In [6]:
```
import pandas as pd
from scipy import stats
import numpy as np
```

In [8]:
```
file_path = '/Users/harriethe/Downloads/Questioneer.xlsx'
df = pd.read_excel(file_path)
df.columns = df.columns.str.strip()
```

In [10]:
```
df_new = pd.read_csv('/Users/harriethe/Downloads/Question_new.csv')
```

In [12]:
```
# 1. Remove rows where Timepoint is '0'
df_cleaned = df_new[df_new['Timepoint relative to drug administration (in minutes)'] != '0']

# 2. Replace 'baseline' with 0 in the Timepoint column
df_cleaned['Timepoint relative to drug administration (in minutes)'] = df_cleaned['Timepoint relative to drug

df_cleaned = df_cleaned[df_cleaned['Timepoint relative to drug administration (in minutes)'] != 'Avg from cap
# 3. Replace 'ms' (missing) values with NaN throughout the entire DataFrame
df_cleaned = df_cleaned.replace('ms', np.nan)

df_cleaned['Timepoint relative to drug administration (in minutes)'] = pd.to_numeric(df_cleaned['Timepoint re

timepoints = df_cleaned['Timepoint relative to drug administration (in minutes)'].unique()
print(timepoints)
```

```
[  0  30  60 120 180 240 300 360]
/var/folders/fh/_crmyvv94rjbbn8m0gv12w2r0000gn/T/ipykernel_53327/2506174059.py:5: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#r
eturning-a-view-versus-a-copy
  df_cleaned['Timepoint relative to drug administration (in minutes)'] = df_cleaned['Timepoint relative to dr
ug administration (in minutes)'].replace('baseline', 0)
```

In [14]:
```
rating_columns = [
    '1. Overall Psilocybin Effect (0 = none to\n10 = strongest imaginable)',
    '2. Now-ness (0 = none to\n10 = strongest imaginable)',
    '3. Letting Go (0 = none to\n10 = strongest imaginable)',
    '4. Equanimity (0 = none to\n10 = strongest imaginable)',
    '5. Pure being and pure awareness (0 = none to\n10 = strongest imaginable)',
    '6. Fusion of your personal self into a larger whole (0 = none to\n10 = strongest imaginable)',
```

```
    '7. Sense of reverence or sacredness (0 = none to\n10 = strongest imaginable)',
    '8. Timelessness (0 = none to\n10 = strongest imaginable)',
    '9. Ineffability (0 = none to\n10 = strongest imaginable)',
    '10. Feelings of joy (0 = none to\n10 = strongest imaginable)',
    '11. Feelings of peace and tranquility (0 = none to\n10 = strongest imaginable)',
    '12. Positive Emotional Valence (0 = none to\n10 = strongest imaginable)',
    '13. Negative emotional valence  (0 = none to\n10 = strongest imaginable)'
]
```

In [16]:
```
df_cleaned.columns = df_cleaned.columns.str.strip()
#print(df_filtered.columns)

df_cleaned[rating_columns] = df_cleaned[rating_columns].apply(pd.to_numeric, errors='coerce')

# Check if the conversion worked by printing the dtypes
#print(df_filtered[rating_columns].dtypes)
```

Sections for Pair T Test

In [18]:
```
from scipy import stats

# Prepare dictionaries to store results for each time point
paired_results_by_time = {}

# Loop through each timepoint
for timepoint in timepoints:
    # Filter data for the current timepoint
    df_timepoint = df_cleaned[df_cleaned['Timepoint relative to drug administration (in minutes)'] == timepoi

    # Filter for placebo and psilocybin participants
    placebo_scores = df_timepoint[df_timepoint['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)'] == 'PL
    exp_scores = df_timepoint[df_timepoint['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)'] == 'EXP'][

    # Initialize a dictionary to hold t-test results for this time point
    paired_results_by_time[timepoint] = {}

    # Perform paired t-test for each question (rating column)
    for col in rating_columns:
        if len(placebo_scores[col]) == len(exp_scores[col]) and len(placebo_scores[col]) > 0:  # Ensure valid
            t_stat, p_value = stats.ttest_rel(placebo_scores[col], exp_scores[col], nan_policy='omit')
            # Transform p-values using -log10(p-value) if p-value > 0
            log_p_value = -np.log10(p_value) if p_value > 0 else None
            paired_results_by_time[timepoint][col] = (t_stat, log_p_value)  # Store log-transformed p-value
```

```
        else:
            paired_results_by_time[timepoint][col] = (None, None)  # In case of insufficient or unequal data

    # Print the results for this timepoint
    print(f"Results for Timepoint {timepoint} (minutes):")
    for col, (t_stat, log_p_value) in paired_results_by_time[timepoint].items():
        print(f"{col}: T-statistic = {t_stat}, -log10(P-value) = {log_p_value}")
    print("\n")
```

```
Results for Timepoint 0 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = nan, -log10(P-value) = None
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = 0.18797789509922808, -log10(P-value) = 0.06915886514948631
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = -0.7056967961720457, -log10(P-value) = 0.31112136557311854
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = -0.9687189593929654, -log10(P-value) = 0.46311943112020176
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = 0.6913837373523726, -log10(P-value) = 0.3034058432732242
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = 0.657595949221429, -log10(P-value) = 0.2854227198691093
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = 0.10347288589592778, -log10(P-value) = 0.0368649478147384
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -0.8154100913168026, -log10(P-value) = 0.372181278713321
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = 1.2403473458920846, -log10(P-value) = 0.6397820977715141
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -0.7096457724119537, -log10(P-value) = 0.3132602853231982
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = -0.26126497213658206, -log10(P-value) = 0.0987816644558655
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -0.4908806936738159, -log10(P-value) = 0.201450339440114
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = 1.698999098923931, -log10(P-value) = 0.9795454845220463


Results for Timepoint 30 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -3.568797893963764, -log10(P-value) = 2.716087991195579
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = 0.6095219666786235, -log10(P-value) = 0.26039511752616745
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = -0.3485075176786614, -log10(P-value) = 0.13602268522010522
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = 0.12299834568337575, -log10(P-value) = 0.04415066298879849
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = 0.13411044519645504, -log10(P-value) = 0.04834410813633313
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = 1.0458250331675942, -log10(P-value) = 0.5112832578441845
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = 0.14637194260221537, -log10(P-value) = 0.053011046420002476
8. Timelessness (0 = none to
```

```
10 = strongest imaginable): T-statistic = -0.6218845001217771, -log10(P-value) = 0.26676829759103565
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -2.3196933857945083, -log10(P-value) = 1.5079154030844428
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -0.18458480505051497, -log10(P-value) = 0.06782387135456634
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = 1.5579423821243894, -log10(P-value) = 0.8698892996890562
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = 0.4179383795285729, -log10(P-value) = 0.167206835658875
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = -0.4278625498405581, -log10(P-value) = 0.171776498366954


Results for Timepoint 60 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -7.319986682297554, -log10(P-value) = 6.214044464489869
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -0.8039020483873397, -log10(P-value) = 0.3651226811882955
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = -0.2756197330161589, -log10(P-value) = 0.10467944719314067
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = 1.1093162417777198, -log10(P-value) = 0.5499122508189178
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -1.0062873929698608, -log10(P-value) = 0.4855562106046149
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -2.7635216651841996, -log10(P-value) = 1.8928736802685713
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = 0.2802935969389348, -log10(P-value) = 0.10654439991580514
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -1.2292725943057183, -log10(P-value) = 0.6276158127944763
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -4.406696305852698, -log10(P-value) = 3.4138582711872676
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -0.7026008204419223, -log10(P-value) = 0.3081988904799919
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = 3.1438385661850643, -log10(P-value) = 2.2276192871497713
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -0.20070964149630047, -log10(P-value) = 0.07401415095226195
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = -1.5312829869775526, -log10(P-value) = 0.8413483712430532


Results for Timepoint 120 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -10.932119067896782, -log10(P-value) = 8.910292199502377
```

```
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -5.569933086615312, -log10(P-value) = 4.645380271065067
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = -2.48305515724224, -log10(P-value) = 1.647235822971726
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = 0.0, -log10(P-value) = -0.0
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -4.2653445539189185, -log10(P-value) = 3.3786898918532935
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -6.362252814024701, -log10(P-value) = 5.377085410371249
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -3.510319506473832, -log10(P-value) = 2.6308035673428947
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -6.272727272727273, -log10(P-value) = 5.296134616113173
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -7.0141826155279965, -log10(P-value) = 5.952634687410637
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -3.1891395762619132, -log10(P-value) = 2.316022663667095
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = -0.48743450538846206, -log10(P-value) = 0.1993970671155538
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -1.7331773447985919, -log10(P-value) = 1.003209274159585
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = -1.0566747075571858, -log10(P-value) = 0.5172534044798517


Results for Timepoint 180 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -16.92254051915307, -log10(P-value) = 12.592907183314807
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -9.093305161368113, -log10(P-value) = 7.422929175512983
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = -7.416493535870903, -log10(P-value) = 6.295401266709697
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = -6.454972243679028, -log10(P-value) = 5.460442996419268
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -8.93519466806411, -log10(P-value) = 7.50519932433605
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -7.777210863692854, -log10(P-value) = 6.594671237184267
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -7.284844920603416, -log10(P-value) = 6.184283687266802
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -5.687824834798567, -log10(P-value) = 4.7563628413523995
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -7.783316947258129, -log10(P-value) = 6.5996720034188545
```

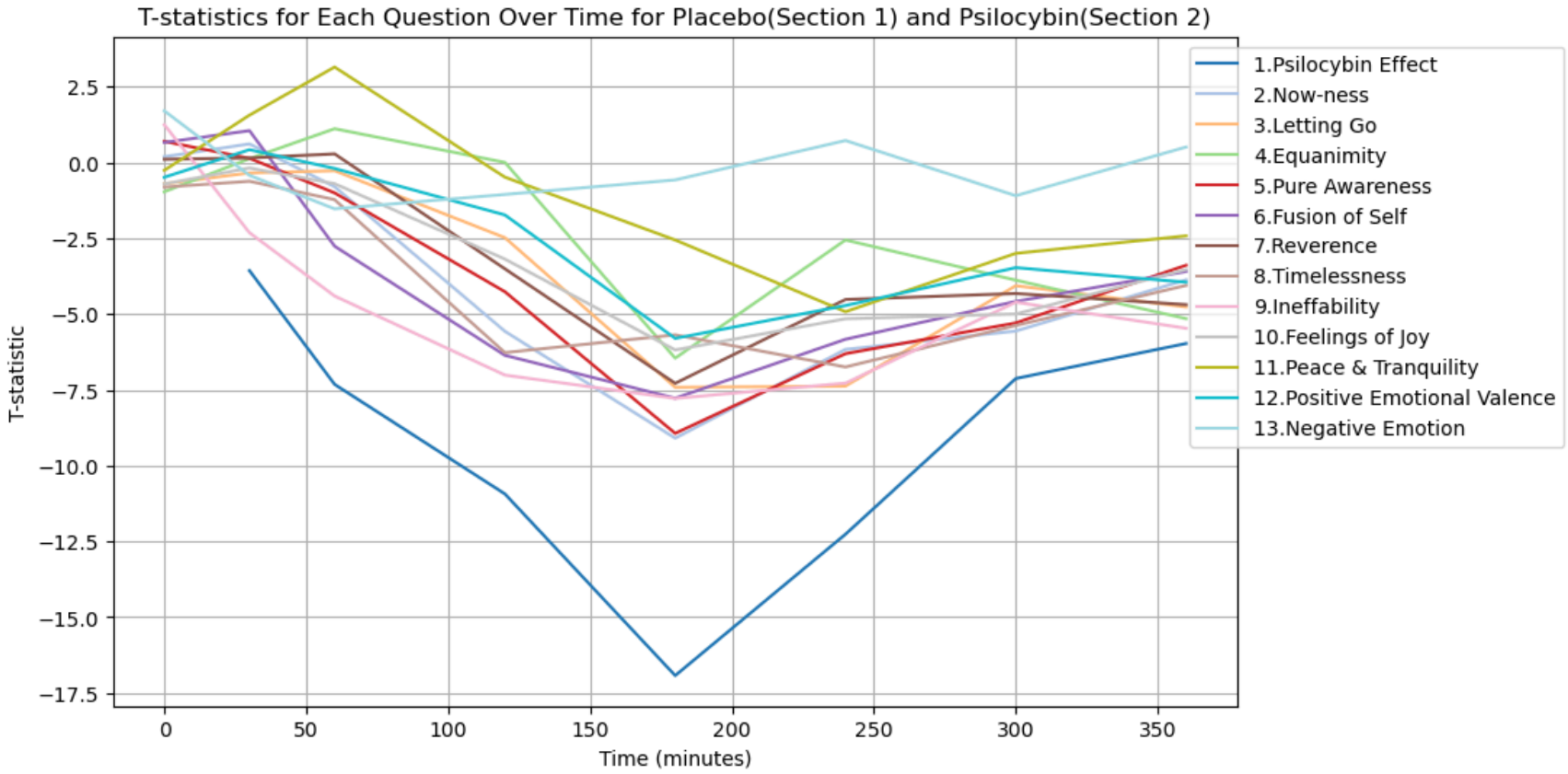
```
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -6.185760537730083, -log10(P-value) = 5.217064284971247
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = -2.5593176062786935, -log10(P-value) = 1.705273979321204
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -5.803639343821998, -log10(P-value) = 4.864698246495434
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = -0.5784790097963374, -log10(P-value) = 0.24432707776025533


Results for Timepoint 240 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -12.261208713114476, -log10(P-value) = 9.744874149981774
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -6.167072032845844, -log10(P-value) = 5.200017321731256
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = -7.377378401994856, -log10(P-value) = 6.262492413405327
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = -2.559343516304476, -log10(P-value) = 1.7172648177036187
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -6.307640191571234, -log10(P-value) = 5.327757627917003
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -5.832660825504768, -log10(P-value) = 4.891735912331623
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -4.520967182069254, -log10(P-value) = 3.631165028852159
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -6.74630238263132, -log10(P-value) = 5.719133012146268
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -7.279943591298901, -log10(P-value) = 6.180127099118932
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -5.156104408169628, -log10(P-value) = 4.250529699721511
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = -4.924091613757983, -log10(P-value) = 4.025913291692642
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -4.720808303895489, -log10(P-value) = 3.827480231888625
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = 0.7205037703302525, -log10(P-value) = 0.3187712053896142


Results for Timepoint 300 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -7.127537641337663, -log10(P-value) = 6.179540979204518
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -5.562213147927255, -log10(P-value) = 4.717869740699925
3. Letting Go (0 = none to
```

```
10 = strongest imaginable): T-statistic = -4.066886812455412, -log10(P-value) = 3.1820109886911725
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = -3.8848299473609478, -log10(P-value) = 3.0014124919094236
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -5.293714326561026, -log10(P-value) = 4.3826984524433845
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -4.584506420002511, -log10(P-value) = 3.693701172726956
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -4.3233154997720336, -log10(P-value) = 3.4360524095419147
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -5.378249582661413, -log10(P-value) = 4.463472270632864
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -4.61043509420293, -log10(P-value) = 3.7191903522187917
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -4.99883254853061, -log10(P-value) = 4.098502084429593
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = -3.0, -log10(P-value) = 2.133020457966206
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -3.4719564436457055, -log10(P-value) = 2.5930048274403967
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = -1.0988733765976275, -log10(P-value) = 0.5443128903955623


Results for Timepoint 360 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -5.971631046748498, -log10(P-value) = 5.112977493089625
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -3.8729833462074166, -log10(P-value) = 3.023801009856832
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = -4.768316485434158, -log10(P-value) = 3.93070277823916
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = -5.152135733635232, -log10(P-value) = 4.314301824039838
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -3.3921747176506836, -log10(P-value) = 2.538638422399038
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -3.5976931812503268, -log10(P-value) = 2.7452224295978698
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -4.690415759823429, -log10(P-value) = 3.852290017177736
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -4.0571550015261115, -log10(P-value) = 3.2107658399508767
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -5.4707703865093915, -log10(P-value) = 4.628515703131563
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -3.534578227065181, -log10(P-value) = 2.6816192749816095
11. Feelings of peace and tranquility (0 = none to
```

```
10 = strongest imaginable): T-statistic = -2.4230670981304208, -log10(P-value) = 1.6020146348519788
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -3.952847075210474, -log10(P-value) = 3.104846526128196
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = 0.5071831293409736, -log10(P-value) = 0.20931159411304626
```

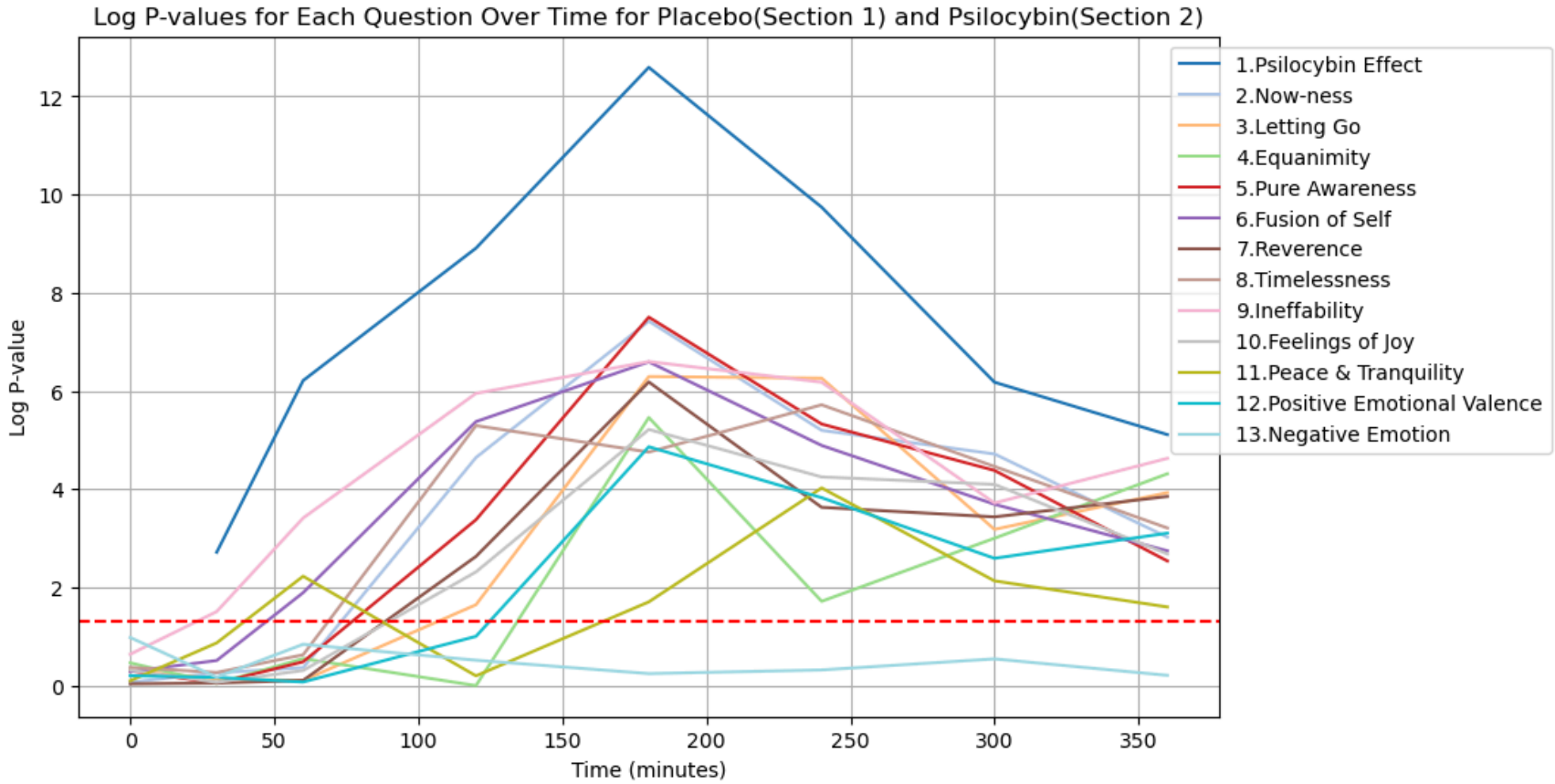
In [20]:

```python
import matplotlib.pyplot as plt

shortened_rating_columns = [
    '1.Psilocybin Effect', '2.Now-ness', '3.Letting Go', '4.Equanimity', '5.Pure Awareness',
    '6.Fusion of Self', '7.Reverence', '8.Timelessness', '9.Ineffability',
    '10.Feelings of Joy', '11.Peace & Tranquility', '12.Positive Emotional Valence', '13.Negative Emotion'
]

timepoints = list(paired_results_by_time.keys())
t_stats_by_question = {col: [] for col in rating_columns}

# Populate the t-statistics for each question at each timepoint
for timepoint in timepoints:
    for col in rating_columns:
        t_stat, _ = paired_results_by_time[timepoint][col]
        t_stats_by_question[col].append(t_stat)

# Plot t-statistics for each question as a line plot
plt.figure(figsize=(10, 6))
#for col in rating_columns:
    #plt.plot(timepoints, t_stats_by_question[col], label=col)
cmap = plt.get_cmap('tab20', len(shortened_rating_columns))

for i,(col, short_col) in enumerate(zip(rating_columns, shortened_rating_columns)):
    plt.plot(timepoints, t_stats_by_question[col], label=short_col,color=cmap(i))
plt.xlabel('Time (minutes)')
plt.ylabel('T-statistic')
plt.title('T-statistics for Each Question Over Time for Placebo(Section 1) and Psilocybin(Section 2)')
plt.legend(loc='upper right', bbox_to_anchor=(1.3, 1))
plt.grid(True)
plt.show()
```



