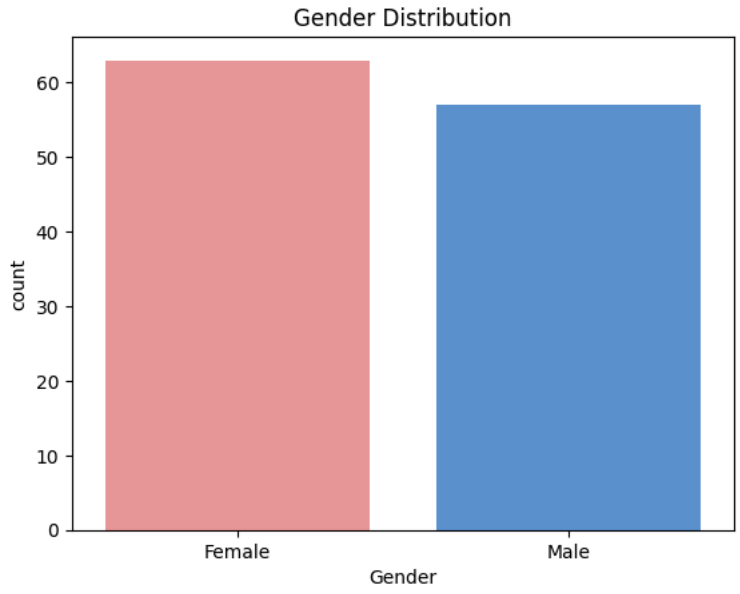
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.preprocessing import LabelEncoder


# Load your dataset
df = pd.read_csv('combined_data.csv')
```

Gender Distribution

How is the gender of participants distributed across the dataset?

```
sns.countplot(x='Gender', data=df, palette={'Female': '#F78888', 'Male': '#4A90E2'})
plt.title('Gender Distribution')
plt.show()
```

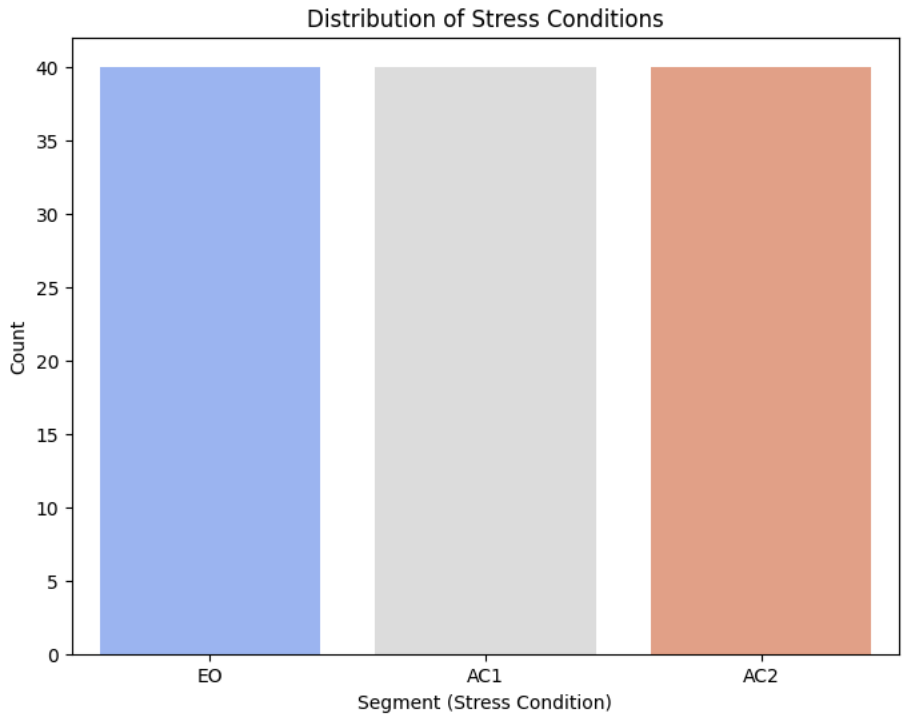
```
<ipython-input-24-a4328a4313c3>:1: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend

  sns.countplot(x='Gender', data=df, palette={'Female': '#F78888', 'Male': '#4A90E2'})
```



Distribution of Stress Conditions (Segment)

