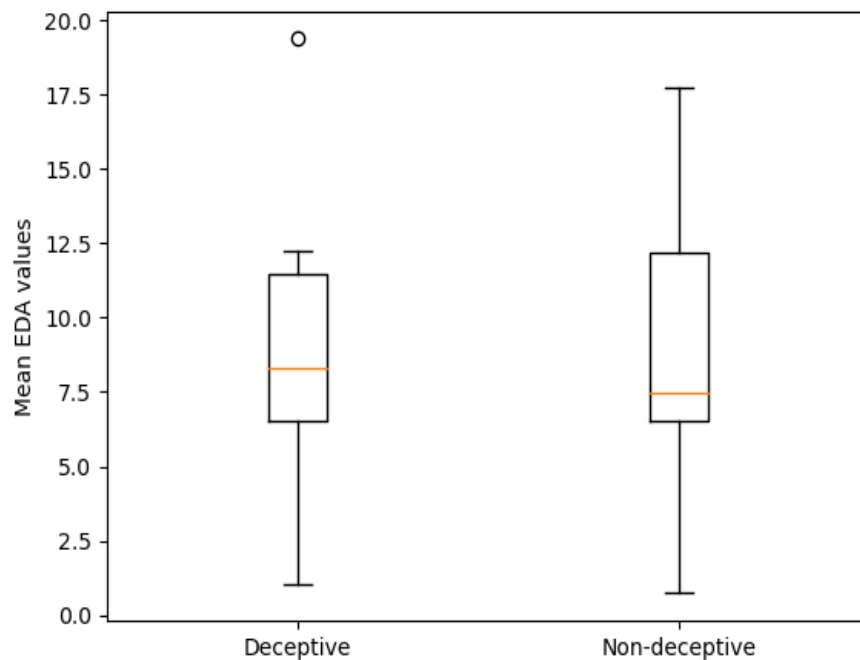
```
Anova
=====
      F Value Num DF  Den DF  Pr > F
-----
block   3.0472  2.0000 42.0000 0.0581
=====
```

As noticed in the below plots, there is a meaningful increase in average EDA for subjects in deceptive blocks.

a. Plot summary for subjects who were deceptive in block 3/4



b. Plot summary for subjects who were deceptive in block 6/7



4. Discussion

Overall, it is certain that there was a reasonable relationship between deceit and EDA signals. As seen in the above plots, there is a rise in the individuals' electro dermal activity in blocks where they had to lie as compared to other blocks. Other characteristics like IBIs and respiration rates had no meaningful impact on the findings. There are some limitations to this experiment, as I have only considered subjects from 8 through 29 for the analysis.

As stated in the study (*Physiological Measures And Detection Of Deception_Podlesny Raskin*), EDA signal is frequently crucial in identifying deceit, and this experiment in some way supported that statement. *To quote the study 'Skin conductance and resistance. Skin conductance responses (SCR) and skin resistance responses (SRR) have been found to be more effective in discriminating deception than have any other measures. Virtually no reported experiment has failed to find significant discrimination between truth and deception, using measures of SCR and SRR'*

5. References

1. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4446301/#:~:text=It%20is%20most%20likely%20that,by%20stress%20and%20cognitive%20load>
2. <https://liedetectorstest.ie/how-do-lie-detection-tests-work/#:~:text=This%20explains%20why%20heart%20rate,levels%20taken%20from%20the%20environment>
3. <https://imotions.com/blog/learning/research-fundamentals/eda-peak-detection/#:~:text=EDA%20often%20also%20referred%20to,on%20your%20specific%20research%20question>
4. <https://www.biopac.com/wp-content/uploads/EDA-SCR-Analysis.pdf>