In [22]:
```
log_p_values_by_question = {col: [] for col in rating_columns}

for timepoint in timepoints:
    for col in rating_columns:
        _, log_p_value = paired_results_by_time[timepoint][col]
        log_p_values_by_question[col].append(log_p_value)

# Plot p-values for each question as a line plot
plt.figure(figsize=(10, 6))
#for col in rating_columns:
    #plt.plot(timepoints, p_values_by_question[col], label=col)
for i,(col, short_col) in enumerate(zip(rating_columns, shortened_rating_columns)):
    plt.plot(timepoints, log_p_values_by_question[col], label=short_col,color=cmap(i))
plt.xlabel('Time (minutes)')
plt.ylabel('Log P-value')
plt.title('Log P-values for Each Question Over Time for Placebo(Section 1) and Psilocybin(Section 2)')
plt.axhline(y=-np.log10(0.05), color='r', linestyle='--')
plt.legend(loc='upper right', bbox_to_anchor=(1.3, 1))
```

```
plt.grid(True)
plt.show()
```



This Section is for Wilcoxon

Wilcoxon is not good with NaN

In [51]:
```
for timepoint in timepoints:
    df_timepoint = df_cleaned_imputed[df_cleaned_imputed['Timepoint relative to drug administration (in minut
    print(f"Missing values for Timepoint {timepoint} (minutes):")
    print(df_cleaned_imputed[rating_columns].isna().sum())
#df_cleaned.to_csv('/Users/harriethe/Downloads/missing_values_check.csv', index=False)

# Drop rows with missing values for the specific columns
df_cleaned_imputed = df_cleaned.copy()
```

```
df_cleaned_imputed[rating_columns] = df_cleaned_imputed[rating_columns].fillna(method='ffill')
print("NaN: ",df_cleaned_imputed.isnull().sum())
#print(df_cleaned_imputed.shape) #(488, 19)
#print(df_cleaned.shape) #(488, 19)
```

```
NaN:  Volunteer number                                                                                  0
Session (1, 2)                                                                                          0
Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)                                                    0
Timepoint relative to drug administration (in minutes)                                                  0
1. Overall Psilocybin Effect (0 = none to\n10 = strongest imaginable)                                   0
2. Now-ness (0 = none to\n10 = strongest imaginable)                                                    0
3. Letting Go (0 = none to\n10 = strongest imaginable)                                                  0
4. Equanimity (0 = none to\n10 = strongest imaginable)                                                  0
5. Pure being and pure awareness (0 = none to\n10 = strongest imaginable)                               0
6. Fusion of your personal self into a larger whole (0 = none to\n10 = strongest imaginable)            0
7. Sense of reverence or sacredness (0 = none to\n10 = strongest imaginable)                            0
8. Timelessness (0 = none to\n10 = strongest imaginable)                                                0
9. Ineffability (0 = none to\n10 = strongest imaginable)                                                0
10. Feelings of joy (0 = none to\n10 = strongest imaginable)                                            0
11. Feelings of peace and tranquility (0 = none to\n10 = strongest imaginable)                          0
12. Positive Emotional Valence (0 = none to\n10 = strongest imaginable)                                 0
13. Negative emotional valence  (0 = none to\n10 = strongest imaginable)                                0
Unnamed: 17                                                                                           488
Unnamed: 18                                                                                           487
dtype: int64
```

In [54]:

```
for timepoint in timepoints:
    # Filter data for the current timepoint
    df_timepoint = df_cleaned_imputed[df_cleaned_imputed['Timepoint relative to drug administration (in minut

    # Filter for placebo and psilocybin participants
    placebo_scores = df_timepoint[df_timepoint['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)'] == 'PL
    exp_scores = df_timepoint[df_timepoint['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)'] == 'EXP'][

    # Initialize a dictionary to hold Wilcoxon test results for this time point
    paired_results_by_time[timepoint] = {}

    # Perform Wilcoxon signed-rank test for each question (rating column)
    for col in rating_columns:
        if len(placebo_scores[col]) == len(exp_scores[col]) and len(placebo_scores[col]) > 0:  # Ensure valid
            try:
                # Perform Wilcoxon signed-rank test
                t_stat, p_value = wilcoxon(placebo_scores[col], exp_scores[col], zero_method='wilcox', correc

                # Transform p-values using -log10(p-value) if p_value > 0
```

```
                log_p_value = -np.log10(p_value) if p_value > 0 else None
                paired_results_by_time[timepoint][col] = (t_stat, log_p_value)  # Store log-transformed p-val
            except ValueError:
                # Handle case where Wilcoxon test cannot be computed (e.g., all zero differences)
                paired_results_by_time[timepoint][col] = (None, None)
        else:
            paired_results_by_time[timepoint][col] = (None, None)  # In case of insufficient or unequal data

    # Print the results for this timepoint
    print(f"Results for Timepoint {timepoint} (minutes):")
    for col, (t_stat, log_p_value) in paired_results_by_time[timepoint].items():
        print(f"{col}: Wilcoxon statistic = {t_stat}, -log10(P-value) = {log_p_value}")
    print("\n")
```

```
Results for Timepoint 0 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): Wilcoxon statistic = None, -log10(P-value) = None
2. Now-ness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 37.5, -log10(P-value) = 0.04309699616319855
3. Letting Go (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 74.0, -log10(P-value) = 0.42613420951199515
4. Equanimity (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 59.5, -log10(P-value) = 0.3850491416458158
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 43.5, -log10(P-value) = 0.2517754306665231
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 33.5, -log10(P-value) = 0.18376707360983105
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 74.0, -log10(P-value) = 0.0437995064710515
8. Timelessness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 48.5, -log10(P-value) = 0.30657899845828623
9. Ineffability (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 28.0, -log10(P-value) = 0.6721257730253355
10. Feelings of joy (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 57.5, -log10(P-value) = 0.44793250003189405
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 51.5, -log10(P-value) = 0.20564662917481213
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 70.0, -log10(P-value) = 0.12286716413377727
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 19.0, -log10(P-value) = 0.9573923498425354


Results for Timepoint 30 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 4.0, -log10(P-value) = 2.6612525901997777
2. Now-ness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 79.5, -log10(P-value) = 0.2796866323392314
3. Letting Go (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 55.0, -log10(P-value) = 0.11165824121285733
4. Equanimity (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 42.0, -log10(P-value) = 0.09537452084724886
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 57.0, -log10(P-value) = 0.25616124509505234
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 37.5, -log10(P-value) = 0.47231887165026537
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 54.0, -log10(P-value) = 0.1361659964660861
8. Timelessness (0 = none to
```

```
10 = strongest imaginable): Wilcoxon statistic = 59.0, -log10(P-value) = 0.3970446811459119
9. Ineffability (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 31.0, -log10(P-value) = 1.521823047543063
10. Feelings of joy (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 56.0, -log10(P-value) = 0.08693756909530834
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 35.5, -log10(P-value) = 0.7978314823726385
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 52.0, -log10(P-value) = 0.4039275321032893
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 32.5, -log10(P-value) = 0.01587997954833769


Results for Timepoint 60 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 1.0, -log10(P-value) = 3.9960060465126856
2. Now-ness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 80.5, -log10(P-value) = 0.6401914742676516
3. Letting Go (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 71.0, -log10(P-value) = 0.28016029937065223
4. Equanimity (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 53.0, -log10(P-value) = 0.36070184692607626
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 63.5, -log10(P-value) = 0.6939887393016618
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 36.0, -log10(P-value) = 1.5207127629527821
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 64.5, -log10(P-value) = 0.06788031237625958
8. Timelessness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 31.5, -log10(P-value) = 0.4880434283864324
9. Ineffability (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 4.0, -log10(P-value) = 3.248117843359602
10. Feelings of joy (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 55.5, -log10(P-value) = 0.2880633568229767
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 15.5, -log10(P-value) = 2.1962844125606966
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 59.0, -log10(P-value) = 0.020378982182386183
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 39.0, -log10(P-value) = 0.6637008527784217


Results for Timepoint 120 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 1.0, -log10(P-value) = 5.719569917615643
```

```
2. Now-ness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 5.0, -log10(P-value) = 3.7540826743672397
3. Letting Go (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 34.0, -log10(P-value) = 1.867240457859476
4. Equanimity (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 110.0, -log10(P-value) = 0.06304051138214437
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 25.0, -log10(P-value) = 2.3449562702977076
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 0.0, -log10(P-value) = 3.9130118509756056
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 15.5, -log10(P-value) = 2.1993215868276943
8. Timelessness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 3.0, -log10(P-value) = 3.8804585981657143
9. Ineffability (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 3.0, -log10(P-value) = 5.321629908943605
10. Feelings of joy (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 25.0, -log10(P-value) = 2.3225517726694545
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 67.5, -log10(P-value) = 0.37727986032295396
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 59.5, -log10(P-value) = 1.0548659063462078
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 42.0, -log10(P-value) = 0.2981615444794743


Results for Timepoint 180 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 0.0, -log10(P-value) = 6.020599913279624
2. Now-ness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 0.0, -log10(P-value) = 6.020599913279624
3. Letting Go (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 0.0, -log10(P-value) = 3.9150977601521513
4. Equanimity (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 10.5, -log10(P-value) = 2.989688030133111
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 12.5, -log10(P-value) = 4.175501873265367
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 2.5, -log10(P-value) = 5.543478658559962
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 5.5, -log10(P-value) = 3.7131981536811347
8. Timelessness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 6.5, -log10(P-value) = 3.441538586005324
9. Ineffability (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 0.0, -log10(P-value) = 4.066898707520493
```

```
10. Feelings of joy (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 7.5, -log10(P-value) = 3.5929039733611363
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 59.0, -log10(P-value) = 1.2993665432623465
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 7.5, -log10(P-value) = 4.741846312326795
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 35.5, -log10(P-value) = 0.10772069750751752


Results for Timepoint 240 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 0.0, -log10(P-value) = 6.020599913279624
2. Now-ness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 2.5, -log10(P-value) = 3.9135559407081075
3. Letting Go (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 0.0, -log10(P-value) = 3.9150977601521513
4. Equanimity (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 22.5, -log10(P-value) = 1.7403041190907478
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 0.0, -log10(P-value) = 3.550179216957633
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 0.0, -log10(P-value) = 3.9040016303671528
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 6.5, -log10(P-value) = 3.255829173288824
8. Timelessness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 3.0, -log10(P-value) = 5.321629908943605
9. Ineffability (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 2.0, -log10(P-value) = 5.543478658559962
10. Feelings of joy (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 7.5, -log10(P-value) = 3.6148339626817103
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 31.0, -log10(P-value) = 2.667260817968319
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 17.0, -log10(P-value) = 3.035400300168952
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 29.0, -log10(P-value) = 0.14509353627161634


Results for Timepoint 300 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 0.0, -log10(P-value) = 3.894350192388102
2. Now-ness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 10.5, -log10(P-value) = 4.387131457700037
3. Letting Go (0 = none to
```

```
10 = strongest imaginable): Wilcoxon statistic = 15.0, -log10(P-value) = 2.934879551154473
4. Equanimity (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 17.5, -log10(P-value) = 2.778675029896778
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 4.0, -log10(P-value) = 3.843981701111279
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 10.0, -log10(P-value) = 3.2293115195581823
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 9.5, -log10(P-value) = 3.2572555017339737
8. Timelessness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 2.0, -log10(P-value) = 3.5959246011717676
9. Ineffability (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 6.5, -log10(P-value) = 3.49151788438078
10. Feelings of joy (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 13.0, -log10(P-value) = 3.2635500154414623
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 28.5, -log10(P-value) = 2.1524878116197868
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 23.0, -log10(P-value) = 2.45420103639572
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 20.0, -log10(P-value) = 0.6229756160117641


Results for Timepoint 360 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 0.0, -log10(P-value) = 3.7289551007646207
2. Now-ness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 8.0, -log10(P-value) = 2.541036720348614
3. Letting Go (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 16.0, -log10(P-value) = 3.1067931933021184
4. Equanimity (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 3.5, -log10(P-value) = 3.302434233844632
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 15.0, -log10(P-value) = 2.471337512612889
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 11.0, -log10(P-value) = 2.5067537101106088
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 0.0, -log10(P-value) = 3.3829738138806915
8. Timelessness (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 10.5, -log10(P-value) = 2.7705517602706937
9. Ineffability (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 1.0, -log10(P-value) = 3.2878541815556357
10. Feelings of joy (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 19.5, -log10(P-value) = 2.413962235796285
11. Feelings of peace and tranquility (0 = none to
```

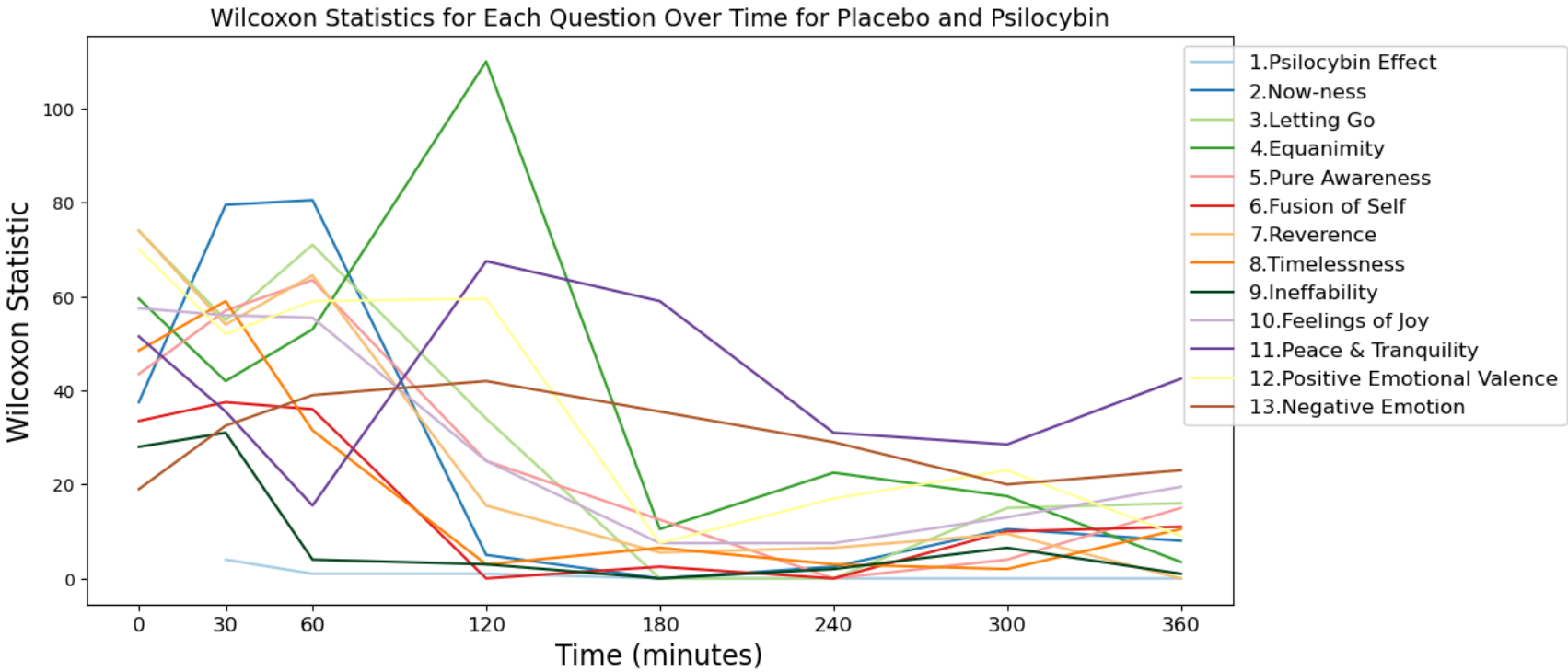
```
10 = strongest imaginable): Wilcoxon statistic = 42.5, -log10(P-value) = 1.4842627276083973
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 9.0, -log10(P-value) = 2.9191335445875586
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): Wilcoxon statistic = 23.0, -log10(P-value) = 0.19468330114860563
```