```
plt.figure(figsize=(8, 6))
sns.countplot(x='Segment', data=df, palette='coolwarm')
plt.title('Distribution of Stress Conditions')
plt.xlabel('Segment (Stress Condition)')
plt.ylabel('Count')
plt.show()
```

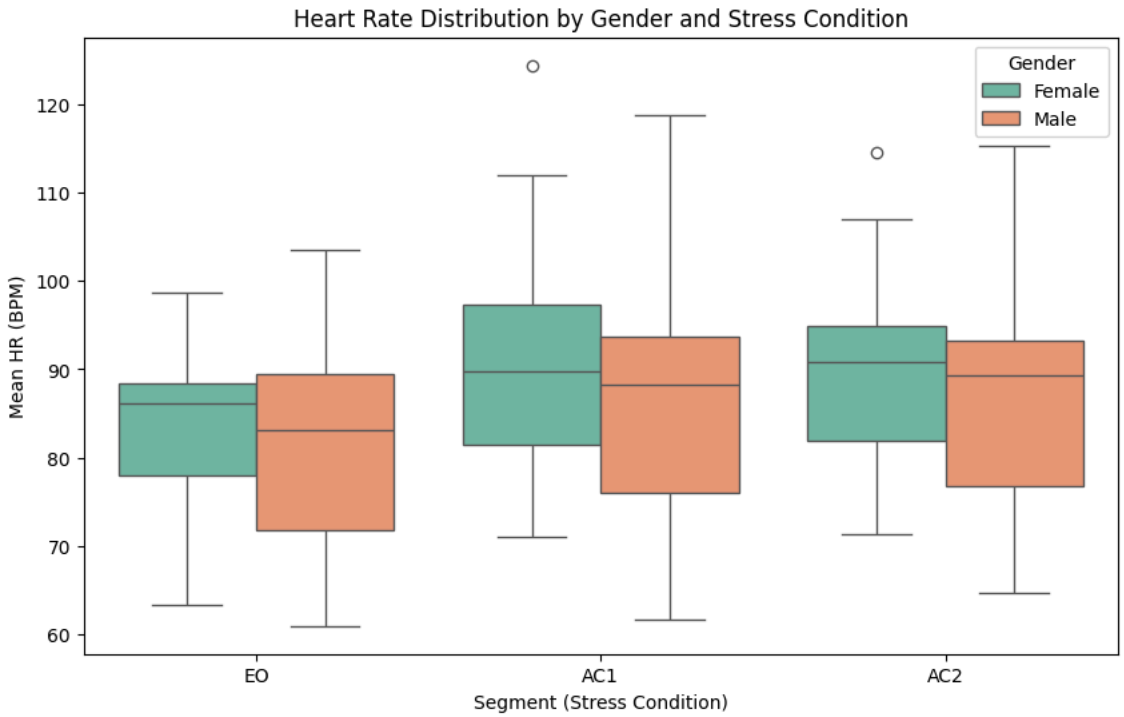
```
<ipython-input-3-14f793c47eb5>:2: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend

  sns.countplot(x='Segment', data=df, palette='coolwarm')
```



This shows the distribution of different stress conditions across the dataset: EO (Baseline/Non-Stress), AC1 (Low Stress), and AC2 (High Stress). The visualization highlights that the number of samples for each stress condition is nearly equal, with each condition having around 40 samples.

Gender Differences in Heart Rate

```
plt.figure(figsize=(10, 6))
sns.boxplot(x='Segment', y='Mean HR (BPM)', hue='Gender', data=df, palette='Set2')
plt.title('Heart Rate Distribution by Gender and Stress Condition')
plt.xlabel('Segment (Stress Condition)')
plt.ylabel('Mean HR (BPM)')
plt.legend(title='Gender')

plt.show()
```



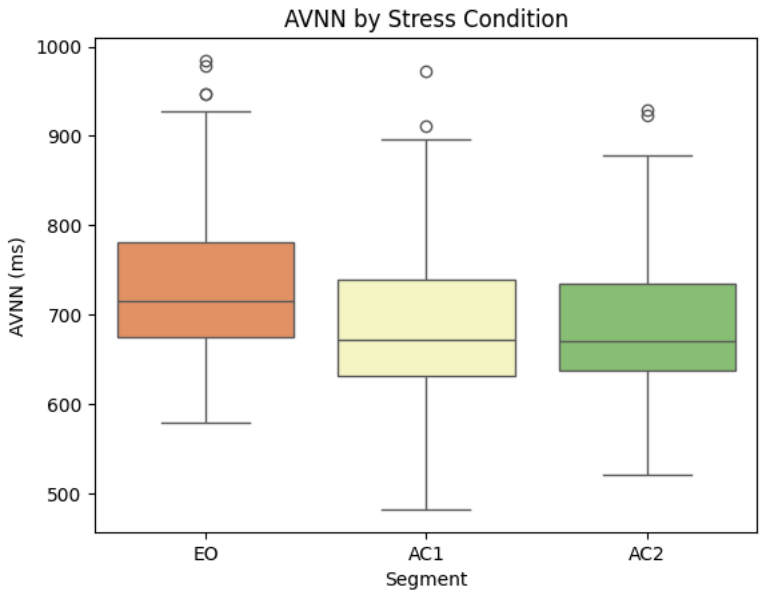
Both genders exhibit similar patterns in terms of heart rate medians, though females appear to have slightly higher heart rate variability under the AC1 condition. The presence of outliers in AC1 and AC2 suggests that some individuals experience significantly elevated heart rates in these scenarios.

HRV Measures by Stress Level

How does HRV change between baseline, low stress, and high stress?

```
sns.boxplot(x='Segment', y='AVNN (ms)', data=df, palette='RdYlGn')
plt.title('AVNN by Stress Condition')
plt.show()
```

```
<ipython-input-34-9d62b67bf70b>:1: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend

  sns.boxplot(x='Segment', y='AVNN (ms)', data=df, palette='RdYlGn')
```

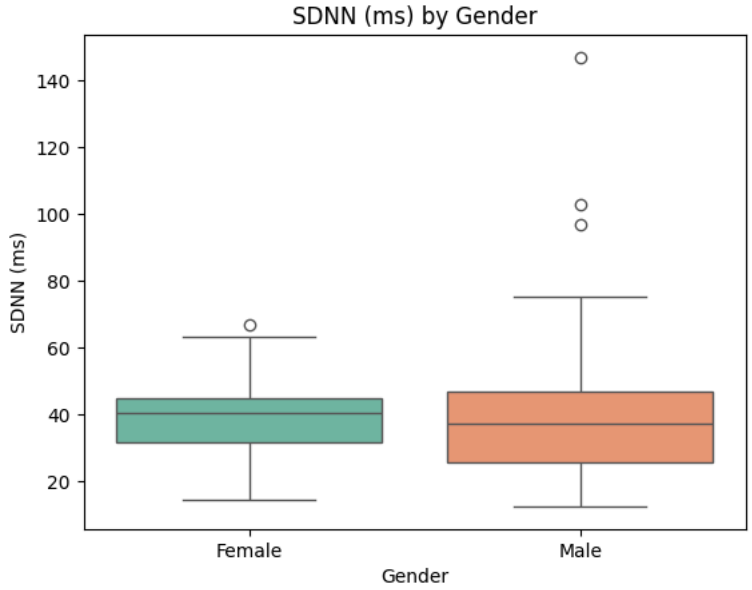


It shows a decrease in HRV from the baseline condition (EO) to low stress (AC1) and high stress (AC2). This suggests that as stress increases, the variability in heart rate decreases, reflecting a physiological response to stress where the heart beats more consistently and with less variability.

How does heart rate variability (SDNN) differ by gender?