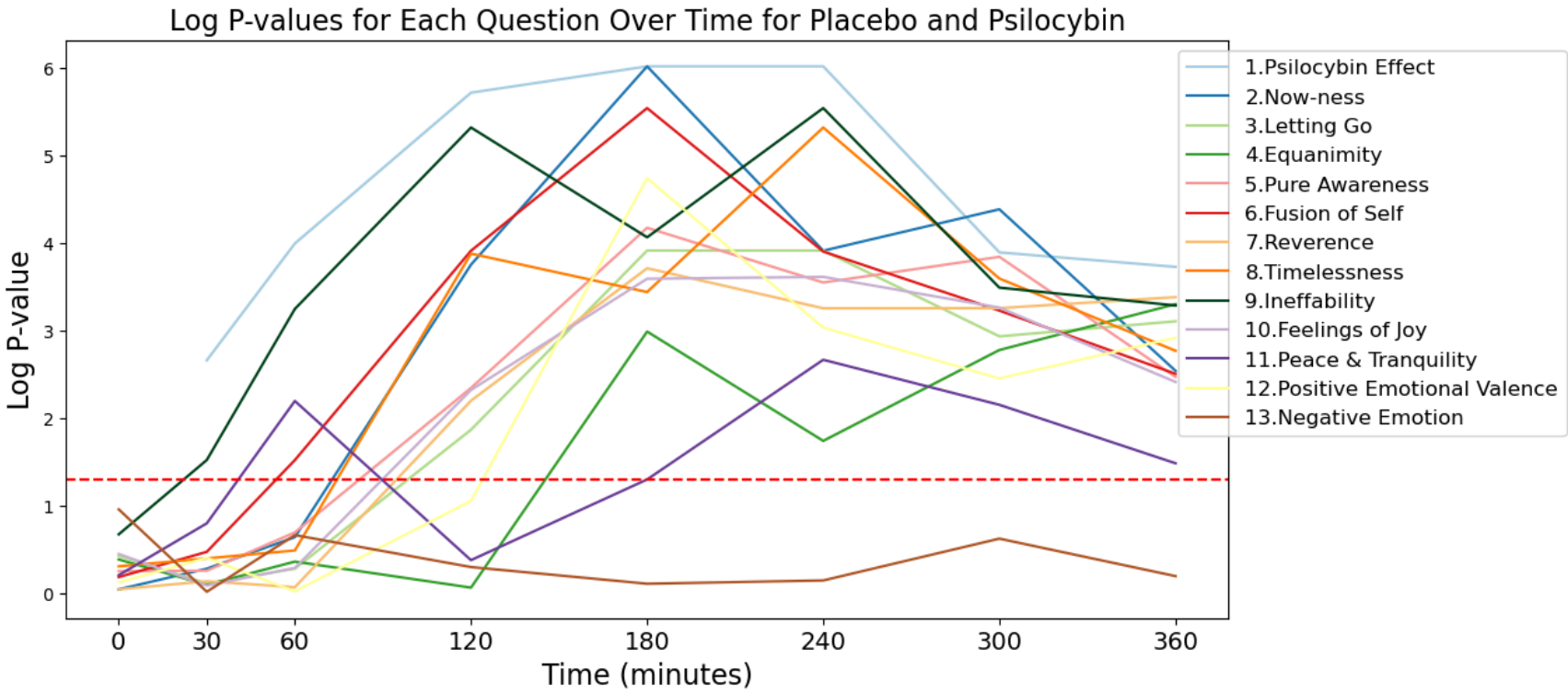
```
/Users/harriethe/anaconda3/lib/python3.11/site-packages/scipy/stats/_morestats.py:3414: UserWarning: Exact p-value calculation does not work if there are zeros. Switching to normal approximation.
  warnings.warn("Exact p-value calculation does not work if there are "
/Users/harriethe/anaconda3/lib/python3.11/site-packages/scipy/stats/_morestats.py:3414: UserWarning: Exact p-value calculation does not work if there are zeros. Switching to normal approximation.
  warnings.warn("Exact p-value calculation does not work if there are "
/Users/harriethe/anaconda3/lib/python3.11/site-packages/scipy/stats/_morestats.py:3414: UserWarning: Exact p-value calculation does not work if there are zeros. Switching to normal approximation.
  warnings.warn("Exact p-value calculation does not work if there are "
/Users/harriethe/anaconda3/lib/python3.11/site-packages/scipy/stats/_morestats.py:3414: UserWarning: Exact p-value calculation does not work if there are zeros. Switching to normal approximation.
  warnings.warn("Exact p-value calculation does not work if there are "
/Users/harriethe/anaconda3/lib/python3.11/site-packages/scipy/stats/_morestats.py:3414: UserWarning: Exact p-value calculation does not work if there are zeros. Switching to normal approximation.
  warnings.warn("Exact p-value calculation does not work if there are "
/Users/harriethe/anaconda3/lib/python3.11/site-packages/scipy/stats/_morestats.py:3414: UserWarning: Exact p-value calculation does not work if there are zeros. Switching to normal approximation.
  warnings.warn("Exact p-value calculation does not work if there are "
/Users/harriethe/anaconda3/lib/python3.11/site-packages/scipy/stats/_morestats.py:3414: UserWarning: Exact p-value calculation does not work if there are zeros. Switching to normal approximation.
  warnings.warn("Exact p-value calculation does not work if there are "
/Users/harriethe/anaconda3/lib/python3.11/site-packages/scipy/stats/_morestats.py:3414: UserWarning: Exact p-value calculation does not work if there are zeros. Switching to normal approximation.
  warnings.warn("Exact p-value calculation does not work if there are "
```

In [84]:

```python
specific_timepoints = [0, 30, 60, 120, 180, 240, 300, 360]
custom_colors = [
    "#a6cee3", "#1f78b4", "#b2df8a", "#33a02c", "#fb9a99", "#e31a1c", "#fdbf6f", "#ff7f00",
    "#00441b", "#cab2d6", "#6a3d9a", "#ffff99", "#b15928"
]

t_stats_by_question = {col: [] for col in rating_columns}
log_p_values_by_question = {col: [] for col in rating_columns}

# Extract Wilcoxon statistics and log p-values from paired_results_by_time
for timepoint in timepoints:
    for col in rating_columns:
        t_stat, log_p_value = paired_results_by_time[timepoint][col]
```

```
        t_stats_by_question[col].append(t_stat if t_stat is not None else np.nan)
        log_p_values_by_question[col].append(log_p_value if log_p_value is not None else np.nan)

plt.figure(figsize=(12, 6))
for i, (col, short_col) in enumerate(zip(rating_columns, shortened_rating_columns)):
    plt.plot(timepoints, t_stats_by_question[col], label=short_col, color=custom_colors[i])
plt.xlabel('Time (minutes)', fontsize=16)
plt.ylabel('Wilcoxon Statistic', fontsize=16)
plt.title('Wilcoxon Statistics for Each Question Over Time for Placebo and Psilocybin', fontsize=14)
plt.xticks(specific_timepoints, fontsize=12)
plt.legend(loc='upper right', bbox_to_anchor=(1.3, 1), fontsize=12)
plt.show()

# Plotting the log p-values over time
plt.figure(figsize=(12, 6))
for i, (col, short_col) in enumerate(zip(rating_columns, shortened_rating_columns)):
    plt.plot(timepoints, log_p_values_by_question[col], label=short_col, color=custom_colors[i])
plt.xlabel('Time (minutes)', fontsize=16)
plt.ylabel('Log P-value', fontsize=16)
plt.title('Log P-values for Each Question Over Time for Placebo and Psilocybin', fontsize=16)
plt.xticks(specific_timepoints, fontsize=14)
plt.axhline(y=-np.log10(0.05), color='r', linestyle='--')
plt.legend(loc='upper right', bbox_to_anchor=(1.3, 1), fontsize=12)
plt.show()
```


Wilcoxon Statistics for Each Question Over Time for Placebo and Psilocybin
Wilcoxon Statistic
Time (minutes)
0
20
40
60
80
100
0
30
60
120
180
240
300
360
1.Psilocybin Effect
2.Now-ness
3.Letting Go
4.Equanimity
5.Pure Awareness
6.Fusion of Self
7.Reverence
8.Timelessness
9.Ineffability
10.Feelings of Joy
11.Peace & Tranquility
12.Positive Emotional Valence
13.Negative Emotion



Sections for Indepedent T Test

In [66]:
```
independent_results_by_time = {}
for timepoint in timepoints:
    df_timepoint = df_cleaned[df_cleaned['Timepoint relative to drug administration (in minutes)'] == timepoi
    placebo_scores = df_timepoint[(df_timepoint['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)'] == 'P
    psilocybin_scores = df_timepoint[(df_timepoint['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)'] ==
    independent_results_by_time[timepoint] = {}

    for col in rating_columns:
        if len(placebo_scores[col]) > 0 and len(psilocybin_scores[col]) > 0:
            t_stat, p_value = stats.ttest_ind(placebo_scores[col], psilocybin_scores[col], nan_policy='omit')
            if p_value > 0:
                log_p_value = -np.log10(p_value)
            else:
                log_p_value = np.nan

            independent_results_by_time[timepoint][col] = (t_stat, log_p_value)
        else:
```

```
            independent_results_by_time[timepoint][col] = (None, None)

    print(f"Results for Timepoint {timepoint} (minutes):")
    for col, (t_stat, log_p_value) in independent_results_by_time[timepoint].items():
        print(f"{col}: T-statistic = {t_stat}, Log P-value = {log_p_value}")
    print("\n")
```

```
Results for Timepoint 0 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = nan, Log P-value = nan
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -0.010462094021844254, Log P-value = 0.00361647085916471
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = 0.4106802868547341, Log P-value = 0.16518929357367135
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = 0.4621971015345972, Log P-value = 0.18938074927893192
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -0.473218228828803, Log P-value = 0.19465909399392595
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -0.41198550354253083, Log P-value = 0.1657924328338002
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -0.9793048011484835, Log P-value = 0.47674360487091244
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -0.47500000000000026, Log P-value = 0.19551585491872814
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = 0.5550387187548214, Log P-value = 0.23498678418393323
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -0.47946061998807177, Log P-value = 0.19766490937919812
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = -0.5434455494020758, Log P-value = 0.22915006728580237
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -0.48424964604039233, Log P-value = 0.19997882859067176
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = 0.4983788459631745, Log P-value = 0.20684577668668774


Results for Timepoint 30 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -2.552540076628362, Log P-value = 1.8287128954272602
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = 0.6171130204740658, Log P-value = 0.26693081074354075
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = 0.2738783380405275, Log P-value = 0.1047645904906807
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = 0.6579810812815282, Log P-value = 0.2886003666343209
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -0.5173156617226574, Log P-value = 0.21614340445963898
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = 0.0276658177100034, Log P-value = 0.009628519675592858
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -0.2931360119622945, Log P-value = 0.11293824316000295
8. Timelessness (0 = none to
```

```
10 = strongest imaginable): T-statistic = -0.9024347734055966, Log P-value = 0.4288610314833735
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -0.33768192496148414, Log P-value = 0.13226078728913251
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = 0.39376246564579326, Log P-value = 0.1574174037229291
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = 1.0035091622007186, Log P-value = 0.4921941727671882
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = 0.06512620114237956, Log P-value = 0.023001614198762524
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = -1.598275917983452, Log P-value = 0.9271446588873713


Results for Timepoint 60 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -5.609360811795251, Log P-value = 5.708782362224379
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -2.0071011576594713, Log P-value = 1.2849096235438884
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = -0.09475440802297211, Log P-value = 0.033854604743290044
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = 1.191249336822786, Log P-value = 0.6180850056818415
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -2.3743176532001242, Log P-value = 1.6432850191839832
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -3.4428667763019623, Log P-value = 2.849019305178854
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -1.460443727519181, Log P-value = 0.8170507877304899
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -2.5905615557851416, Log P-value = 1.869180595621615
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -2.6199512209740337, Log P-value = 1.9006735532348553
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = 0.1725465173831758, Log P-value = 0.06352464536480368
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = 1.9569001793369099, Log P-value = 1.2385533192947473
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = 1.1571144961609732, Log P-value = 0.5944014697773713
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = -1.822620655442316, Log P-value = 1.1178353963188323


Results for Timepoint 120 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -8.397877196380845, Log P-value = 9.370322220783283
```

```
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -4.306786252937956, Log P-value = 3.9316113290470107
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = -2.1713023427546254, Log P-value = 1.4389666978521953
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = -1.0773600561542935, Log P-value = 0.5398750824743798
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -3.677960297090931, Log P-value = 3.1176992535430923
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -4.649606863364117, Log P-value = 4.360450976619434
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -3.8031427313111275, Log P-value = 3.2730757049155876
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -4.659447841401154, Log P-value = 4.37337598826506
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -6.14444806887787, Log P-value = 6.350854280577462
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -4.091046091234391, Log P-value = 3.636515681021554
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = -1.6484029994003755, Log P-value = 0.9666909970017974
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -1.5357635672725498, Log P-value = 0.8750409067804981
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = -0.7812923889748282, Log P-value = 0.35680542652210656


Results for Timepoint 180 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -7.22036229249013, Log P-value = 7.840260078751263
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -4.198546363120864, Log P-value = 3.7908578217590185
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = -2.6391743317111516, Log P-value = 1.9175194599878307
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = 0.48101930580864766, Log P-value = 0.1983663651242965
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -4.204356447076646, Log P-value = 3.7983893702826297
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -4.774023223334771, Log P-value = 4.548300411137217
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -3.1628899060271296, Log P-value = 2.5063605209988
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -4.928558160231003, Log P-value = 4.754805675205589
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -4.973612117973084, Log P-value = 4.815192210695449
```

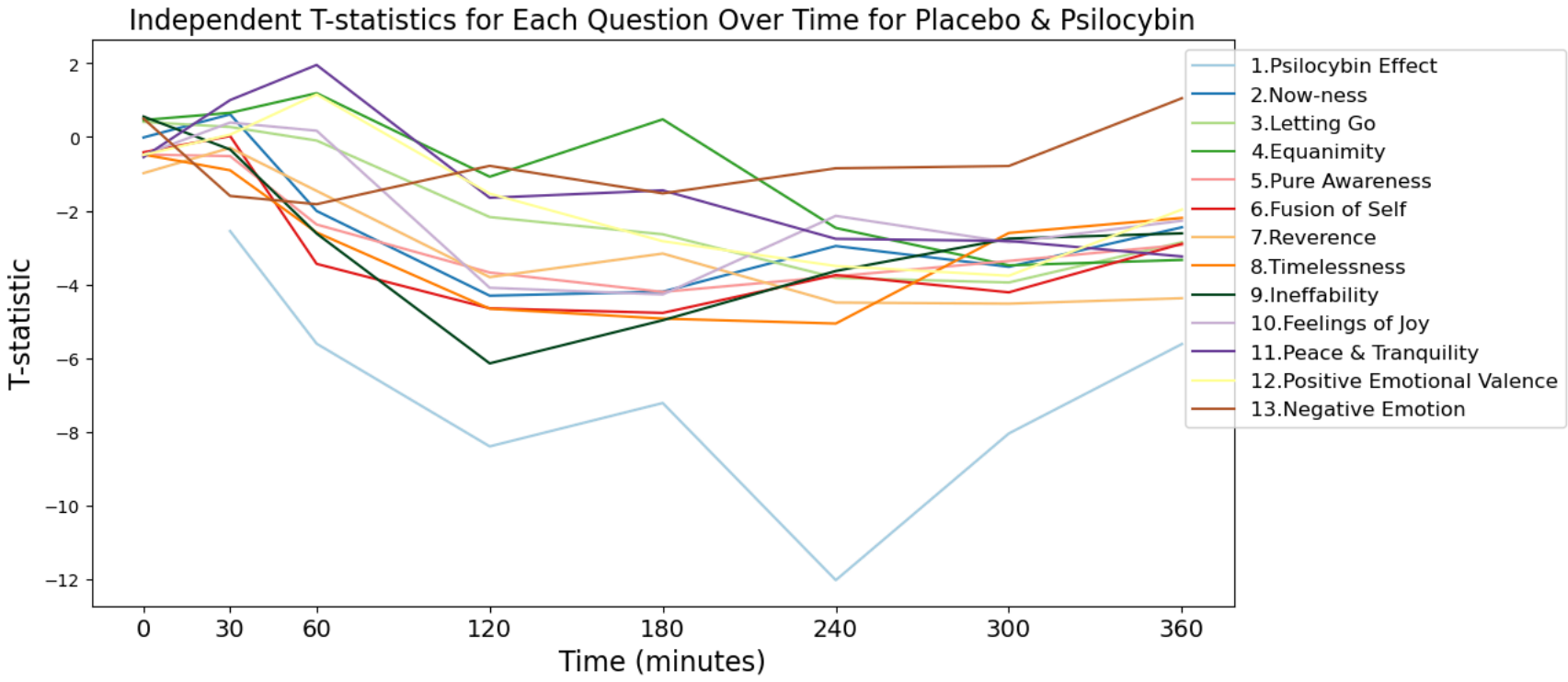
```
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -4.27259321176331, Log P-value = 3.8870479144184675
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = -1.4477421376546065, Log P-value = 0.8065688381387213
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -2.8274163513169084, Log P-value = 2.1232832482470356
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = -1.5288611986004108, Log P-value = 0.8702973470603437


Results for Timepoint 240 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -12.029107670838291, Log P-value = 13.800100203000218
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -2.9579553749169363, Log P-value = 2.275485961089013
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = -3.820768804014625, Log P-value = 3.319881098291173
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = -2.467065289170506, Log P-value = 1.7388926713267387
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -3.781557596063955, Log P-value = 3.270196398135797
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -3.747081273988446, Log P-value = 3.2152267745033623
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -4.492936147654533, Log P-value = 4.195200951199913
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -5.062558286368434, Log P-value = 4.961853502889305
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -3.636120261141892, Log P-value = 3.0770807279463006
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -2.139075208020157, Log P-value = 1.409869933872211
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = -2.763146693773034, Log P-value = 2.052243671432825
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -3.5003629557137463, Log P-value = 2.910148078487308
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = -0.8482743481222549, Log P-value = 0.39605514669615755


Results for Timepoint 300 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -8.046642060832863, Log P-value = 8.92063504013598
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -3.521691897602136, Log P-value = 2.93621587938563
3. Letting Go (0 = none to
```

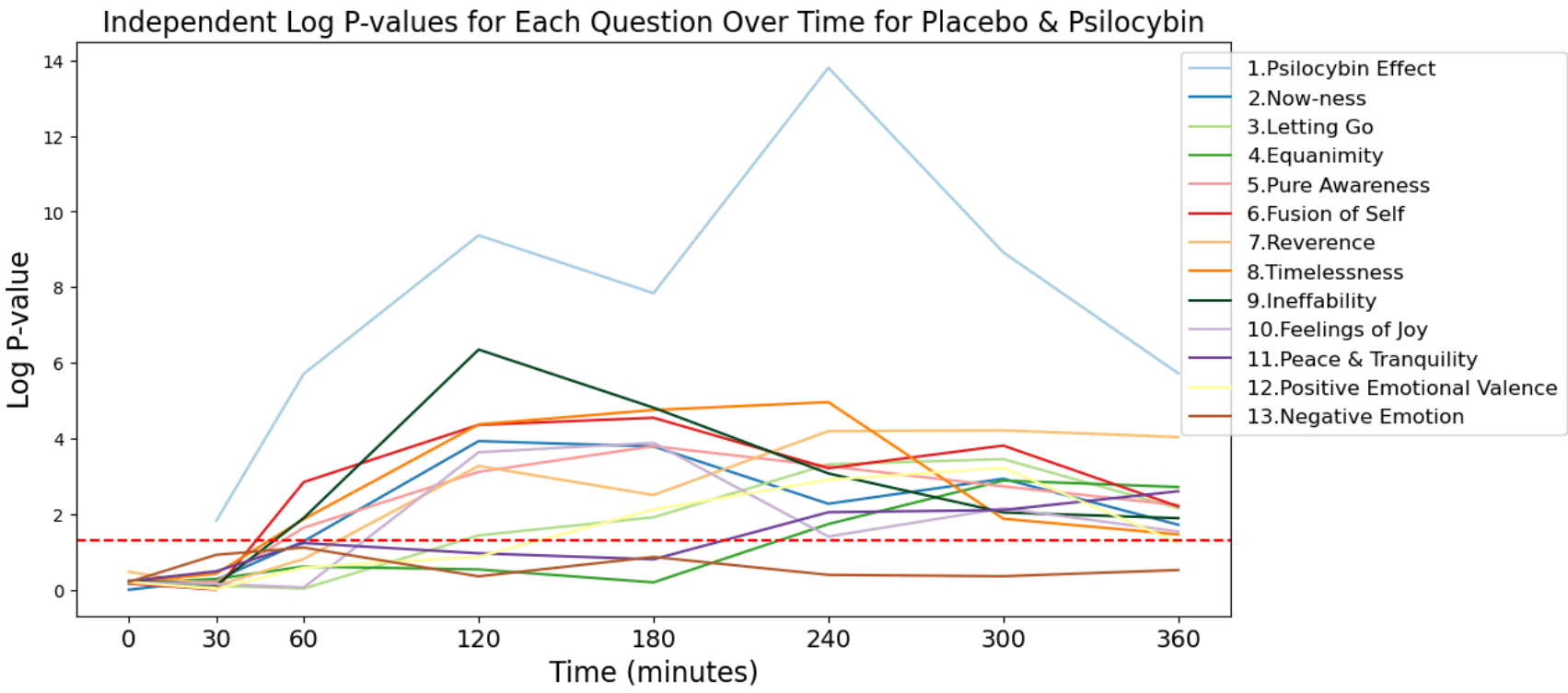
```
10 = strongest imaginable): T-statistic = -3.9483891194337253, Log P-value = 3.4554374172602973
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = -3.4824525063780047, Log P-value = 2.8883055450130137
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -3.363986766633626, Log P-value = 2.7363403973549443
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -4.215967318574018, Log P-value = 3.8134487110218047
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -4.523273065551275, Log P-value = 4.215692092017545
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -2.6042869041324974, Log P-value = 1.8801715599477382
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -2.7570549376997024, Log P-value = 2.045551892881205
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -2.8576367734377195, Log P-value = 2.1569604627015155
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = -2.8201929671731722, Log P-value = 2.110279538084074
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -3.7653747535249797, Log P-value = 3.226015497001095
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = -0.7860267253630013, Log P-value = 0.35952329287264


Results for Timepoint 360 (minutes):
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -5.61962115183335, Log P-value = 5.722848623428037
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -2.4501332397753726, Log P-value = 1.72129265479445
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = -2.855177677501452, Log P-value = 2.159148131817999
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = -3.3357291090473784, Log P-value = 2.719070202949851
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -2.926078476401547, Log P-value = 2.239191635948896
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -2.8967465012584706, Log P-value = 2.2059620311248986
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -4.374638829163784, Log P-value = 4.0383674258437905
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -2.195887879822549, Log P-value = 1.4650125670372043
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -2.613822899356994, Log P-value = 1.8940914891486196
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -2.272482913726537, Log P-value = 1.5406079128768155
11. Feelings of peace and tranquility (0 = none to
```

```
10 = strongest imaginable): T-statistic = -3.2414033023014923, Log P-value = 2.606103877455944
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -1.9674107033687713, Log P-value = 1.2482043709465582
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = 1.0539774830183923, Log P-value = 0.5249844354740643
```

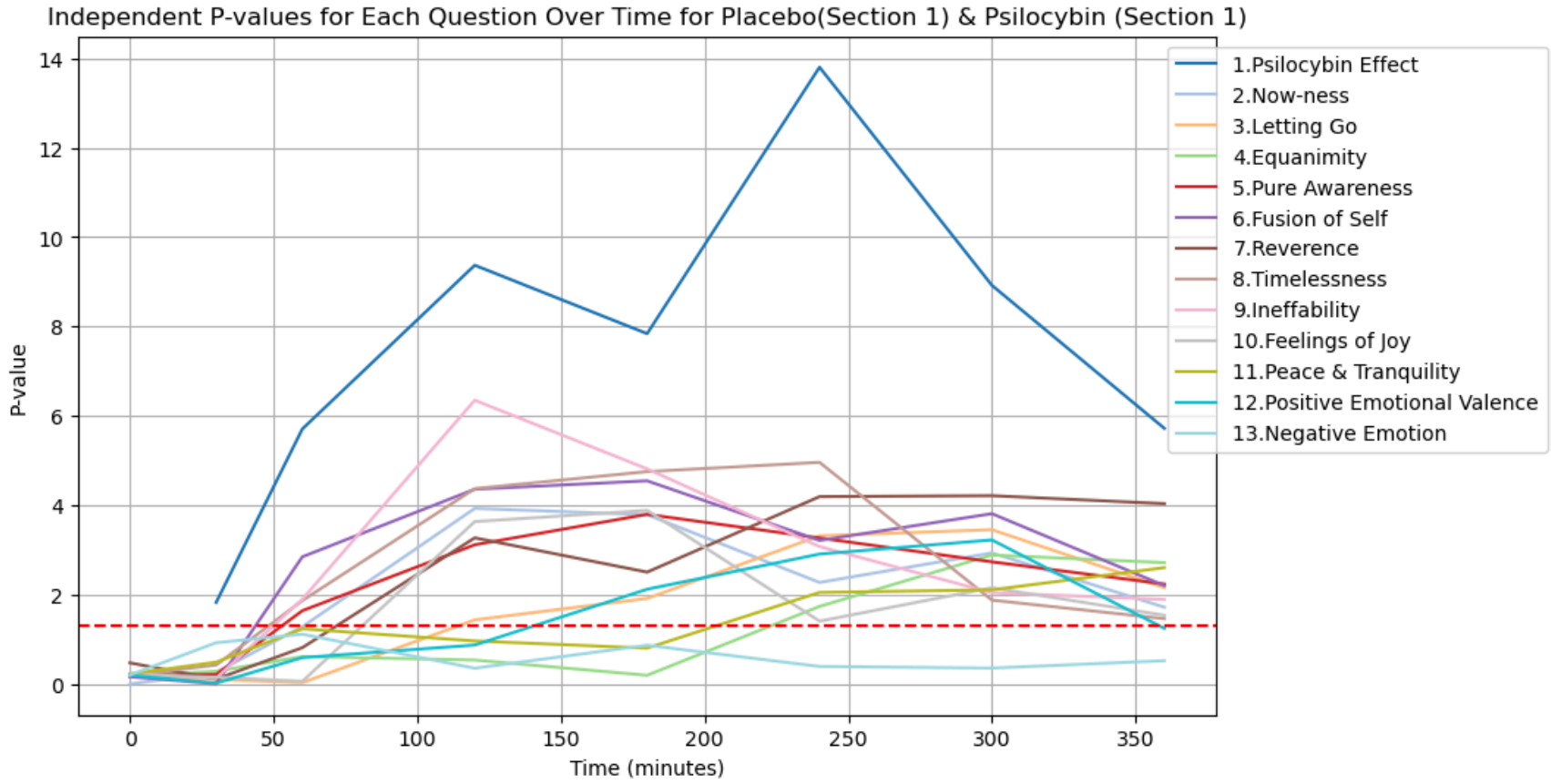
In [86]:

```
t_stats_by_question_independent = {col: [] for col in rating_columns}
log_p_value_by_question_independent = {col: [] for col in rating_columns}

# Extract T-statistics and log P-values from independent_results_by_time
for timepoint in timepoints:
    for col in rating_columns:
        t_stat, log_p_value = independent_results_by_time[timepoint][col]

        # Store T-statistics
        t_stats_by_question_independent[col].append(t_stat if t_stat is not None else np.nan)

        # Store log P-values
        log_p_value_by_question_independent[col].append(log_p_value if log_p_value is not None else np.nan)

# Plotting the T-statistics over time
plt.figure(figsize=(12, 6))
for i, (col, short_col) in enumerate(zip(rating_columns, shortened_rating_columns)):
    plt.plot(timepoints, t_stats_by_question_independent[col], label=short_col, color=custom_colors[i])
plt.xlabel('Time (minutes)', fontsize=16)
plt.ylabel('T-statistic', fontsize=16)
plt.title('Independent T-statistics for Each Question Over Time for Placebo & Psilocybin', fontsize=16)
plt.xticks(specific_timepoints, fontsize=14)
plt.legend(loc='upper right', bbox_to_anchor=(1.3, 1), fontsize=12)
plt.show()

# Plotting the log P-values over time
plt.figure(figsize=(12, 6))
for i, (col, short_col) in enumerate(zip(rating_columns, shortened_rating_columns)):
    plt.plot(timepoints, log_p_value_by_question_independent[col], label=short_col, color=custom_colors[i])
plt.xlabel('Time (minutes)', fontsize=16)
plt.ylabel('Log P-value', fontsize=16)
plt.title('Independent Log P-values for Each Question Over Time for Placebo & Psilocybin', fontsize=16)
plt.xticks(specific_timepoints, fontsize=14)
plt.axhline(y=-np.log10(0.05), color='r', linestyle='--')  # Threshold for significance
plt.legend(loc='upper right', bbox_to_anchor=(1.3, 1), fontsize=12)
plt.show()
```


Independent T-statistics for Each Question Over Time for Placebo & Psilocybin
T-statistic
Time (minutes)
2
0
−2
−4
−6
−8
−10
−12
0
30
60
120
180
240
300
360
1.Psilocybin Effect
2.Now-ness
3.Letting Go
4.Equanimity
5.Pure Awareness
6.Fusion of Self
7.Reverence
8.Timelessness
9.Ineffability
10.Feelings of Joy
11.Peace & Tranquility
12.Positive Emotional Valence
13.Negative Emotion



In [63]:
```
log_p_value_by_question_independent = {col: [] for col in rating_columns}

for timepoint in timepoints:
    for col in rating_columns:
        _, p_value = independent_results_by_time[timepoint][col]
        log_p_value_by_question_independent[col].append(p_value)

# Plot p-values for each question as a line plot
plt.figure(figsize=(10, 6))
#for col in rating_columns:
    #plt.plot(timepoints, p_value_by_question_independent[col], label=col)
for i,(col, short_col) in enumerate(zip(rating_columns, shortened_rating_columns)):
    plt.plot(timepoints, log_p_value_by_question_independent[col], label=short_col,color=cmap(i))
plt.xlabel('Time (minutes)')
plt.ylabel('P-value')
plt.title('Independent P-values for Each Question Over Time for Placebo(Section 1) & Psilocybin (Section 1)')
plt.axhline(y=-np.log10(0.05), color='r', linestyle='--')
plt.legend(loc='upper right', bbox_to_anchor=(1.3, 1))
plt.grid(True)
plt.show()
```