```
sns.boxplot(x='Gender', y='SDNN (ms)', data=df, palette='Set2')
plt.title('SDNN (ms) by Gender')
plt.show()
```

```
<ipython-input-27-26d0a52baf27>:1: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend

  sns.boxplot(x='Gender', y='SDNN (ms)', data=df, palette='Set2')
```

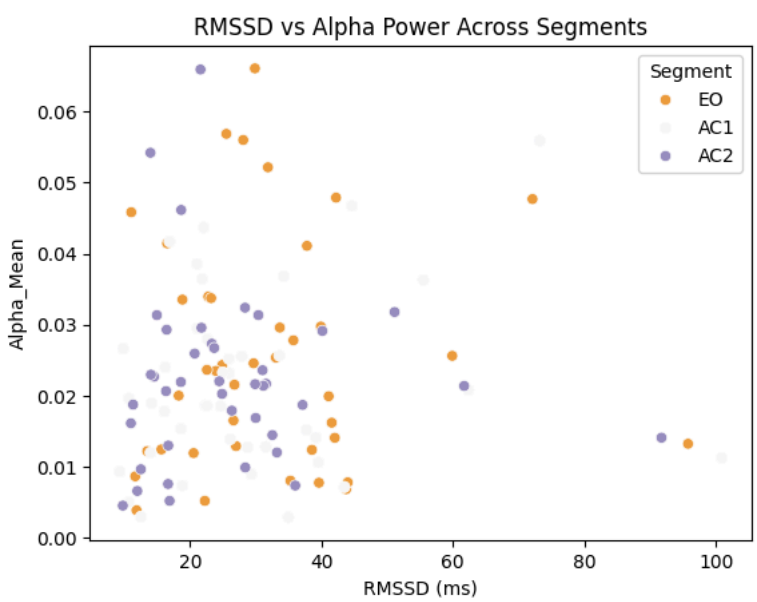


Males tend to have higher and more variable heart rate variability compared to females, suggesting potential differences in autonomic regulation between genders. This insight can inform gender-specific approaches in stress or health management.

ECG vs EEG Analysis (RMSSD vs Alpha Power)

Is there any relationship between HRV and brainwave activity (Alpha power)?

```
sns.scatterplot(x='RMSSD (ms)', y='Alpha_Mean', hue='Segment', data=df, palette='PuOr')
plt.title('RMSSD vs Alpha Power Across Segments')
plt.show()
```

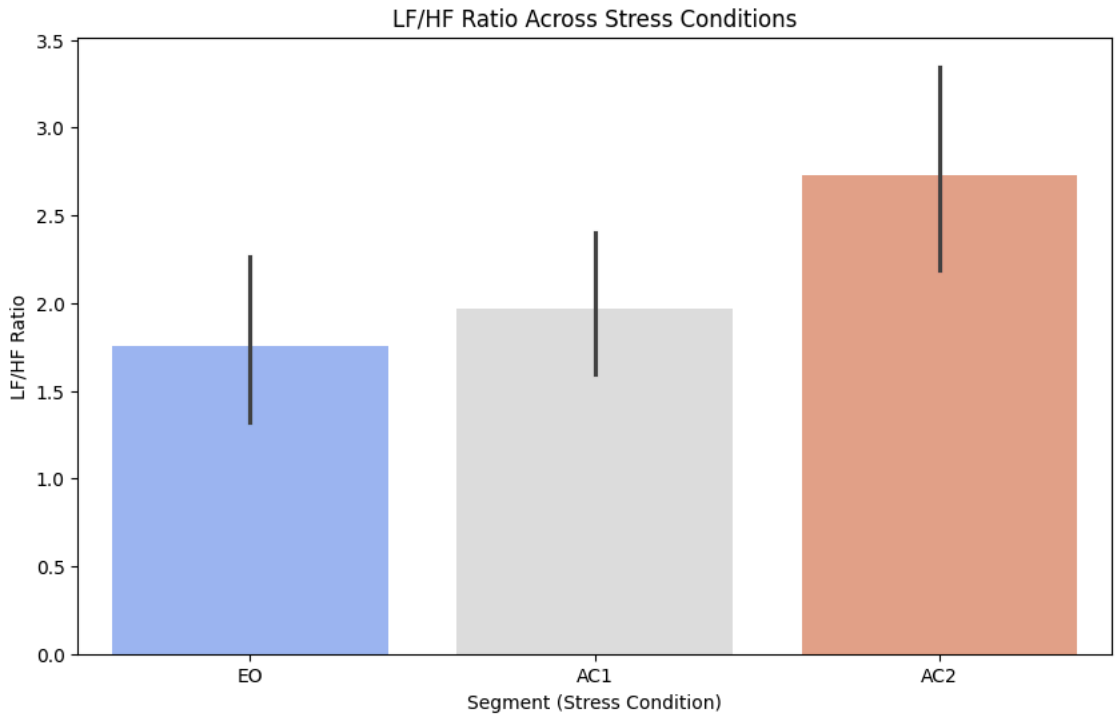


It shows no clear relationship between RMSSD (HRV) and Alpha power across segments. This suggests that HRV and Alpha brainwave activity may not be directly correlated under these stress conditions.

Does stress level affect the balance between sympathetic and parasympathetic nervous systems?