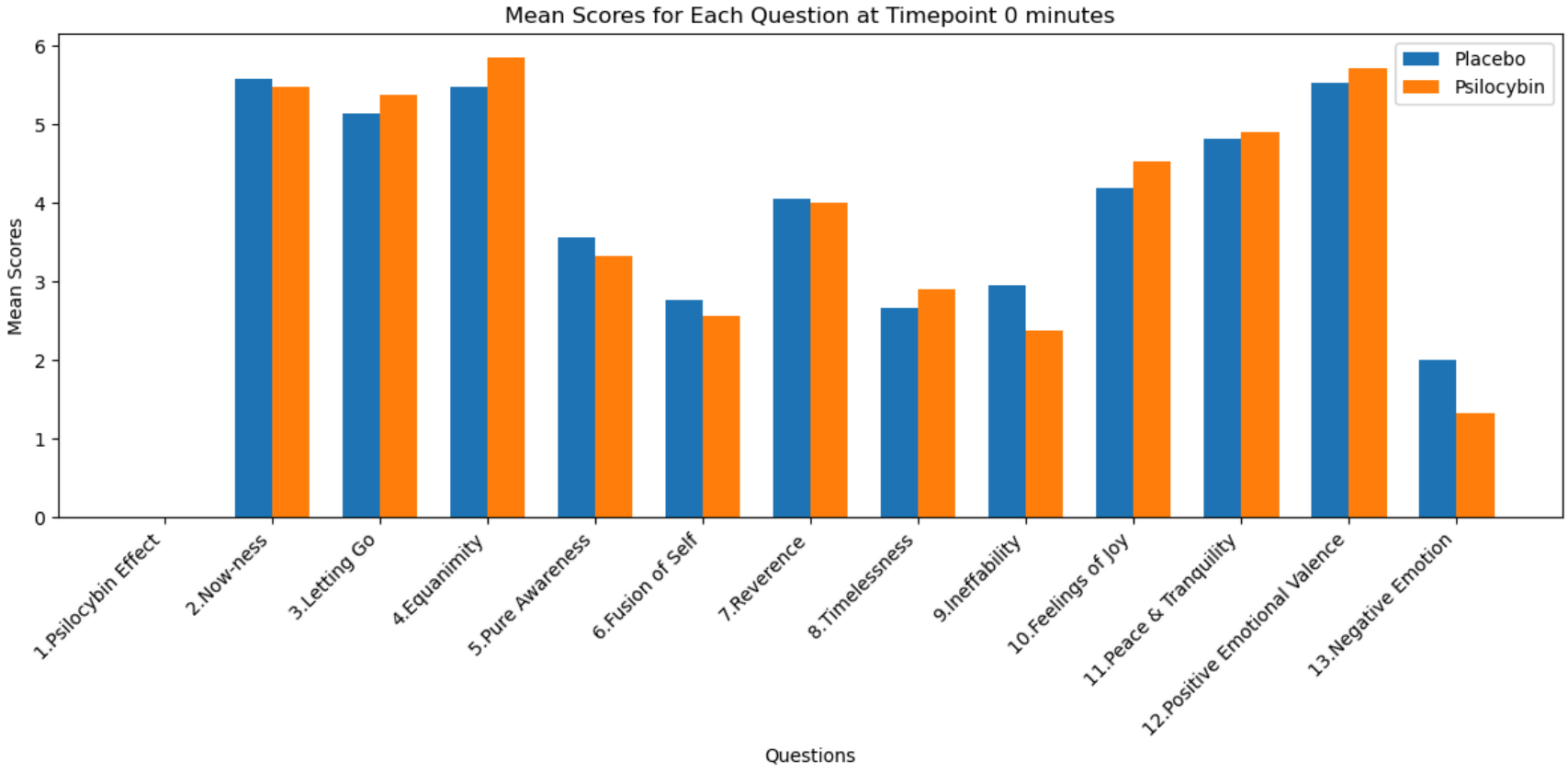


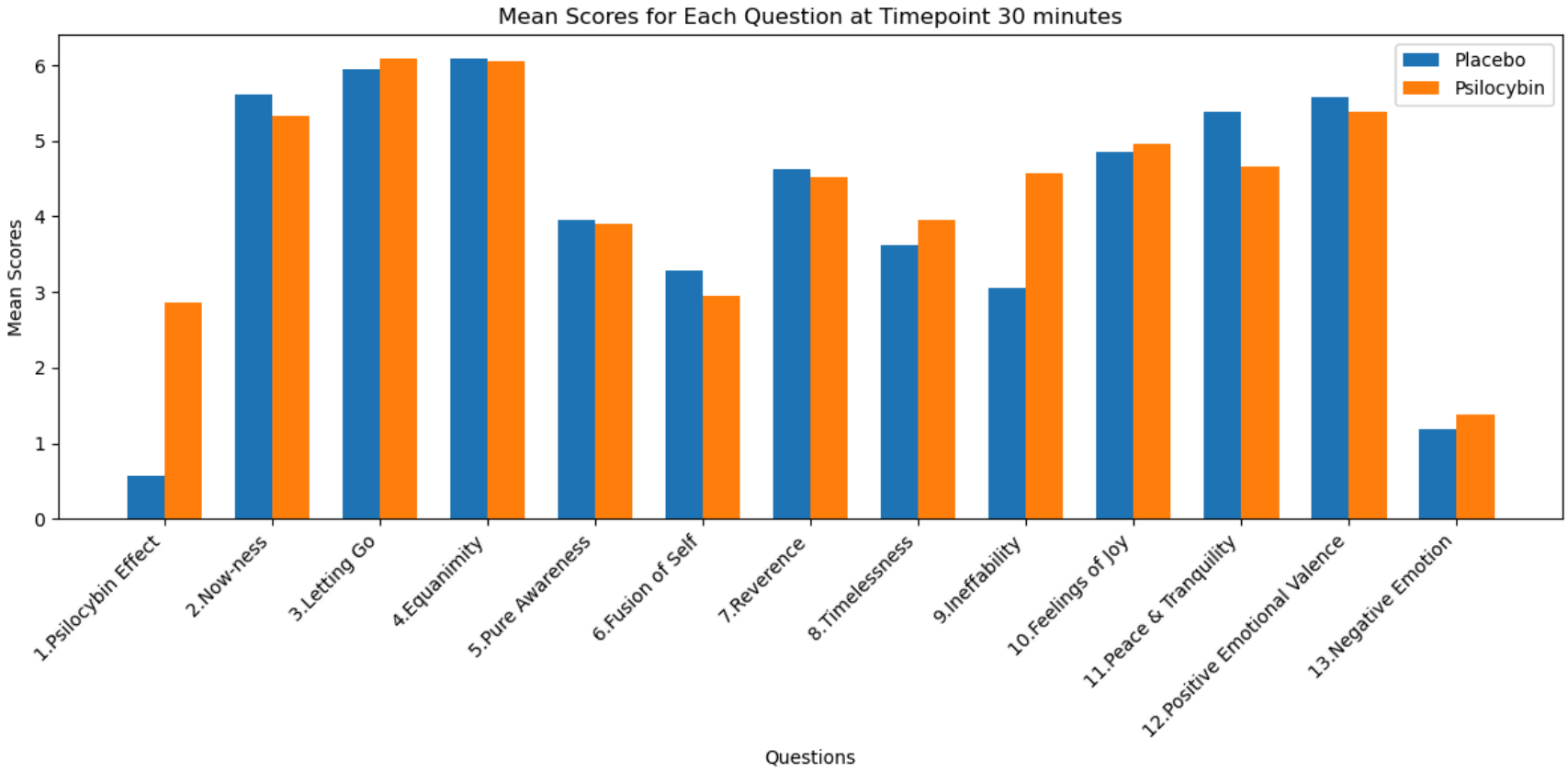
Data Exploration

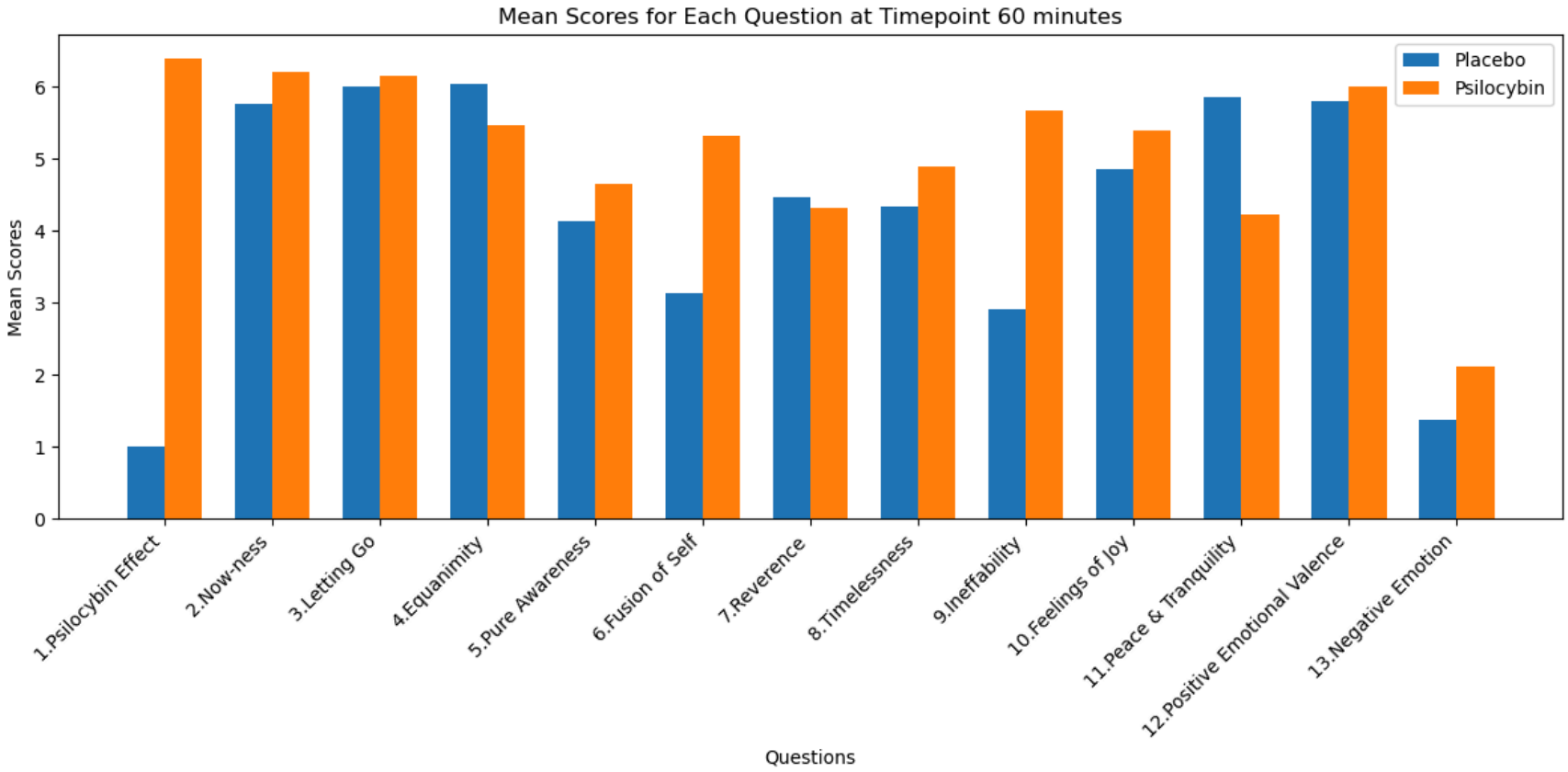
In [370…

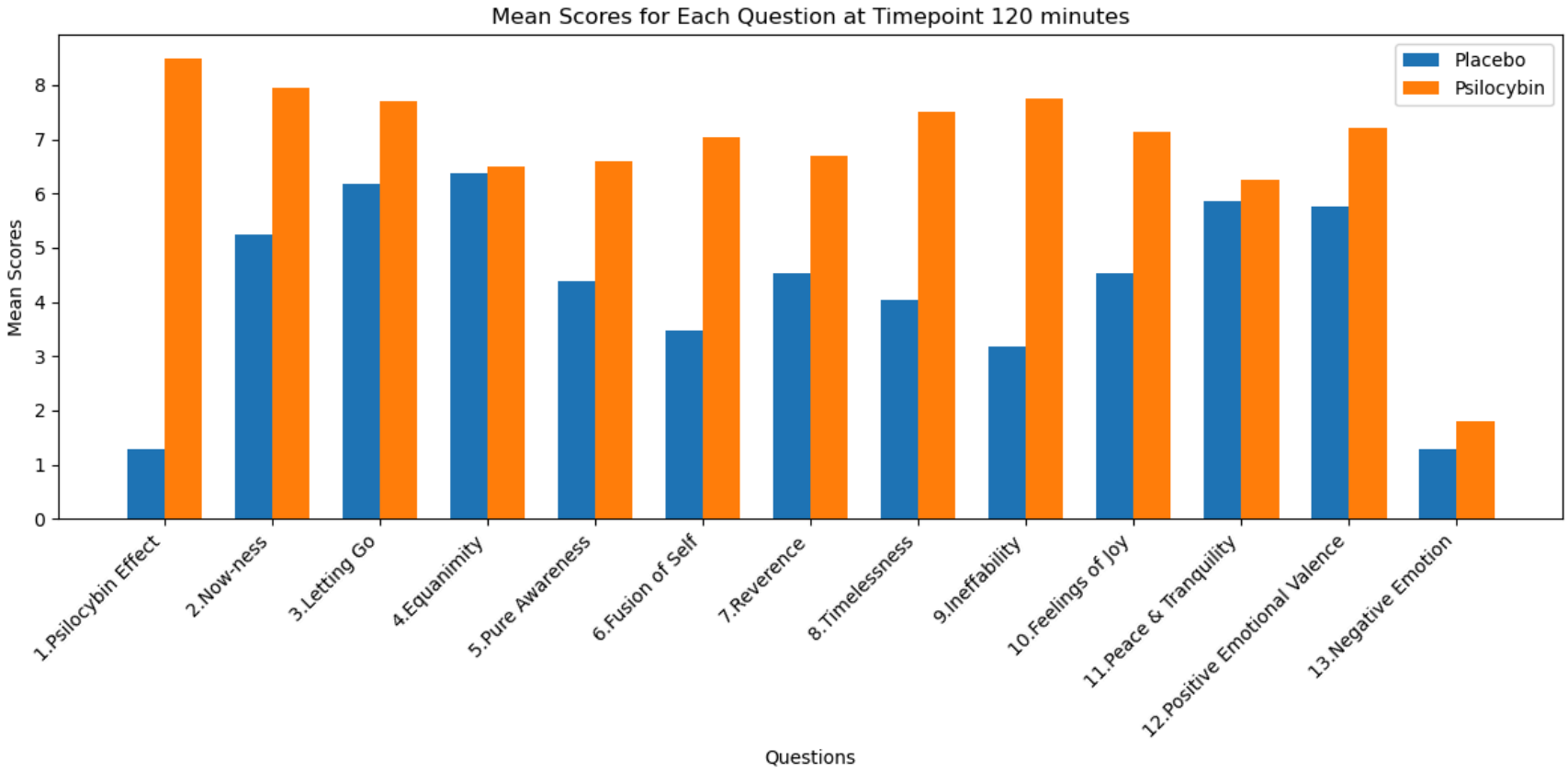
```
for timepoint in timepoints:
    # Filter data for the current timepoint and section 1
    df_timepoint = df_cleaned[df_cleaned['Timepoint relative to drug administration (in minutes)'] == timepoi

    df_placebo = df_timepoint[(df_timepoint['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)'] == 'PLA')
    df_exp = df_timepoint[(df_timepoint['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)'] == 'EXP') & (

    placebo_means = df_placebo[rating_columns].mean()
    exp_means = df_exp[rating_columns].mean()

    # Create a bar plot
    x = np.arange(len(rating_columns))  # the label locations
    width = 0.35  # the width of the bars
```

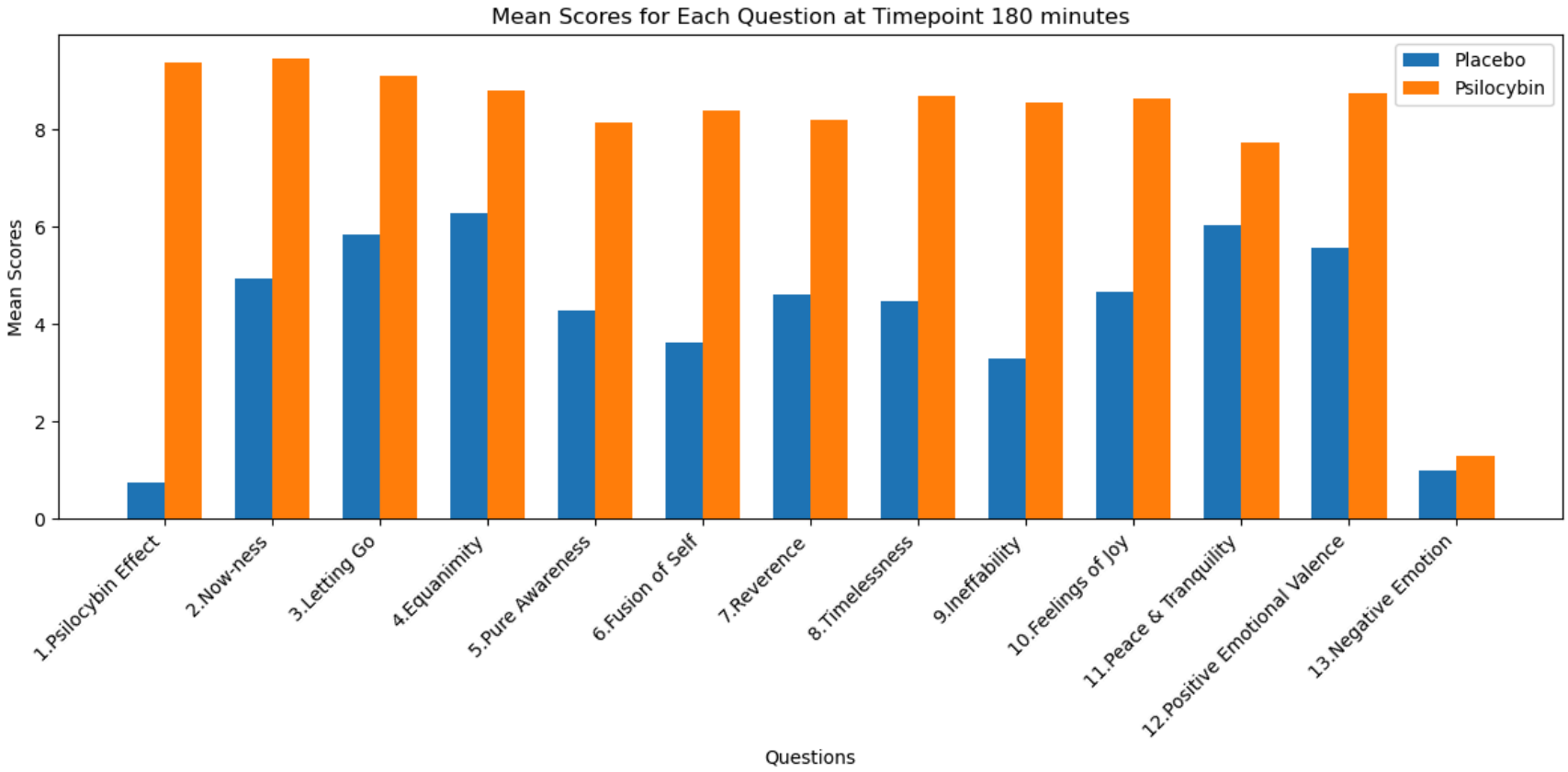
```
fig, ax = plt.subplots(figsize=(12, 6))

# Bar plot for placebo and psilocybin
ax.bar(x - width/2, placebo_means, width, label='Placebo')
ax.bar(x + width/2, exp_means, width, label='Psilocybin')

# Add labels, title, and custom x-axis tick labels
ax.set_xlabel('Questions')
ax.set_ylabel('Mean Scores')
ax.set_title(f'Mean Scores for Each Question at Timepoint {timepoint} minutes')
ax.set_xticks(x)
ax.set_xticklabels(shortened_rating_columns, rotation=45, ha='right')
ax.legend()

fig.tight_layout()
plt.show()
```

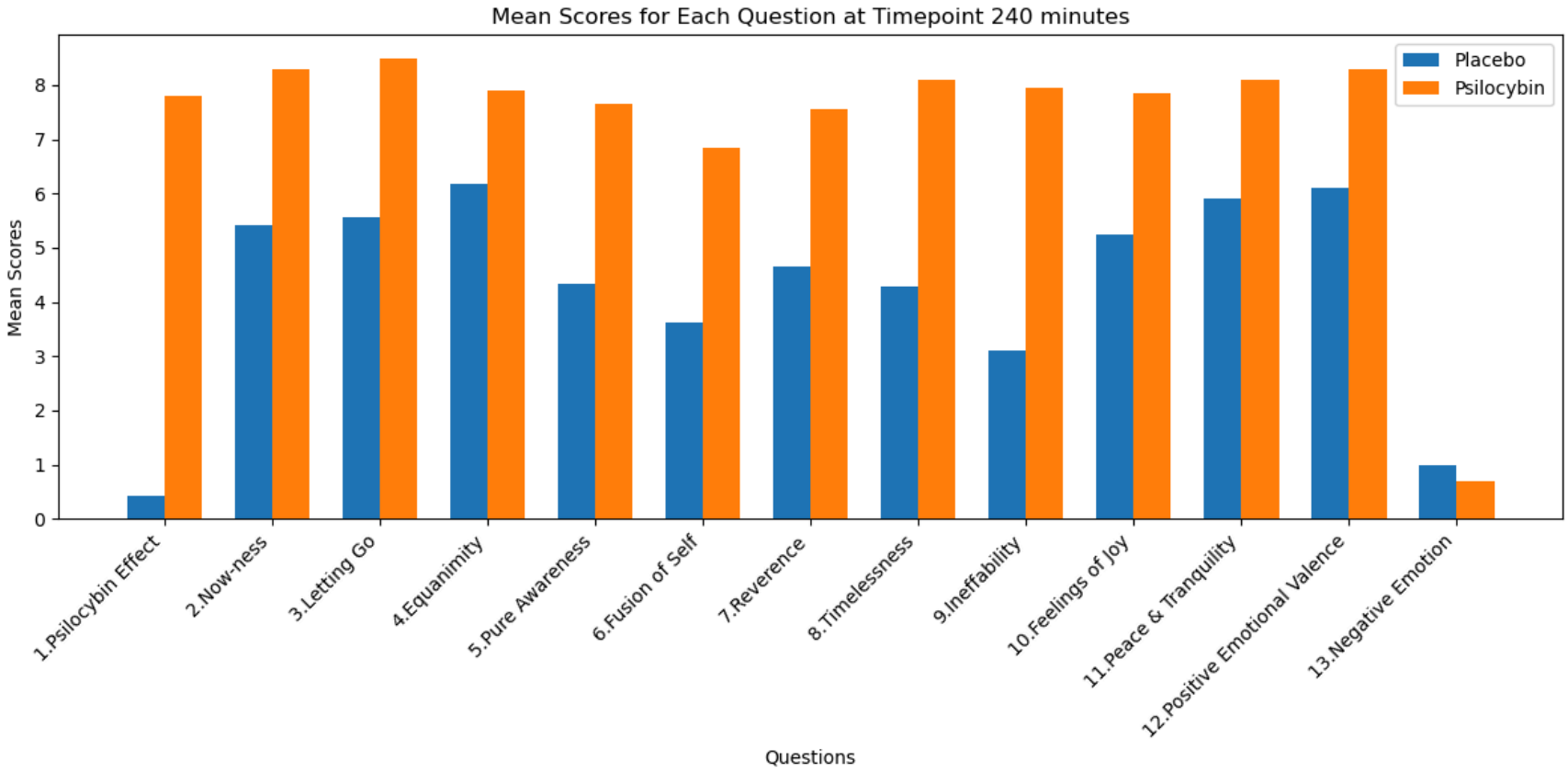


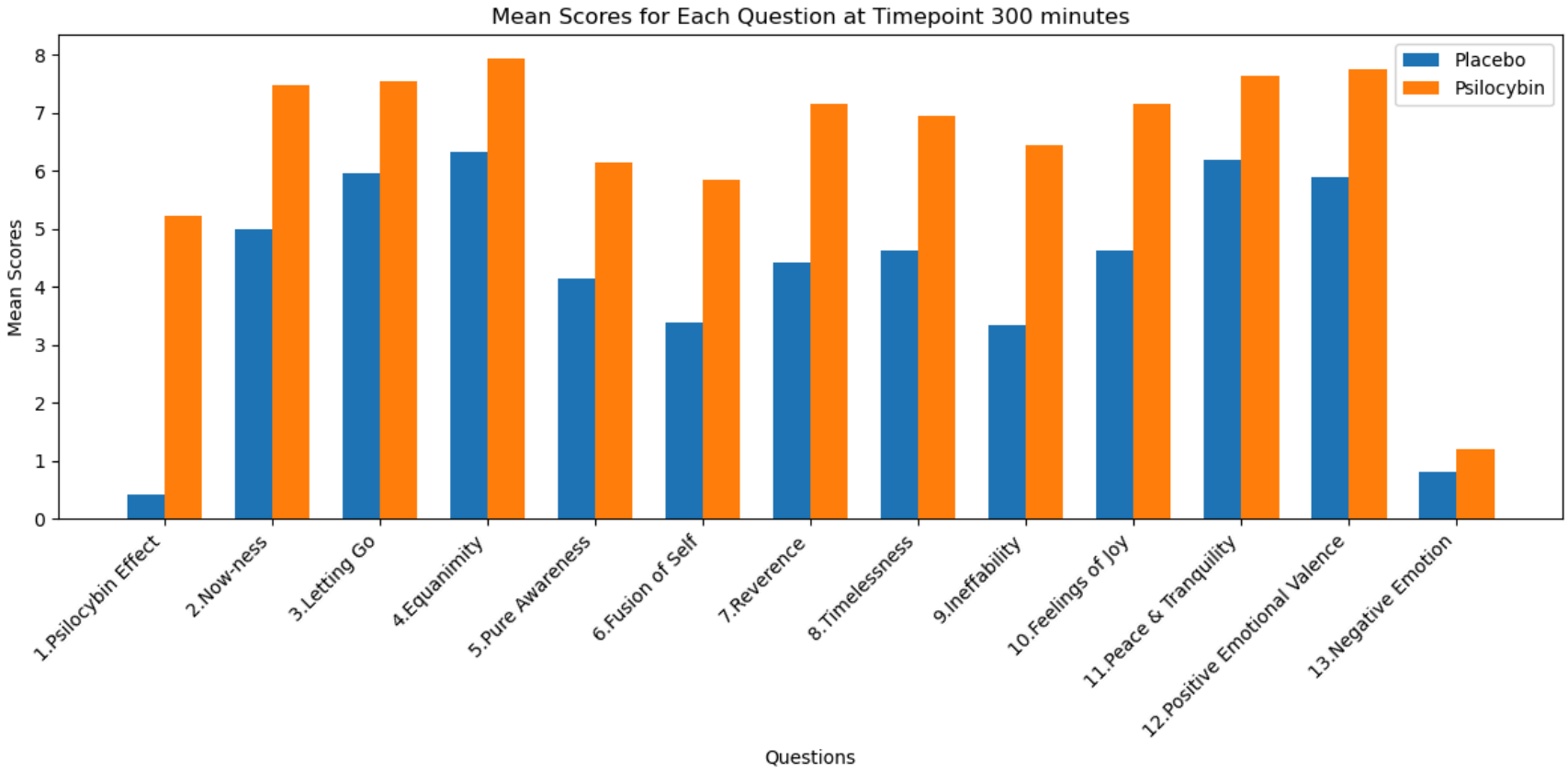

Mean Scores for Each Question at Timepoint 30 minutes
Placebo
Psilocybin
Mean Scores
0
1
2
3
4
5
6
1.Psilocybin Effect
2.Now-ness
3.Letting Go
4.Equanimity
5.Pure Awareness
6.Fusion of Self
7.Reverence
8.Timelessness
9.Ineffability
10.Feelings of Joy
11.Peace & Tranquility
12.Positive Emotional Valence
13.Negative Emotion
Questions

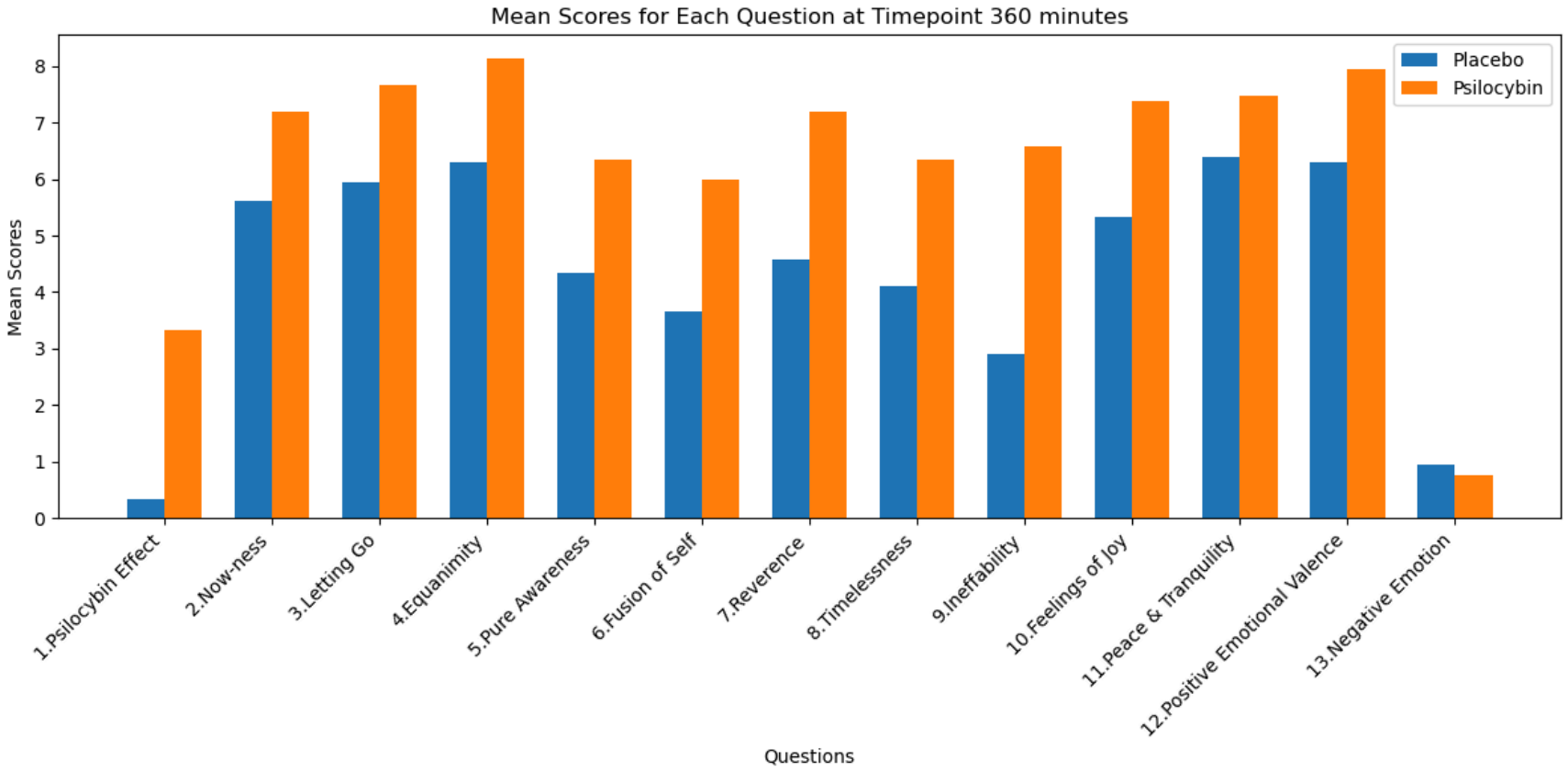

Mean Scores for Each Question at Timepoint 60 minutes
Placebo
Psilocybin
Mean Scores
0
1
2
3
4
5
6
1.Psilocybin Effect
2.Now-ness
3.Letting Go
4.Equanimity
5.Pure Awareness
6.Fusion of Self
7.Reverence
8.Timelessness
9.Ineffability
10.Feelings of Joy
11.Peace & Tranquility
12.Positive Emotional Valence
13.Negative Emotion
Questions