```
plt.figure(figsize=(10, 6))
sns.barplot(x='Segment', y='LF/HF Ratio', data=df, palette='coolwarm')
plt.title('LF/HF Ratio Across Stress Conditions')
plt.xlabel('Segment (Stress Condition)')
plt.ylabel('LF/HF Ratio')
plt.show()
```

```
<ipython-input-13-da86cee06fe0>:2: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend

  sns.barplot(x='Segment', y='LF/HF Ratio', data=df, palette='coolwarm')
```



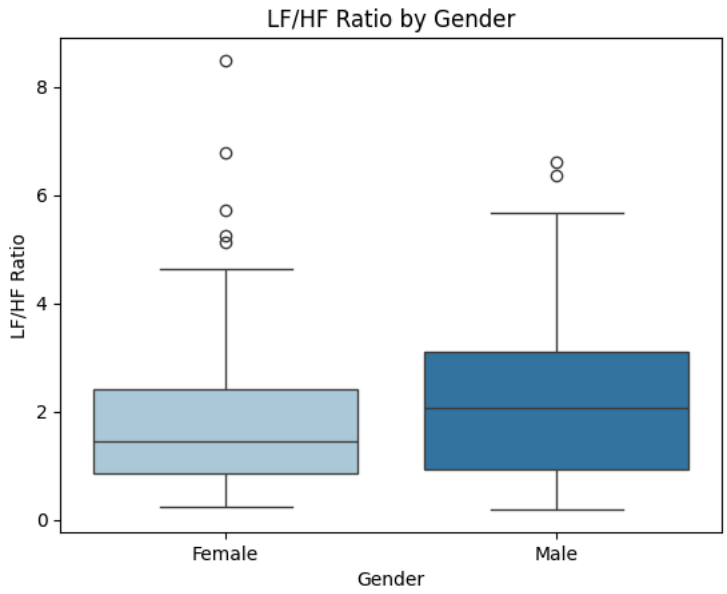
Higher stress levels lead to a higher LF/HF Ratio, indicating a shift towards sympathetic dominance. This suggests that stress indeed affects the balance between the sympathetic and parasympathetic nervous systems, highlighting the physiological impact of stress on autonomic regulation.

Gender vs LF/HF Ratio

Does gender influence the balance between sympathetic and parasympathetic nervous systems?

```
sns.boxplot(x='Gender', y='LF/HF Ratio', data=df, palette='Paired')
plt.title('LF/HF Ratio by Gender')
plt.show()
```

```
<ipython-input-37-82186972ecdf>:1: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend

  sns.boxplot(x='Gender', y='LF/HF Ratio', data=df, palette='Paired')
```

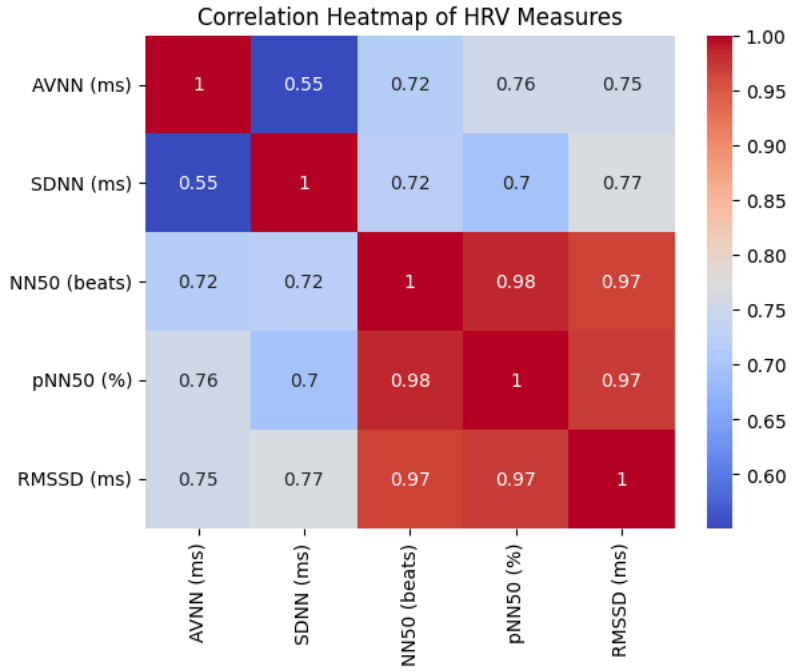


Males generally exhibit a higher LF/HF Ratio, suggesting a greater balance towards sympathetic dominance compared to females. This gender-specific trend highlights potential differences in autonomic regulation between men and women.

Correlation Heatmap of HRV Measures

How are heart rate variability measures related?

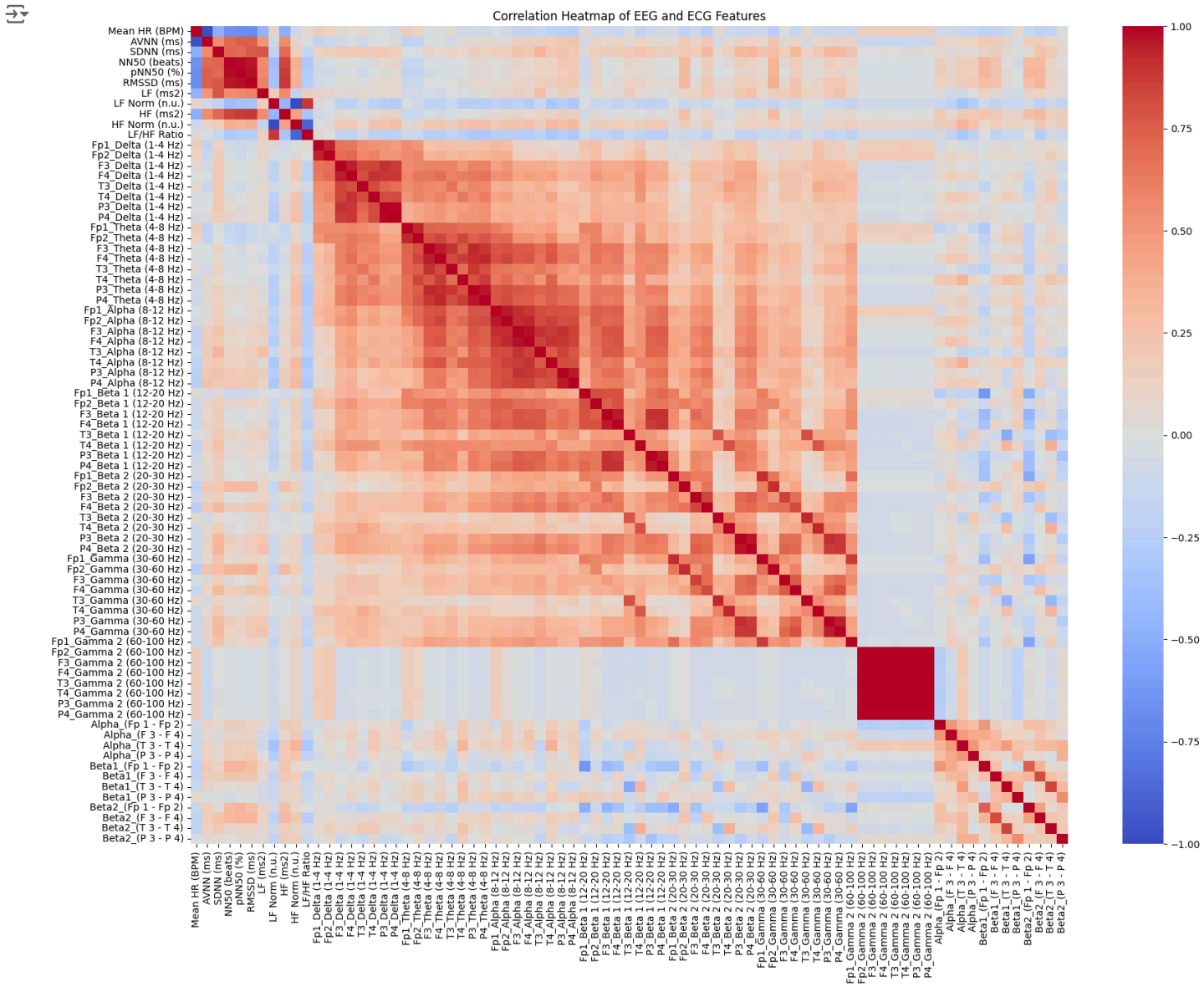
```
corr_matrix = df[['AVNN (ms)', 'SDNN (ms)', 'NN50 (beats)', 'pNN50 (%)', 'RMSSD (ms)']].corr()
sns.heatmap(corr_matrix, annot=True, cmap='coolwarm')
plt.title('Correlation Heatmap of HRV Measures')
plt.show()
```



Heart rate variability measures are closely interrelated, with some pairs (like RMSSD and pNN50) almost perfectly correlated. This interconnection indicates these measures capture similar aspects of autonomic regulation.

Correlation Heatmap of EEG/ECG Features

```
## Exclude non-numeric columns and the 'subject no' column
numeric_df = df.drop(columns=['Subject NO.']).select_dtypes(include=['float64', 'int64'])