Mean Scores for Each Question at Timepoint 120 minutes
Placebo
Psilocybin
Mean Scores
0
1
2
3
4
5
6
7
8
1.Psilocybin Effect
2.Now-ness
3.Letting Go
4.Equanimity
5.Pure Awareness
6.Fusion of Self
7.Reverence
8.Timelessness
9.Ineffability
10.Feelings of Joy
11.Peace & Tranquility
12.Positive Emotional Valence
13.Negative Emotion
Questions


Mean Scores for Each Question at Timepoint 180 minutes
Placebo
Psilocybin
Mean Scores
0
2
4
6
8
1.Psilocybin Effect
2.Now-ness
3.Letting Go
4.Equanimity
5.Pure Awareness
6.Fusion of Self
7.Reverence
8.Timelessness
9.Ineffability
10.Feelings of Joy
11.Peace & Tranquility
12.Positive Emotional Valence
13.Negative Emotion
Questions


Mean Scores for Each Question at Timepoint 240 minutes
Placebo
Psilocybin
Mean Scores
0
1
2
3
4
5
6
7
8
1.Psilocybin Effect
2.Now-ness
3.Letting Go
4.Equanimity
5.Pure Awareness
6.Fusion of Self
7.Reverence
8.Timelessness
9.Ineffability
10.Feelings of Joy
11.Peace & Tranquility
12.Positive Emotional Valence
13.Negative Emotion
Questions

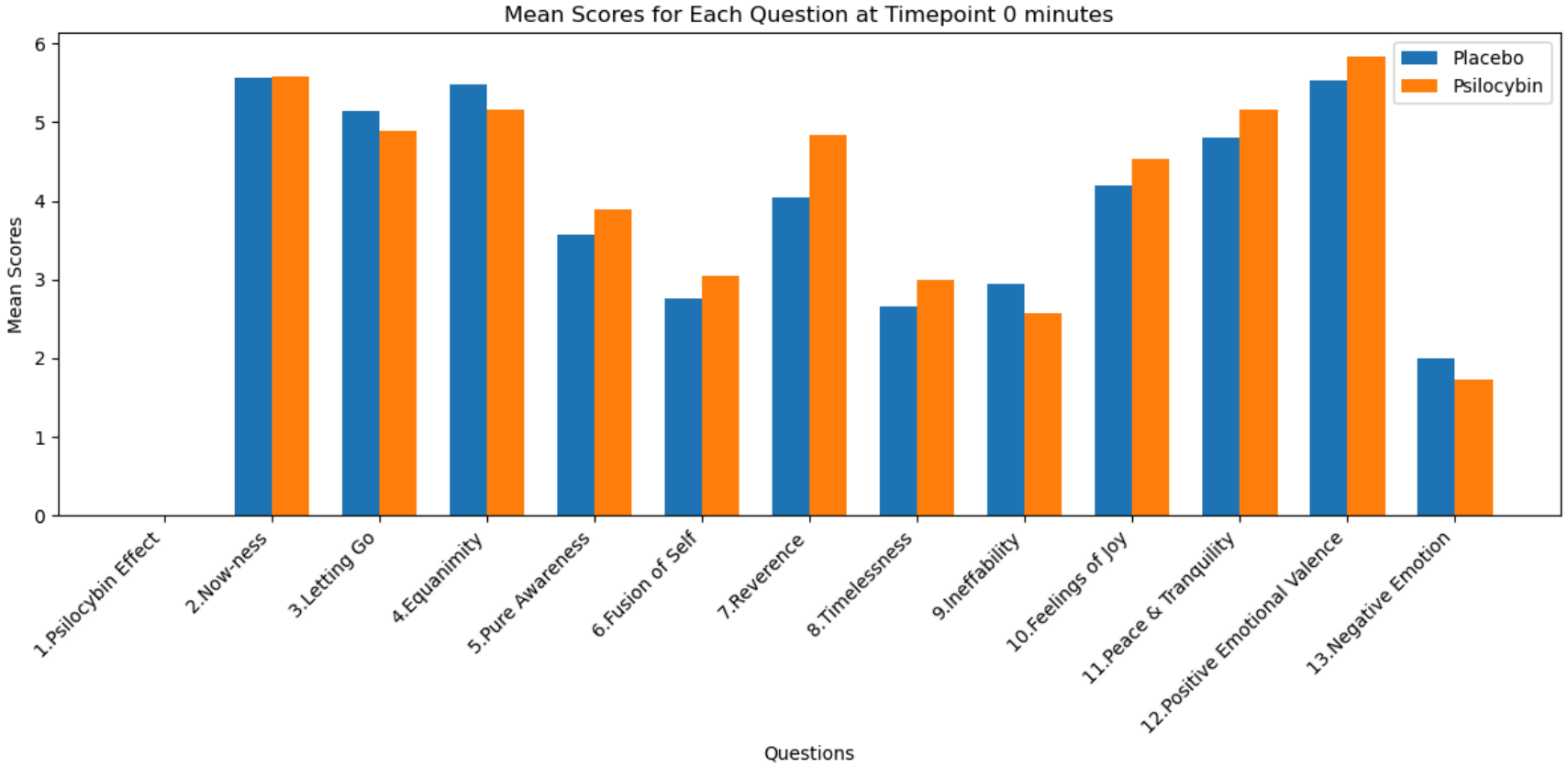

Mean Scores for Each Question at Timepoint 300 minutes
Placebo
Psilocybin
Mean Scores
0
1
2
3
4
5
6
7
8
1.Psilocybin Effect
2.Now-ness
3.Letting Go
4.Equanimity
5.Pure Awareness
6.Fusion of Self
7.Reverence
8.Timelessness
9.Ineffability
10.Feelings of Joy
11.Peace & Tranquility
12.Positive Emotional Valence
13.Negative Emotion
Questions

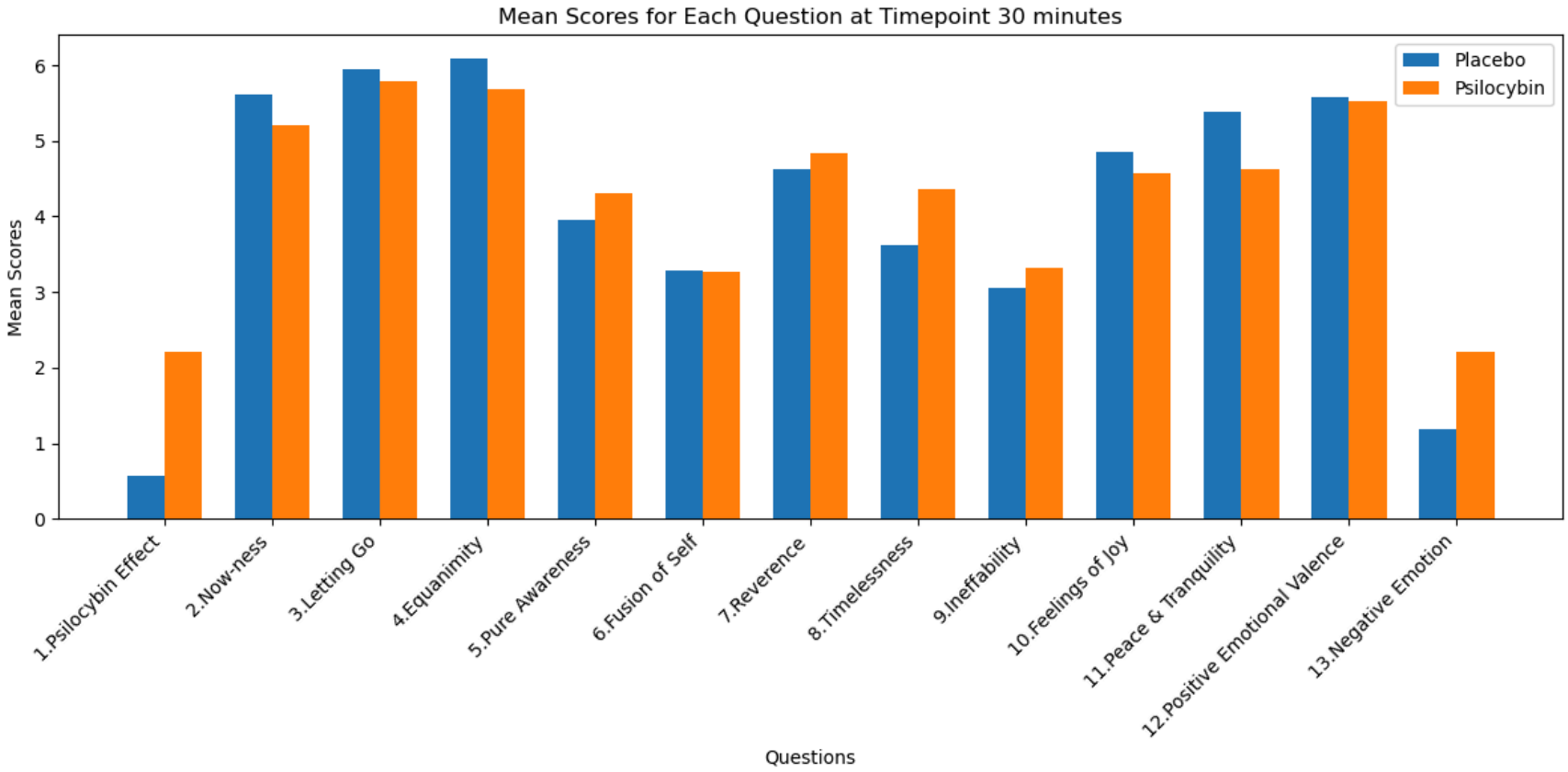


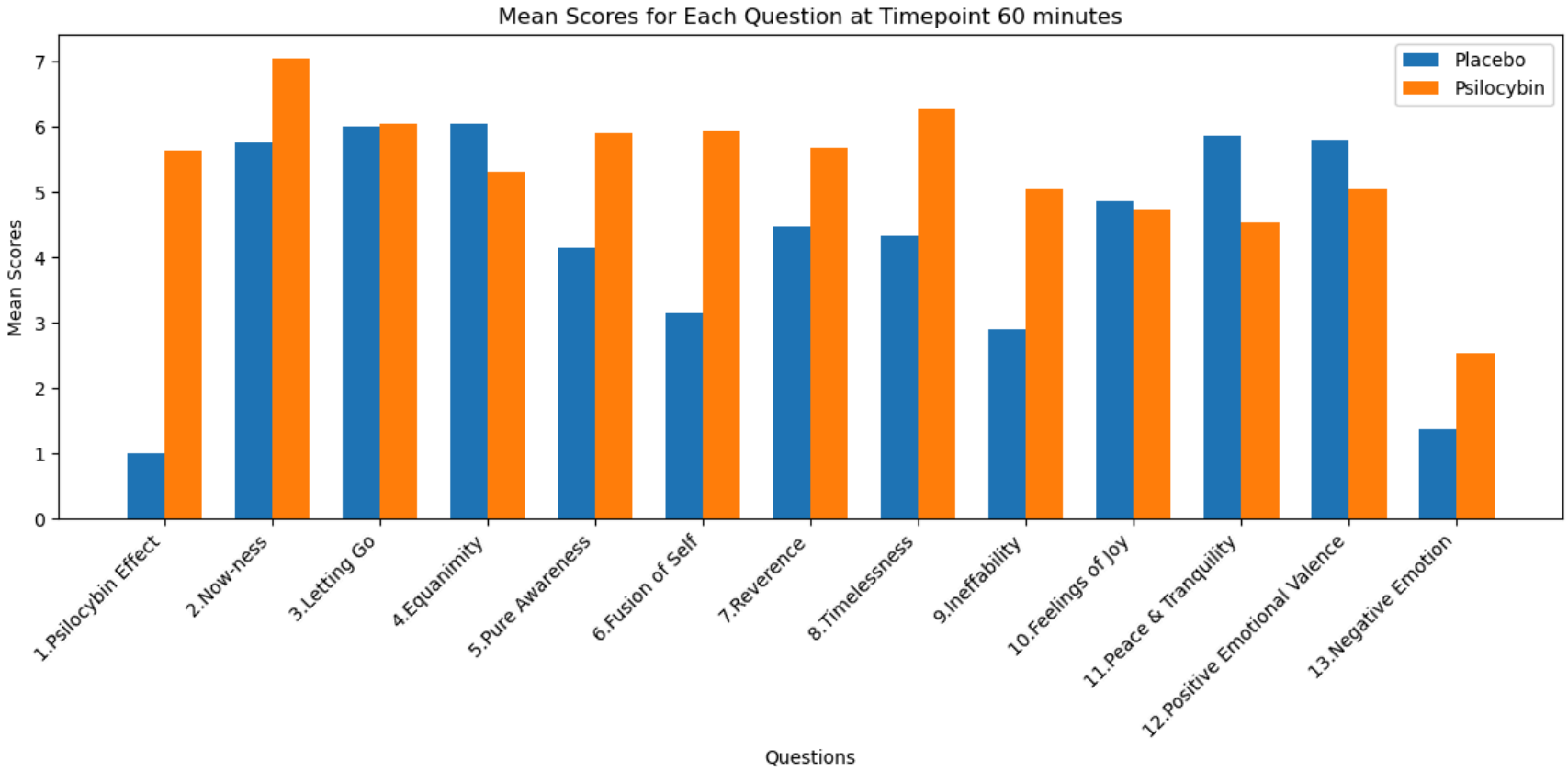
In [380…

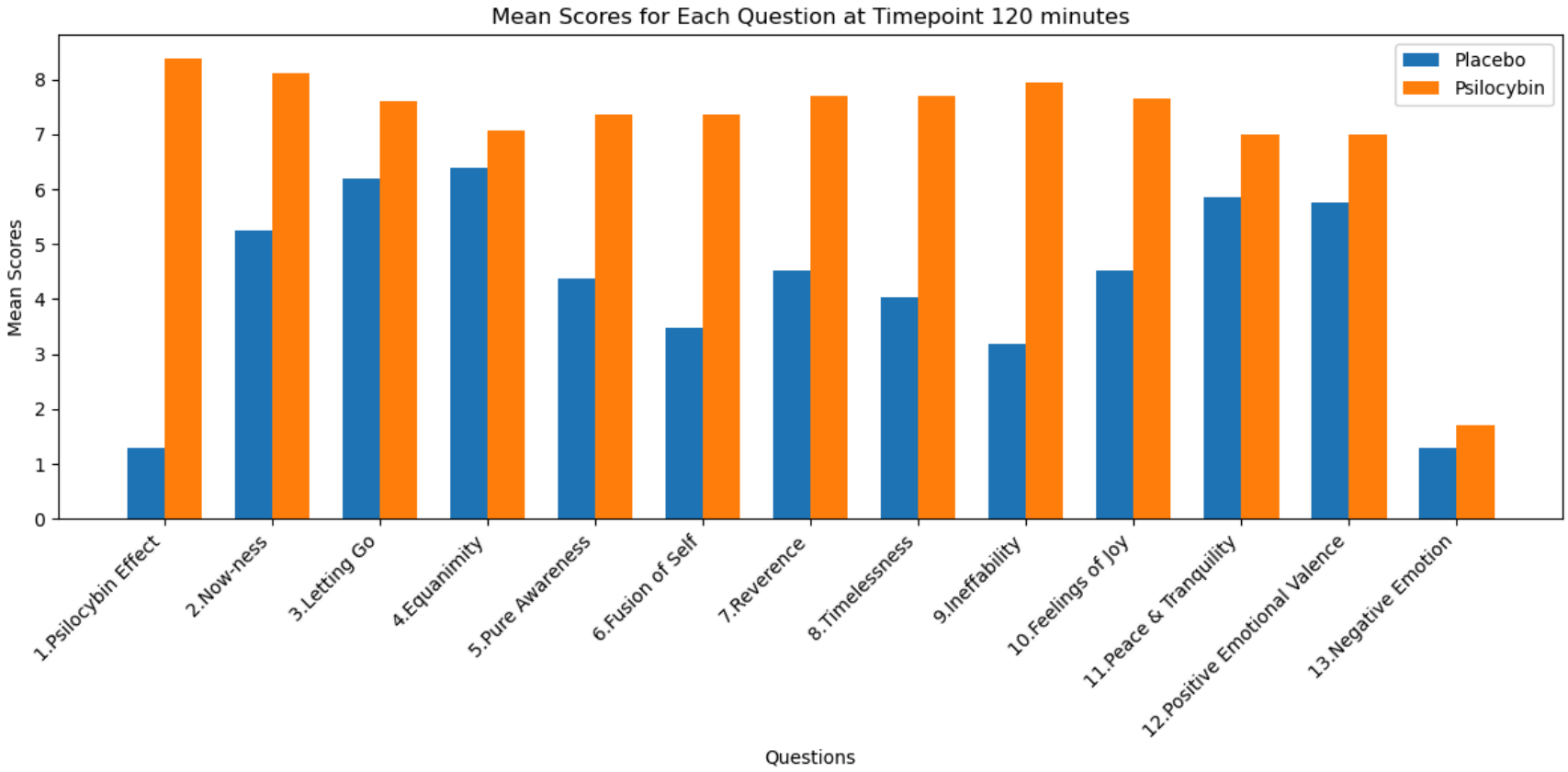
```
for timepoint in timepoints:
    df_timepoint = df_cleaned[df_cleaned['Timepoint relative to drug administration (in minutes)'] == timepoi
    df_placebo = df_timepoint[(df_timepoint['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)'] == 'PLA')
    df_psilocybin = df_timepoint[(df_timepoint['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)'] == 'PS

    placebo_means = df_placebo[rating_columns].mean()
    psilocybin_means = df_psilocybin[rating_columns].mean()

    x = np.arange(len(rating_columns))
    width = 0.35

    fig, ax = plt.subplots(figsize=(12, 6))

    ax.bar(x - width/2, placebo_means, width, label='Placebo')
    ax.bar(x + width/2, psilocybin_means, width, label='Psilocybin')

    ax.set_xlabel('Questions')
    ax.set_ylabel('Mean Scores')
```