plt.figure(figsize=(20, 15))
correlation_matrix = numeric_df.corr()  # Compute correlation matrix
sns.heatmap(correlation_matrix, annot=False, cmap='coolwarm', vmin=-1, vmax=1, cbar=True)
plt.title("Correlation Heatmap of EEG and ECG Features")
plt.show()
```

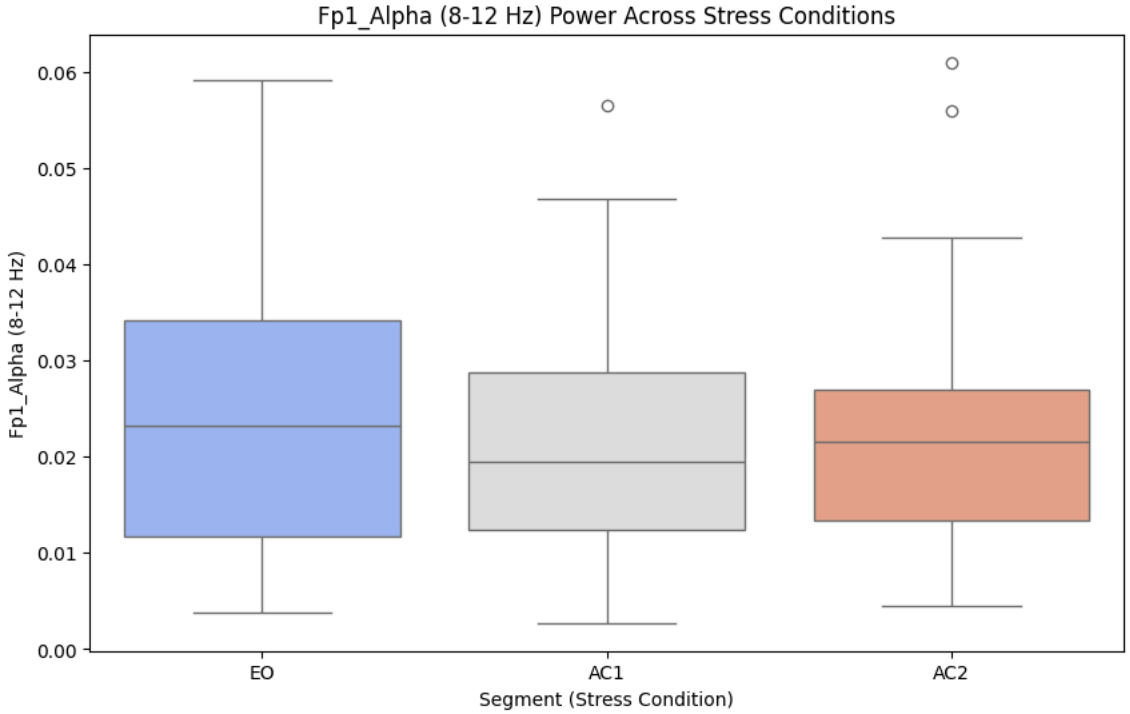


EEG Power Band Differences between Conditions

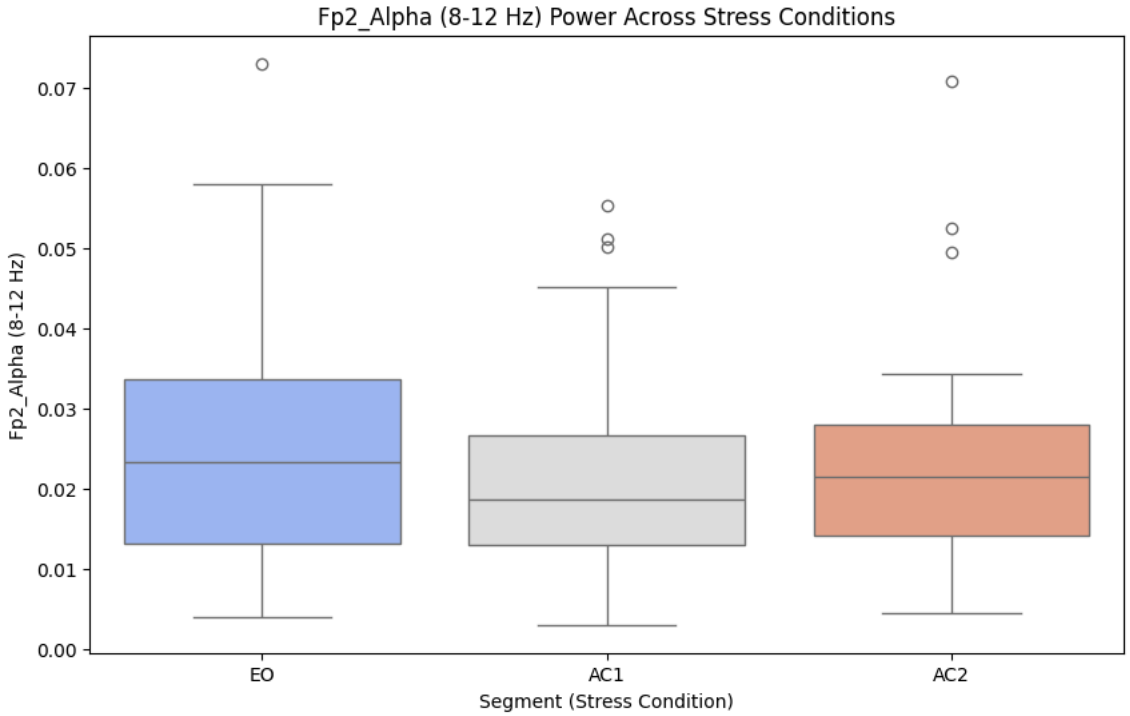
How does Alpha and Beta power vary across stress conditions?

```
power_bands = ['Fp1_Alpha (8-12 Hz)', 'Fp2_Alpha (8-12 Hz)', 'Fp1_Beta 1 (12-20 Hz)', 'Fp2_Beta 1 (12-20 Hz)']

for band in power_bands:
    plt.figure(figsize=(10, 6))
    sns.boxplot(x='Segment', y=band, data=df, palette='coolwarm')
    plt.title(f'{band} Power Across Stress Conditions')
    plt.xlabel('Segment (Stress Condition)')
    plt.ylabel(f'{band}')
    plt.show()
```

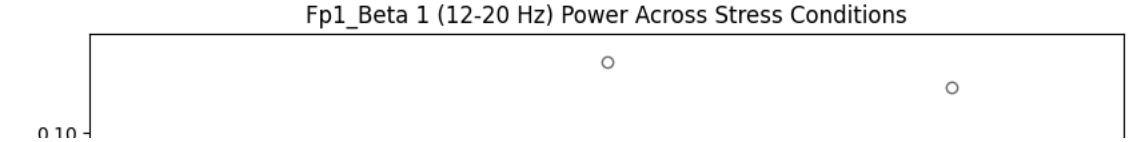
```
<ipython-input-14-a3a23fccbfaa>:5: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend

  sns.boxplot(x='Segment', y=band, data=df, palette='coolwarm')
```

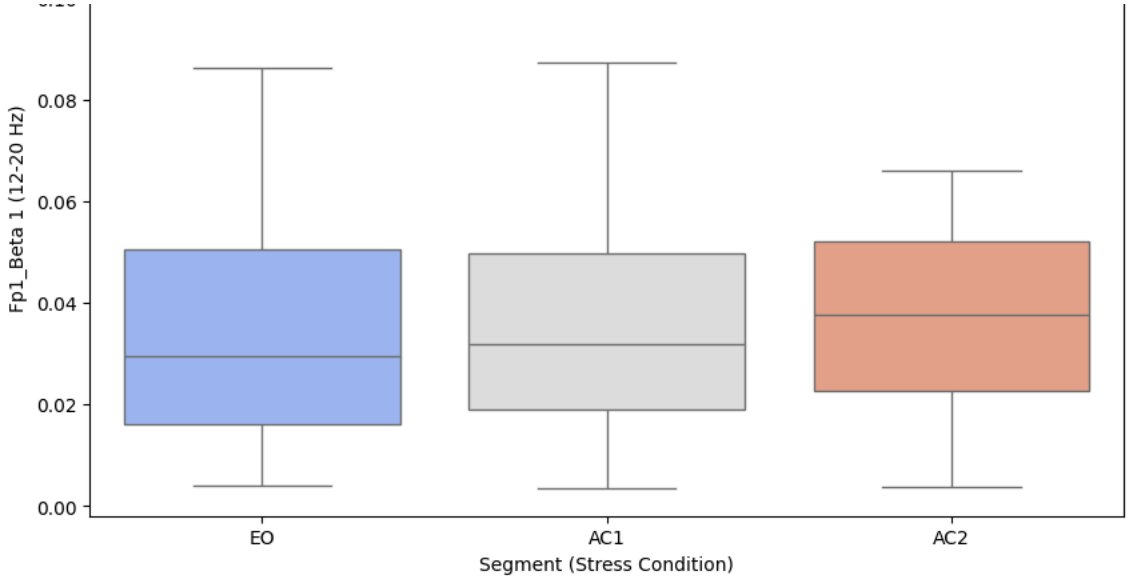



```
<ipython-input-14-a3a23fccbfaa>:5: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend

  sns.boxplot(x='Segment', y=band, data=df, palette='coolwarm')
```

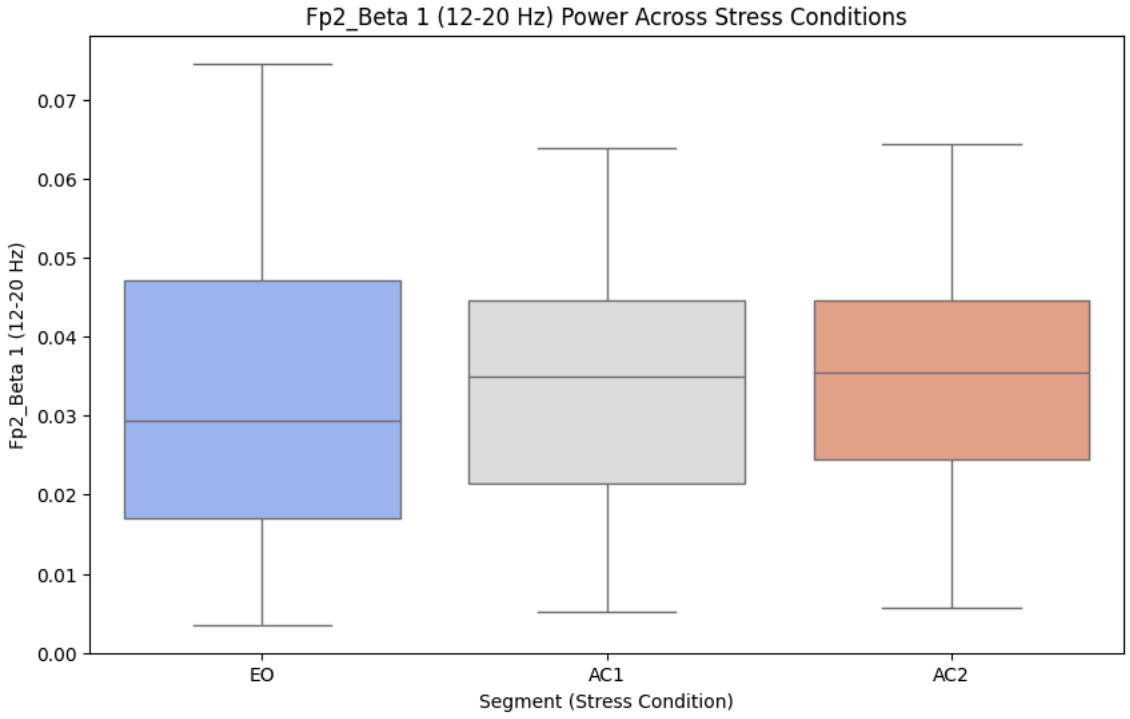



```
<ipython-input-14-a3a23fccbfaa>:5: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend

  sns.boxplot(x='Segment', y=band, data=df, palette='coolwarm')
```






```
<ipython-input-14-a3a23fccbfaa>:5: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend