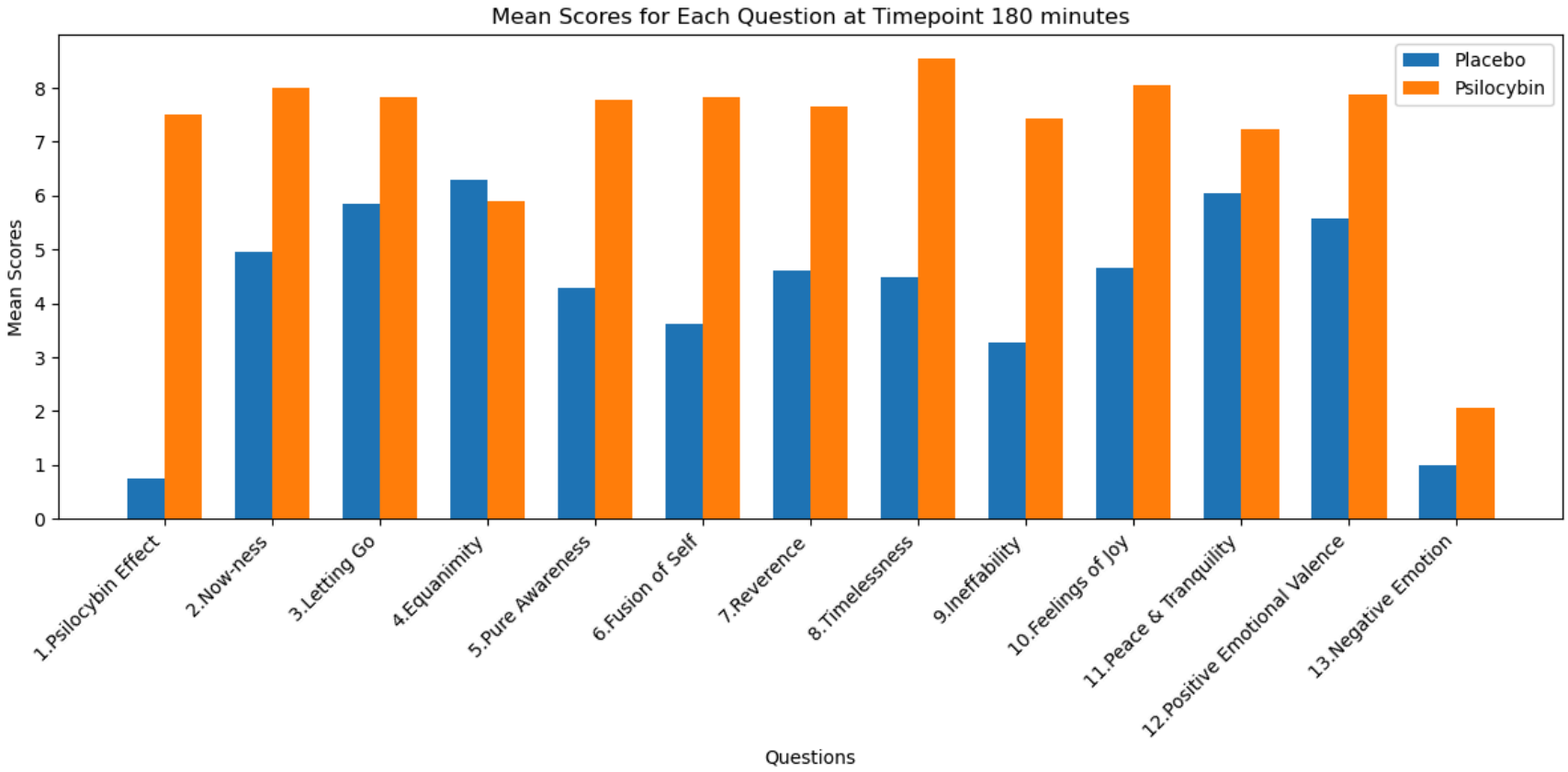
```
    ax.set_title(f'Mean Scores for Each Question at Timepoint {timepoint} minutes')
    ax.set_xticks(x)
    ax.set_xticklabels(shortened_rating_columns, rotation=45, ha='right')
    ax.legend()

    fig.tight_layout()
    plt.show()
```

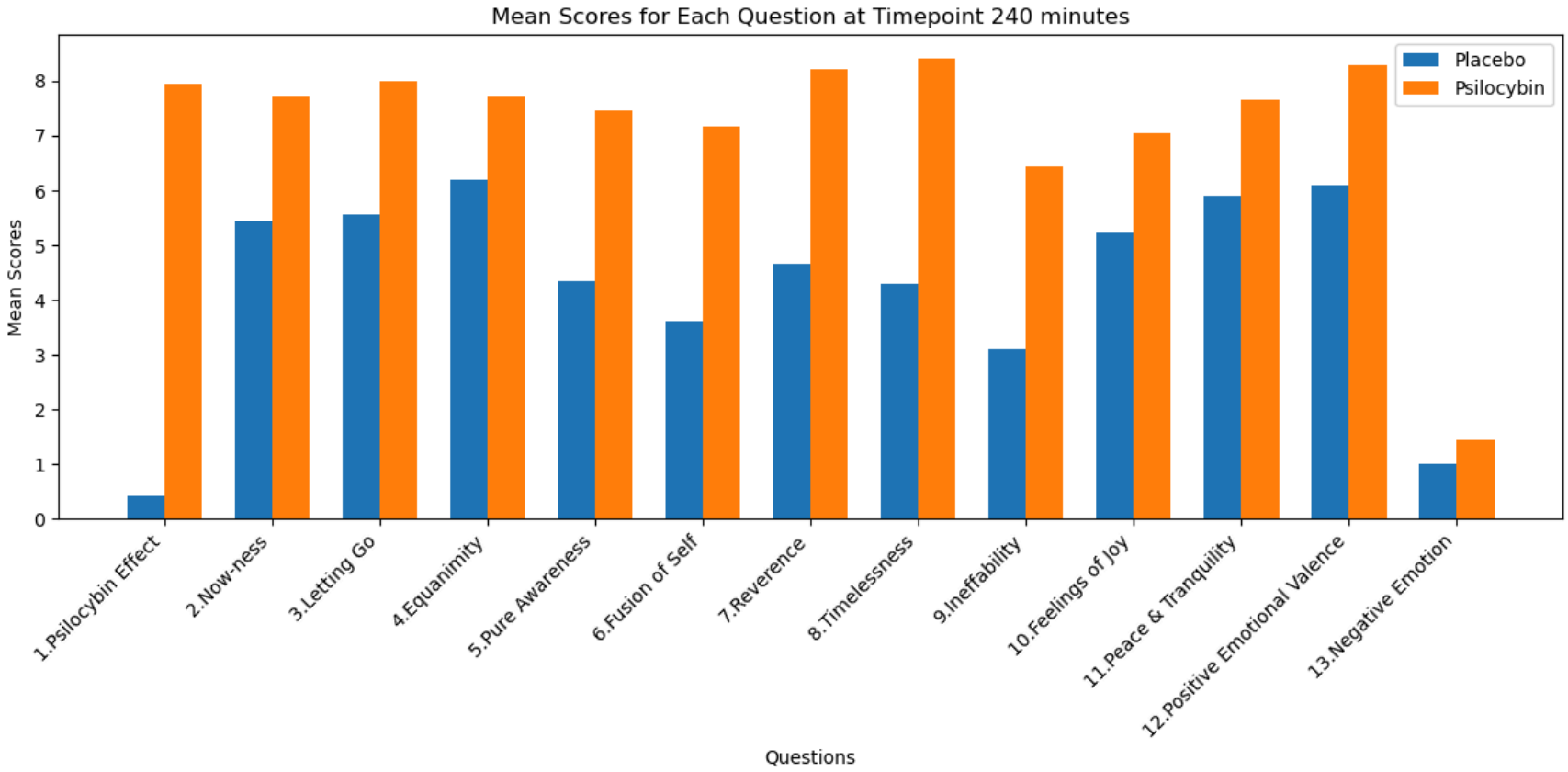


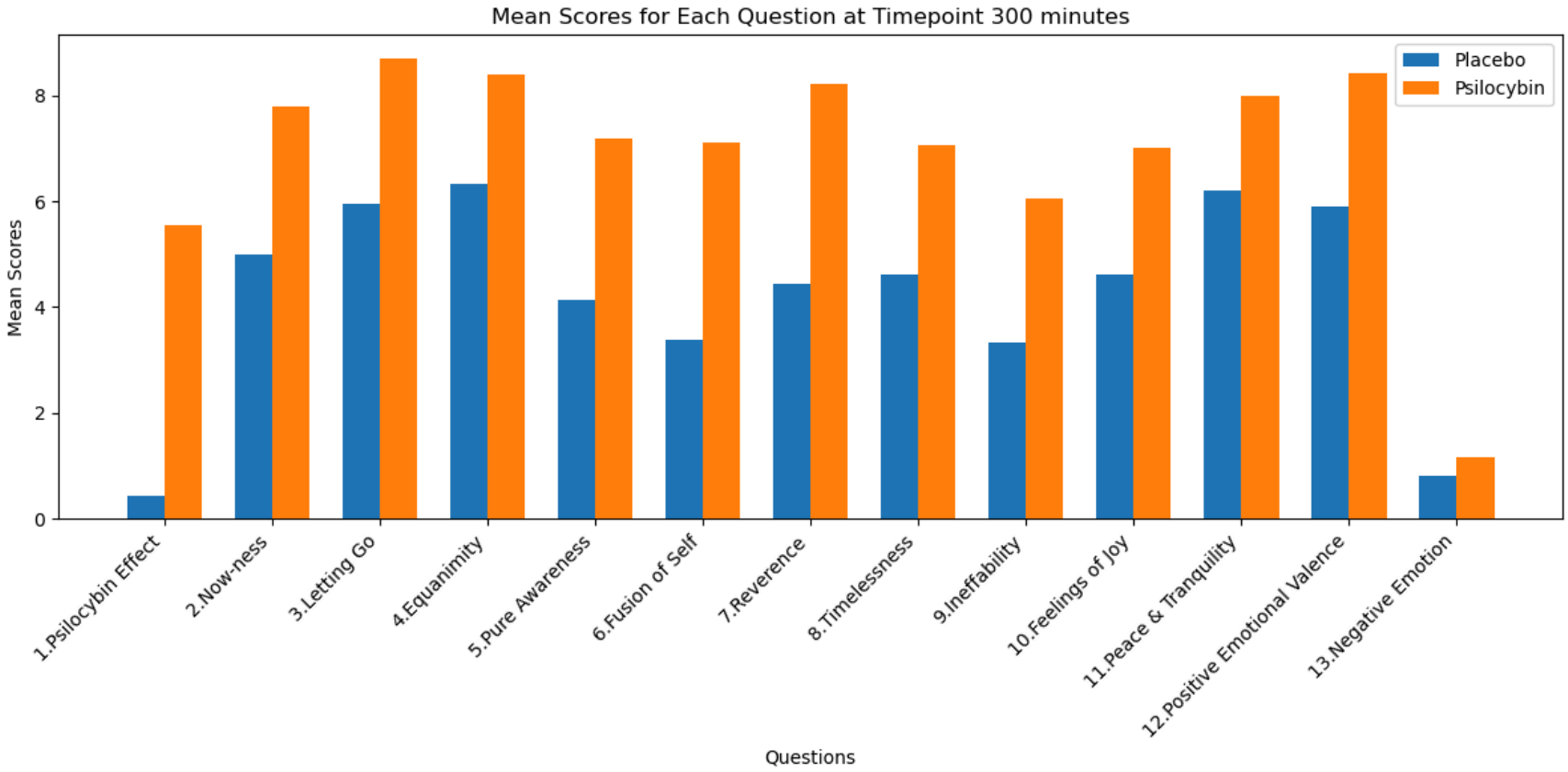

Mean Scores for Each Question at Timepoint 30 minutes
Placebo
Psilocybin
Mean Scores
0
1
2
3
4
5
6
1.Psilocybin Effect
2.Now-ness
3.Letting Go
4.Equanimity
5.Pure Awareness
6.Fusion of Self
7.Reverence
8.Timelessness
9.Ineffability
10.Feelings of Joy
11.Peace & Tranquility
12.Positive Emotional Valence
13.Negative Emotion
Questions

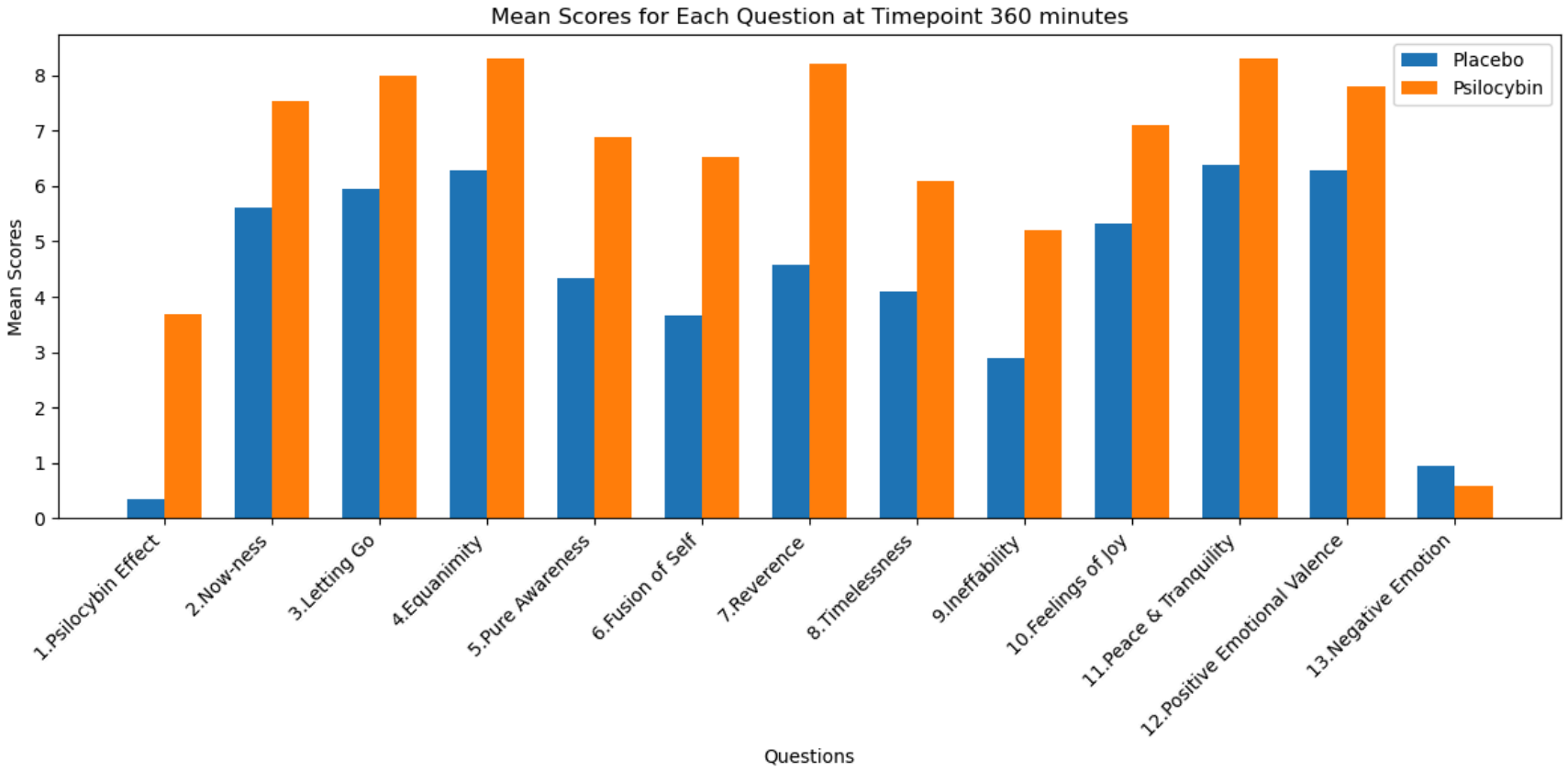

Mean Scores for Each Question at Timepoint 60 minutes
Placebo
Psilocybin
Mean Scores
0
1
2
3
4
5
6
7
1.Psilocybin Effect
2.Now-ness
3.Letting Go
4.Equanimity
5.Pure Awareness
6.Fusion of Self
7.Reverence
8.Timelessness
9.Ineffability
10.Feelings of Joy
11.Peace & Tranquility
12.Positive Emotional Valence
13.Negative Emotion
Questions


Mean Scores for Each Question at Timepoint 120 minutes
Placebo
Psilocybin
Mean Scores
0
1
2
3
4
5
6
7
8
1.Psilocybin Effect
2.Now-ness
3.Letting Go
4.Equanimity
5.Pure Awareness
6.Fusion of Self
7.Reverence
8.Timelessness
9.Ineffability
10.Feelings of Joy
11.Peace & Tranquility
12.Positive Emotional Valence
13.Negative Emotion
Questions


Mean Scores for Each Question at Timepoint 180 minutes
Placebo
Psilocybin
Mean Scores
0
1
2
3
4
5
6
7
8
1.Psilocybin Effect
2.Now-ness
3.Letting Go
4.Equanimity
5.Pure Awareness
6.Fusion of Self
7.Reverence
8.Timelessness
9.Ineffability
10.Feelings of Joy
11.Peace & Tranquility
12.Positive Emotional Valence
13.Negative Emotion
Questions


Mean Scores for Each Question at Timepoint 240 minutes
Placebo
Psilocybin
Mean Scores
0
1
2
3
4
5
6
7
8
1.Psilocybin Effect
2.Now-ness
3.Letting Go
4.Equanimity
5.Pure Awareness
6.Fusion of Self
7.Reverence
8.Timelessness
9.Ineffability
10.Feelings of Joy
11.Peace & Tranquility
12.Positive Emotional Valence
13.Negative Emotion
Questions


Mean Scores for Each Question at Timepoint 300 minutes
Placebo
Psilocybin
Mean Scores
0
2
4
6
8
1.Psilocybin Effect
2.Now-ness
3.Letting Go
4.Equanimity
5.Pure Awareness
6.Fusion of Self
7.Reverence
8.Timelessness
9.Ineffability
10.Feelings of Joy
11.Peace & Tranquility
12.Positive Emotional Valence
13.Negative Emotion
Questions



In [19]:
```
df[rating_columns] = df[rating_columns].apply(pd.to_numeric, errors='coerce')
```

In [21]:
```
session_1 = df[df['Session (1, 2)'] == 1]
session_2 = df[df['Session (1, 2)'] == 2]
crossover_participants = session_1[(session_1['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)'] == 'PLA
```

In [25]:
```
results_paired = {}
for col in rating_columns:
    placebo_scores = session_1[session_1['Volunteer number'].isin(crossover_participants['Volunteer number'])
    psilocybin_scores = session_2[session_2['Volunteer number'].isin(crossover_participants['Volunteer number
        # Perform paired t-test
    t_stat, p_value = stats.ttest_rel(placebo_scores, psilocybin_scores, nan_policy='omit')
    results_paired[col] = (t_stat, p_value)

for col, (t_stat, p_value) in results_paired.items():
    print(f"{col}: T-statistic = {t_stat}, P-value = {p_value}")
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
Cell In[25], line 6
      4     psilocybin_scores = session_2[session_2['Volunteer number'].isin(crossover_participants['Voluntee
r number'])][col]
      5         # Perform paired t-test
----> 6     t_stat, p_value = stats.ttest_rel(placebo_scores, psilocybin_scores, nan_policy='omit')
      7     results_paired[col] = (t_stat, p_value)
      9 for col, (t_stat, p_value) in results_paired.items():

File ~/anaconda3/lib/python3.11/site-packages/scipy/stats/_axis_nan_policy.py:502, in _axis_nan_policy_factor
y.<locals>.axis_nan_policy_decorator.<locals>.axis_nan_policy_wrapper(***failed resolving arguments***)
    500 if sentinel:
    501     samples = _remove_sentinel(samples, paired, sentinel)
--> 502 res = hypotest_fun_out(*samples, **kwds)
    503 res = result_to_tuple(res)
    504 res = _add_reduced_axes(res, reduced_axes, keepdims)

File ~/anaconda3/lib/python3.11/site-packages/scipy/stats/_stats_py.py:7133, in ttest_rel(a, b, axis, nan_pol
icy, alternative)
   7131 nb = _get_len(b, axis, "second argument")
   7132 if na != nb:
-> 7133     raise ValueError('unequal length arrays')
   7135 if na == 0 or nb == 0:
   7136     # _axis_nan_policy decorator ensures this only happens with 1d input
   7137     return TtestResult(np.nan, np.nan, df=np.nan, alternative=np.nan,
   7138                        standard_error=np.nan, estimate=np.nan)

ValueError: unequal length arrays
```

For the participants who received placebo in session 1 and were crossed over to psilocybin in session 2, a paired t-test was performed for each subjective rating variable. This test was performed to determine if there was a significant difference in responses before and after the crossover from placebo to psilocybin. The results indicated significant differences between conditions for most variables, such as "Overall Psilocybin Effect", "Now-ness", "Letting Go", and others, with extremely low p-values, implying strong statistical significance.