  sns.boxplot(x='Segment', y=band, data=df, palette='coolwarm')
```

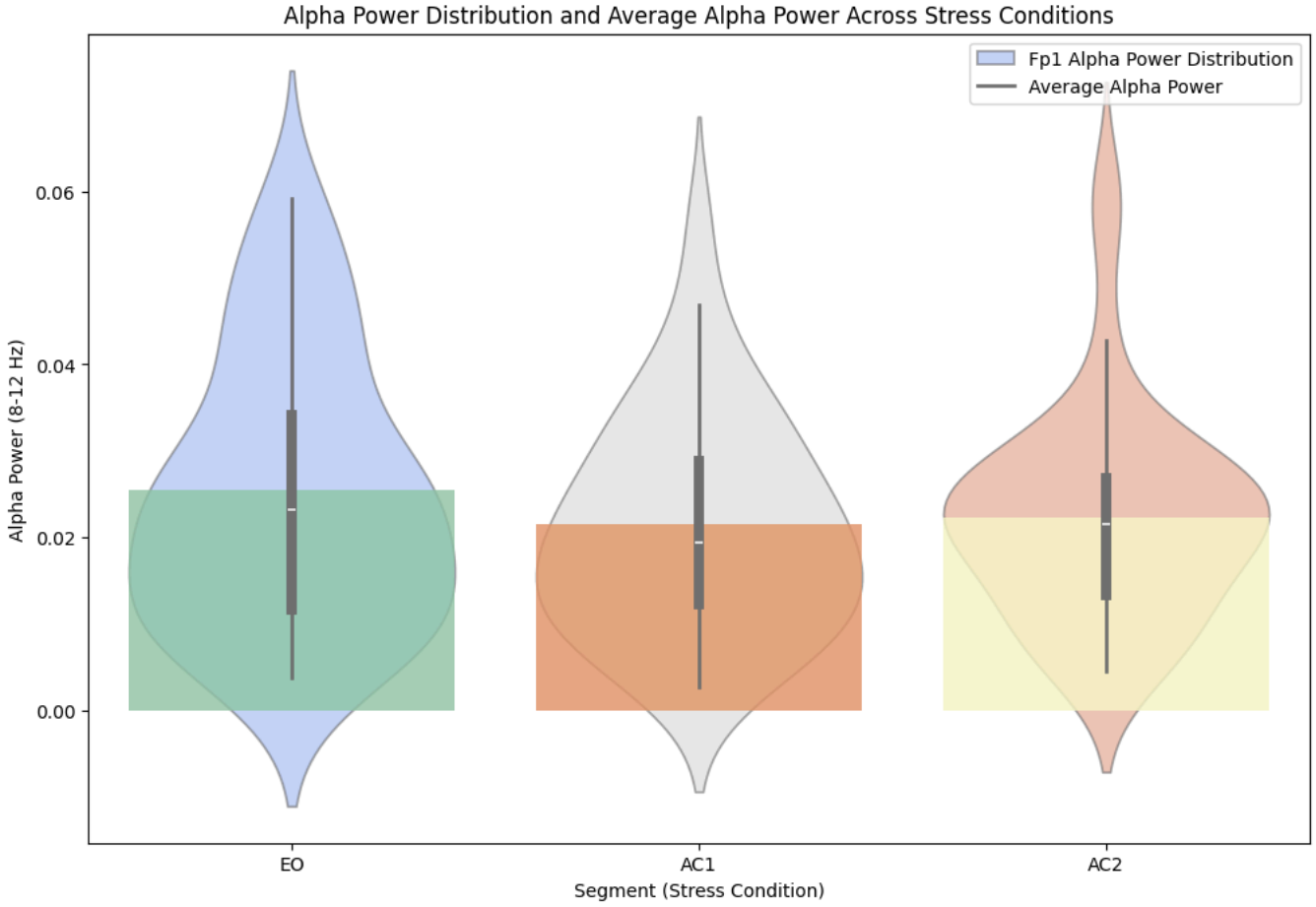


Alpha power decreases with stress, whereas Beta power remains relatively stable with minor variations. Gender differences are notable in Beta power levels, but stress conditions don't drastically alter Beta activity.

How does alpha brainwave activity vary with stress?

```
plt.figure(figsize=(12, 8))

# Create a violin plot for Alpha Power in Fp1
sns.violinplot(x='Segment', y='Fp1_Alpha (8-12 Hz)', data=df, palette='coolwarm', alpha=0.6)

# Calculate average Alpha power across segments and add it as a bar plot
alpha_cols = ['Fp1_Alpha (8-12 Hz)', 'Fp2_Alpha (8-12 Hz)']
df['Alpha_Mean'] = df[alpha_cols].mean(axis=1)

# Calculate average Alpha power for each segment
average_alpha = df.groupby('Segment')['Alpha_Mean'].mean().reset_index()

# Overlay the bar plot for Average Alpha Power
sns.barplot(x='Segment', y='Alpha_Mean', data=average_alpha, palette='Spectral', alpha=0.8)

# Set title and labels
plt.title('Alpha Power Distribution and Average Alpha Power Across Stress Conditions')
plt.xlabel('Segment (Stress Condition)')
plt.ylabel('Alpha Power (8-12 Hz)')

# Add a legend
plt.legend(['Fp1 Alpha Power Distribution', 'Average Alpha Power'], loc='upper right')

# Show the plot
plt.show()
```

```
<ipython-input-7-4df5217ab1a0>:4: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend

  sns.violinplot(x='Segment', y='Fp1_Alpha (8-12 Hz)', data=df, palette='coolwarm', alpha=0.6)
<ipython-input-7-4df5217ab1a0>:14: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend

  sns.barplot(x='Segment', y='Alpha_Mean', data=average_alpha, palette='Spectral', alpha=0.8)
```



Alpha brainwave activity tends to drop with increasing stress levels, indicating a potential inverse relationship between alpha power and stress. This highlights how stress can dampen certain brain activities, useful for stress management strategies.

Is there a significant difference in beta activity between genders?

```
beta_cols = ['Fp1_Beta 1 (12-20 Hz)', 'Fp2_Beta 1 (12-20 Hz)']
df['Beta_Mean'] = df[beta_cols].mean(axis=1)
sns.boxplot(x='Gender', y='Beta_Mean', data=df, palette='Set3')
plt.title('Beta Power by Gender')
plt.show()
```