In [27]:
```
psilocybin_only = session_1[session_1['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)'] == 'PSIL']
placebo_only = session_1[session_1['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)'] == 'PLA']
#for col in rating_columns:
   #print(f"{col}: {placebo_only[col].isna().sum()} missing values in placebo group")
   #print(f"{col}: {psilocybin_only[col].isna().sum()} missing values in psilocybin group")
placebo_only_cleaned = placebo_only.dropna(subset=rating_columns)
psilocybin_only_cleaned = psilocybin_only.dropna(subset=rating_columns)
```

```
#print(placebo_only.shape)
#print(placebo_only_cleaned.shape)
```

In [29]:
```
results_independent = {}
for col in rating_columns:
    placebo_scores = placebo_only[col]
    psilocybin_scores = psilocybin_only[col]

    # Perform the two-sample t-test
    t_stat, p_value = stats.ttest_ind(placebo_scores, psilocybin_scores, nan_policy='omit')
    results_independent[col] = (t_stat, p_value)

for col, (t_stat, p_value) in results_independent.items():
    print(f"{col}: T-statistic = {t_stat}, P-value = {p_value}")
```

```
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -15.429444401377932, P-value = 1.82996864804383e-41
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -5.807565754223764, P-value = 1.408653081980698e-08
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = -3.4222356395405535, P-value = 0.000693751208854987
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = -1.0788089163713, P-value = 0.28140743509900423
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -7.920759406904275, P-value = 3.10622139867374e-14
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -8.695702299863871, P-value = 1.322030541783588e-16
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -8.321093126288845, P-value = 1.9135481802495092e-15
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -8.060714853347394, P-value = 1.1795072006004211e-14
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -7.908199881368684, P-value = 3.384240878100939e-14
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -4.6455268571770985, P-value = 4.790566385977174e-06
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = -1.6738433562308155, P-value = 0.0950496913112998
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -2.4437250220681954, P-value = 0.015026933942036944
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = -2.5920627906530083, P-value = 0.009937648347856558
```

In [31]:
```
for col in rating_columns:
    placebo_scores = placebo_only_cleaned[col]
    psilocybin_scores = psilocybin_only_cleaned[col]
```

```
    t_stat, p_value = stats.ttest_ind(placebo_scores, psilocybin_scores, nan_policy='omit')
    results_independent[col] = (t_stat, p_value)

for col, (t_stat, p_value) in results_independent.items():
    print(f"{col}: T-statistic = {t_stat}, P-value = {p_value}")
```

```
1. Overall Psilocybin Effect (0 = none to
10 = strongest imaginable): T-statistic = -15.121591921917284, P-value = 3.919616204202543e-40
2. Now-ness (0 = none to
10 = strongest imaginable): T-statistic = -5.7045505543911155, P-value = 2.480418165038184e-08
3. Letting Go (0 = none to
10 = strongest imaginable): T-statistic = -3.2329655931459844, P-value = 0.0013412746126078713
4. Equanimity (0 = none to
10 = strongest imaginable): T-statistic = -0.9192942150934472, P-value = 0.35857301622430715
5. Pure being and pure awareness (0 = none to
10 = strongest imaginable): T-statistic = -7.7813754952725285, P-value = 8.100984271662408e-14
6. Fusion of your personal self into a larger whole (0 = none to
10 = strongest imaginable): T-statistic = -8.56778916092202, P-value = 3.387383170660452e-16
7. Sense of reverence or sacredness (0 = none to
10 = strongest imaginable): T-statistic = -8.094743032561867, P-value = 9.520313653651218e-15
8. Timelessness (0 = none to
10 = strongest imaginable): T-statistic = -7.865891329449438, P-value = 4.572585179423882e-14
9. Ineffability (0 = none to
10 = strongest imaginable): T-statistic = -8.026053821879076, P-value = 1.529553487023367e-14
10. Feelings of joy (0 = none to
10 = strongest imaginable): T-statistic = -4.899774759162811, P-value = 1.467974092642273e-06
11. Feelings of peace and tranquility (0 = none to
10 = strongest imaginable): T-statistic = -1.6597118800429018, P-value = 0.09786555058434498
12. Positive Emotional Valence (0 = none to
10 = strongest imaginable): T-statistic = -2.3868296782583407, P-value = 0.017523356844877214
13. Negative emotional valence  (0 = none to
10 = strongest imaginable): T-statistic = -2.440220296377513, P-value = 0.01517242003345195
```

an independent t-test for participants who received either psilocybin or placebo in session 1, comparing these two groups. This test was first conducted with missing data and later with cleaned data (remove NaN).For the cleaned data, you found significant differences between the psilocybin and placebo groups across several variables, including "Overall Psilocybin Effect", "Letting Go", "Sense of reverence or sacredness", and others, with p-values showing strong statistical significance (e.g., p-values < 0.001)

Both the paired and independent t-tests indicated that psilocybin had a statistically significant effect on participants' subjective experiences when compared to placebo.

Trying Lazy Predict

In [95]:
```
!pip install opendatasets --upgrade --quiet
!pip3 install lazypredict
!pip3 install graphviz
```

```
Requirement already satisfied: lazypredict in /Users/harriethe/anaconda3/lib/python3.11/site-packages (0.2.1
2)
Requirement already satisfied: click in /Users/harriethe/anaconda3/lib/python3.11/site-packages (from lazypre
dict) (8.0.4)
Requirement already satisfied: scikit-learn in /Users/harriethe/anaconda3/lib/python3.11/site-packages (from
lazypredict) (1.5.2)
Requirement already satisfied: pandas in /Users/harriethe/anaconda3/lib/python3.11/site-packages (from lazypr
edict) (1.5.3)
Requirement already satisfied: tqdm in /Users/harriethe/anaconda3/lib/python3.11/site-packages (from lazypred
ict) (4.65.0)
Requirement already satisfied: joblib in /Users/harriethe/anaconda3/lib/python3.11/site-packages (from lazypr
edict) (1.2.0)
Requirement already satisfied: lightgbm in /Users/harriethe/anaconda3/lib/python3.11/site-packages (from lazy
predict) (4.5.0)
Requirement already satisfied: xgboost in /Users/harriethe/anaconda3/lib/python3.11/site-packages (from lazyp
redict) (2.1.1)
Requirement already satisfied: numpy>=1.17.0 in /Users/harriethe/anaconda3/lib/python3.11/site-packages (from
lightgbm->lazypredict) (1.24.3)
Requirement already satisfied: scipy in /Users/harriethe/anaconda3/lib/python3.11/site-packages (from lightgb
m->lazypredict) (1.10.1)
Requirement already satisfied: python-dateutil>=2.8.1 in /Users/harriethe/anaconda3/lib/python3.11/site-packa
ges (from pandas->lazypredict) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in /Users/harriethe/anaconda3/lib/python3.11/site-packages (from
pandas->lazypredict) (2022.7)
Requirement already satisfied: threadpoolctl>=3.1.0 in /Users/harriethe/anaconda3/lib/python3.11/site-package
s (from scikit-learn->lazypredict) (3.5.0)
Requirement already satisfied: six>=1.5 in /Users/harriethe/anaconda3/lib/python3.11/site-packages (from pyth
on-dateutil>=2.8.1->pandas->lazypredict) (1.16.0)
Requirement already satisfied: graphviz in /Users/harriethe/anaconda3/lib/python3.11/site-packages (0.20.3)
```

In [103…
```
import os
import numpy as np
import pandas as pd
import opendatasets as od
import lazypredict
from lazypredict.Supervised import LazyClassifier
from sklearn.model_selection import train_test_split
```

```
from sklearn.ensemble import RandomForestClassifier # for Random Forest Classifier
from sklearn.metrics import accuracy_score, confusion_matrix, precision_score, recall_score, ConfusionMatrixD
from sklearn.tree import export_graphviz
from IPython.display import Image
import graphviz
```

In [112…

```
X = df[rating_columns]
y = df['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)']
```

In [114…

```
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
y = le.fit_transform(y)

# Split the data
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Initialize LazyClassifier
clf = LazyClassifier(verbose=0, ignore_warnings=True, custom_metric=None)

# Fit and predict
models, predictions = clf.fit(X_train, X_test, y_train, y_test)

# View results
print(models)
```

```
100%|██████████| 31/31 [00:03<00:00, 10.29it/s]
```

```
[LightGBM] [Info] Auto-choosing row-wise multi-threading, the overhead of testing was 0.000488 seconds.
You can set `force_row_wise=true` to remove the overhead.
And if memory is not enough, you can set `force_col_wise=true`.
[LightGBM] [Info] Total Bins 183
[LightGBM] [Info] Number of data points in the train set: 488, number of used features: 8
[LightGBM] [Info] Start training from score -1.025529
[LightGBM] [Info] Start training from score -1.042821
[LightGBM] [Info] Start training from score -1.241556
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                               Accuracy  Balanced Accuracy ROC AUC  F1 Score  \
Model
LGBMClassifier                     0.50               0.52    None      0.49
NuSVC                              0.49               0.52    None      0.46
LogisticRegression                 0.49               0.52    None      0.46
CalibratedClassifierCV             0.48               0.51    None      0.42
LabelSpreading                     0.50               0.50    None      0.49
```

RidgeClassifier	0.47	0.50	None	0.40
RandomForestClassifier	0.48	0.50	None	0.46
LinearSVC	0.47	0.50	None	0.41
SVC	0.47	0.50	None	0.41
RidgeClassifierCV	0.46	0.50	None	0.38
LabelPropagation	0.49	0.50	None	0.48
KNeighborsClassifier	0.47	0.49	None	0.44
ExtraTreesClassifier	0.48	0.49	None	0.46
LinearDiscriminantAnalysis	0.46	0.49	None	0.41
XGBClassifier	0.48	0.49	None	0.47
BaggingClassifier	0.45	0.47	None	0.43
AdaBoostClassifier	0.47	0.47	None	0.46
PassiveAggressiveClassifier	0.45	0.45	None	0.45
QuadraticDiscriminantAnalysis	0.45	0.45	None	0.42
SGDClassifier	0.43	0.44	None	0.40
ExtraTreeClassifier	0.42	0.43	None	0.40
Perceptron	0.43	0.42	None	0.43
GaussianNB	0.42	0.42	None	0.40
DecisionTreeClassifier	0.40	0.41	None	0.40
NearestCentroid	0.40	0.40	None	0.37
BernoulliNB	0.37	0.37	None	0.35
DummyClassifier	0.29	0.33	None	0.13

Model	Time Taken
LGBMClassifier	0.18
NuSVC	0.06
LogisticRegression	0.03
CalibratedClassifierCV	0.11
LabelSpreading	0.04
RidgeClassifier	0.02
RandomForestClassifier	0.25
LinearSVC	0.02
SVC	0.04
RidgeClassifierCV	0.02
LabelPropagation	0.04
KNeighborsClassifier	0.03
ExtraTreesClassifier	0.22
LinearDiscriminantAnalysis	0.04
XGBClassifier	1.36
BaggingClassifier	0.06
AdaBoostClassifier	0.25
PassiveAggressiveClassifier	0.03
QuadraticDiscriminantAnalysis	0.02
SGDClassifier	0.02

```
ExtraTreeClassifier                0.02
Perceptron                         0.02
GaussianNB                         0.02
DecisionTreeClassifier             0.02
NearestCentroid                    0.02
BernoulliNB                        0.02
DummyClassifier                    0.02
```

Some Random PCA I done

In [116…
```
from sklearn.decomposition import PCA
from sklearn.preprocessing import StandardScaler
import matplotlib.pyplot as plt
```

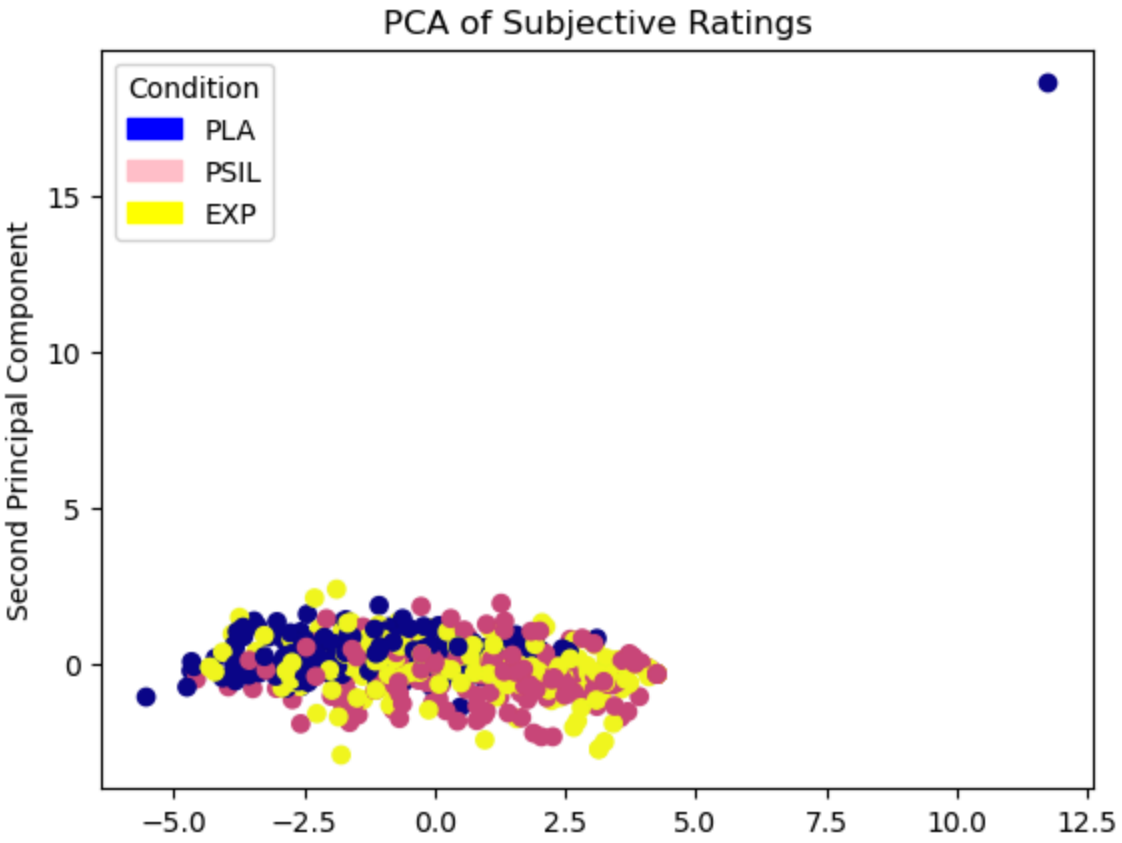
In [146…
```
from sklearn.impute import SimpleImputer
imputer = SimpleImputer(strategy='mean')
X_imputed = imputer.fit_transform(df[rating_columns])
scaler = StandardScaler()
X_scaled = scaler.fit_transform(X_imputed)
```

In [172…
```
pca = PCA(n_components=X_scaled.shape[1])
X_pca = pca.fit_transform(X_scaled)
explained_variance = pca.explained_variance_ratio_
print("Explained Variance Ratio:", explained_variance)
print("Total Variance Explained by 2 components:", sum(explained_variance))
```

```
Explained Variance Ratio: [0.62776203 0.14278614 0.0789812  0.04592319 0.03807703 0.02993752
 0.01986962 0.01666328]
Total Variance Explained by 2 components: 0.9999999999999999
```

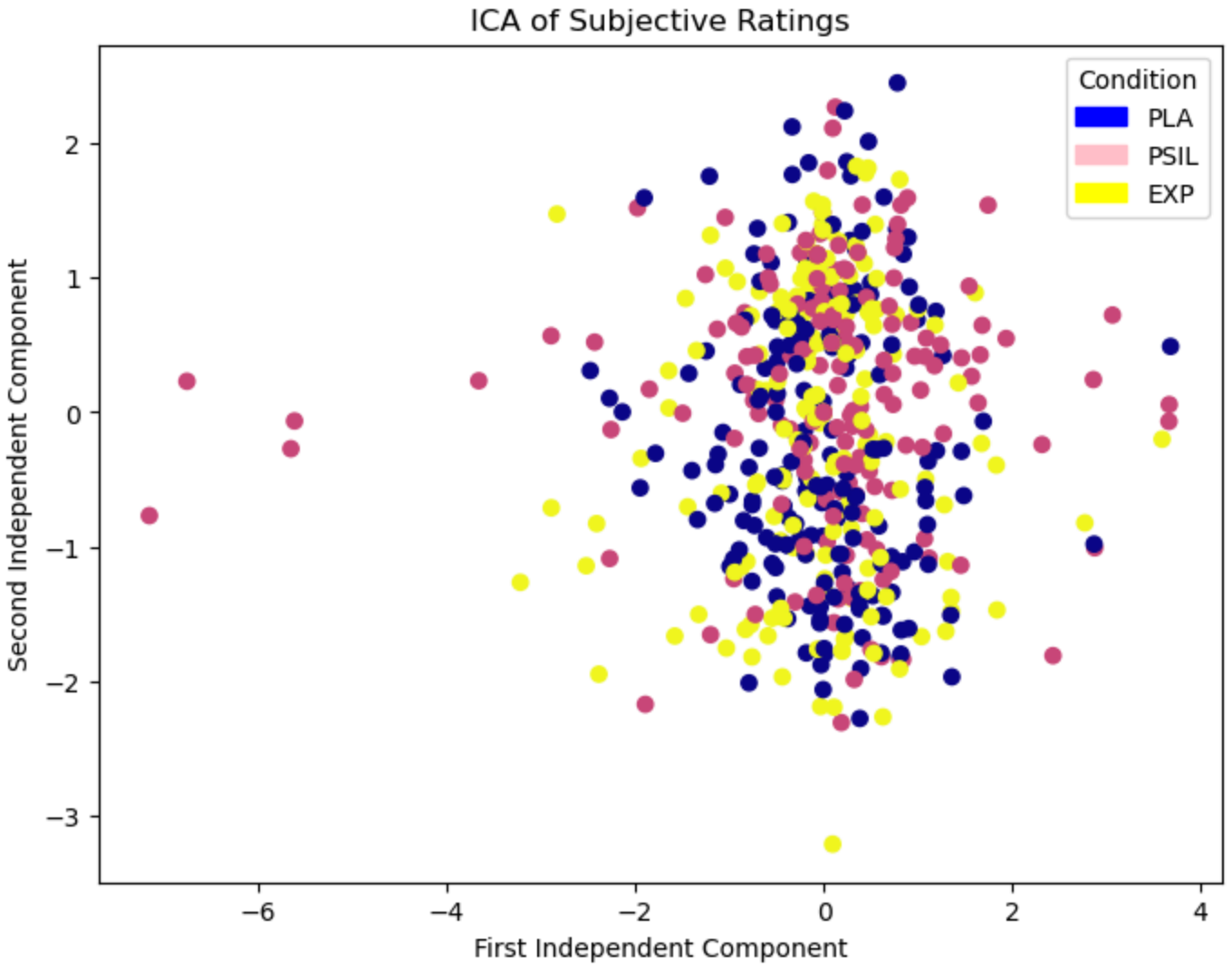
In [206…
```
import matplotlib.patches as mpatches
df['Condition_encoded'] = df['Condition (PLA: placebo, EXP: 25 mg/70 kg psilocybi)'].map({'PLA': 0, 'PSIL': 1

# Use the encoded values for the 'c' argument
plt.scatter(X_pca[:, 0], X_pca[:, 1], c=df['Condition_encoded'], cmap='plasma')
plt.ylabel('Second Principal Component')
plt.title('PCA of Subjective Ratings')
legend_handles = [mpatches.Patch(color='blue', label='PLA'),
                  mpatches.Patch(color='pink', label='PSIL'),
                  mpatches.Patch(color='yellow', label='EXP')]
plt.legend(handles=legend_handles, title='Condition')
plt.show()
```



In [208…
```
from sklearn.decomposition import FastICA
ica = FastICA(n_components=X_scaled.shape[1], random_state=42)
X_ica = ica.fit_transform(X_scaled)
```

In [216…
```
plt.figure(figsize=(8, 6))
plt.scatter(X_ica[:, 0], X_ica[:, 1], c=df['Condition_encoded'], cmap='plasma')
plt.xlabel('First Independent Component')
plt.ylabel('Second Independent Component')
plt.title('ICA of Subjective Ratings')
#plt.colorbar(label='Condition (PLA, PSIL, EXP)')
nd_handles = [mpatches.Patch(color='blue', label='PLA'),
                  mpatches.Patch(color='pink', label='PSIL'),
                  mpatches.Patch(color='yellow', label='EXP')]
plt.legend(handles=legend_handles, title='Condition')
plt.show()
```


ICA of Subjective Ratings
Condition
PLA
PSIL
EXP
Second Independent Component
First Independent Component
2
1
0
−1
−2
−3
−6
−4
−2
0
2
4

In [ ]: