

BRSM Final Project Report

Temperature of Emotions

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Dataset and Its Study

The dataset contains data gathered as a part of a study that aimed to understand how do we relate a given temperature with some emotions both explicitly and implicitly. The research study contains 2 experiments.

Experiment 1 -

The first experiment involved matching 12 different emotions with 5 temperature values and rating this matching on a scale of 1 to 5. Better explained, the participant's response was recorded on how correlated every emotion is with the given temperature values according to him with 5 being the most correlated and 1 being the least. This experiment was conducted in 4 languages namely English, Spanish, Chinese and Japanese.

Experiment 2 -

The second experiment involved Implicit Association Tests (IATs) with temperature words (cold and hot) and opposing pairs of emotional adjectives for each dimension of valence (Unhappy/Dissatisfied vs. Happy/Satisfied) and arousal (Passive/Quiet vs. Active/Alert) on native English speakers. The Response time and accuracy of responses for each participant were recorded.

In the Implicit Association Task, participants were asked to match the stimulus according to a specific key mapping that is Left key 'f' and right key 'J'. The experiment contained 2 variations namely 'Congruent' and 'Incongruent' tasks. In the congruent task, the low valence, low arousal emotions and cold temperature values were assigned to the same button and high valence, high arousal emotions and high-temperature values are assigned to the same button.

In the case of the Incongruent task, the assignment was the opposite of the congruent task. The responses were counted as correct if the button pressed by the participant

matched the above-mentioned assignment. The experimenters hypothesized that better accuracy and reaction time would be obtained for the congruent task as compared to the incongruent task.

Along with the data corresponding to the responses, some demographic details like age, gender, country of residence and first language were also gathered.

Dataset Link - <https://osf.io/tcbg5/>

Research Paper Link - [Temperature of Emotions](#)

Previous Work

Data Analysis -

Various tests were conducted in the study to analyze the correlation between temperature and emotions. Rank-based analysis of variance-type statistics (ATS) was conducted on ratings for each of the temperature values. It was performed on Response times for congruent and incongruent conditions. Principle Component Analysis (PCA) was used to find the association between temperature and emotion across the 4 languages. Wilcoxon Signed Ranked test was used to find the correlation between emotions and temperature.

Data Visualization -

EXPERIMENT 1 - Heatmap was used to visualize the average ratings of the temperature-emotion associations with all the data. Less saturated red or orange indicates stronger associations.

It was also used to show the Pearson Correlation between each pair of languages' 12X5 temperature-emotion association. Higher values indicate higher similarity between the association.

EXPERIMENT 2 - Boxplot was used to visualize the relation of valence and arousal with response time and error rates in both congruent and incongruent pairings.

Results

Analysis was done to understand the mapping between temperature values and emotions. It was compared across the selected 4 languages and was found to be highly correlated across these languages.

They found that a lower temperature is associated with negative valence, and low arousal emotions while a higher temperature is associated with positive valence, and high arousal emotions.

Similarly, 'Hot' was associated with emotions with high valence and high arousal and 'Cold' was associated with emotions with low valence and low arousal.

Our Work

Based on different demographic features provided in the dataset, we aim to analyze the data from their perspective and find out if a statistically significant relationship is found among these.

Experiment 1 -

For the first experiment, we divided the dataset based on three demographic factors that are age, country of residence and gender. The data was then analyzed to find if there is a statistically significant difference across these groups and what can we conclude from them.

Experiment 2 -

For the second experiment, we divided the dataset based on two demographic factors that are age and gender. Since this experiment was only performed on native English speakers, the country of residence was the UK for most of the participants. The data was then analyzed to find if there is a statistically significant difference across these groups for both valence and arousal in congruent and incongruent conditions.

Hypothesis Testing 1

Based on Gender -

- **Dataset Division -** The dataset was divided into 2 groups
 - Group 1 - Females - 250 participants
 - Group 2 - Males - 199 participants
- **Null Hypothesis -** There is no significant effect of the gender of participants on the ratings provided regarding the association between temperature values and emotions.

- **Alternate Hypothesis** - There is some significant effect of the gender of participants on the ratings provided regarding the association between temperature values and emotions.
- **Statistical Method:** Mann-Whitney test + 2-way ANOVA

Based on Country of Residence -

- **Dataset Division** - The dataset was divided into 2 groups based on their country's yearly average temperature (YAT)
 - Group 1 - YAT>13 - 176 participants
 - Group 2 - YAT<13 - 246 participants
- **Null Hypothesis** - There is no significant effect of the country of residence of participants on the ratings provided regarding the association between temperature values and emotions.
- **Alternate Hypothesis** - There is some significant effect of the country of residence of participants on the ratings provided regarding the association between temperature values and emotions.
- **Statistical Method:** Mann-Whitney test + 2-way ANOVA

Based on Age -

- **Dataset Division** - The dataset was divided into 3 groups
 - Group 1 - $16 \leq \text{age} \leq 28$ - 156 participants
 - Group 2 - $29 \leq \text{age} \leq 39$ - 161 participants
 - Group 3 - $40 \leq \text{age}$ - 134 participants
- **Null Hypothesis** - There is no significant effect of the age of participants on the ratings provided regarding the association between temperature values and emotions.
- **Alternate Hypothesis** - There is some significant effect of the age of participants on the ratings provided regarding the association between temperature values and emotions.
- **Statistical Method:** 1-way and 2-way ANOVA + Games Howell post hoc test

Results for Experiment 1

Based on Gender -

1. Visualization

	emotion	temp0	temp10	temp20	temp30	temp40
0	Energetic, Excited	1.204	1.804	2.956	3.528	3.428
1	Secure, At ease	1.680	2.424	3.600	2.780	1.840
2	Jittery, Nervous	1.964	2.140	2.252	2.756	3.084
3	Dull, Bored	3.108	3.004	2.400	1.972	1.796
4	Passive, Quiet	2.996	3.156	2.944	1.940	1.588
5	Unhappy, Dissatisfied	3.072	2.724	2.156	2.068	2.348
6	Tense, Bothered	2.024	2.100	2.200	2.812	3.304
7	Relaxed, Calm	2.120	2.784	3.580	2.612	1.628
8	Active, Alert	1.344	1.976	3.048	3.344	3.060
9	Happy, Satisfied	1.400	2.140	3.488	3.308	2.508
10	Blue, Uninspired	3.704	3.172	2.232	1.652	1.500
11	Enthusiastic, Inspired	1.296	1.932	3.060	3.356	3.100

Plotting the average ratings for every emotion for all the temperatures for both the groups, we found out that the temperature associated with the highest average rating for a particular emotion remains the same across both the groups but the values differed a bit.

The first table is the average rating for the females while the second is for the males.

	emotion	temp0	temp10	temp20	temp30	temp40
0	Energetic, Excited	1.376884	1.924623	2.954774	3.432161	3.361809
1	Secure, At ease	1.758794	2.547739	3.793970	2.678392	1.743719
2	Jittery, Nervous	2.060302	2.201005	2.301508	2.974874	3.221106
3	Dull, Bored	3.050251	3.040201	2.432161	1.974874	1.763819
4	Passive, Quiet	3.075377	3.170854	2.778894	1.949749	1.587940
5	Unhappy, Dissatisfied	3.135678	2.633166	2.125628	2.276382	2.678392
6	Tense, Bothered	2.251256	2.256281	2.291457	2.879397	3.311558
7	Relaxed, Calm	2.195980	2.874372	3.713568	2.326633	1.376884
8	Active, Alert	1.442211	2.120603	3.286432	3.291457	3.005025
9	Happy, Satisfied	1.381910	2.201005	3.597990	3.140704	2.286432
10	Blue, Uninspired	3.557789	3.160804	2.296482	1.783920	1.723618
11	Enthusiastic, Inspired	1.336683	1.899497	2.954774	3.306533	3.231156

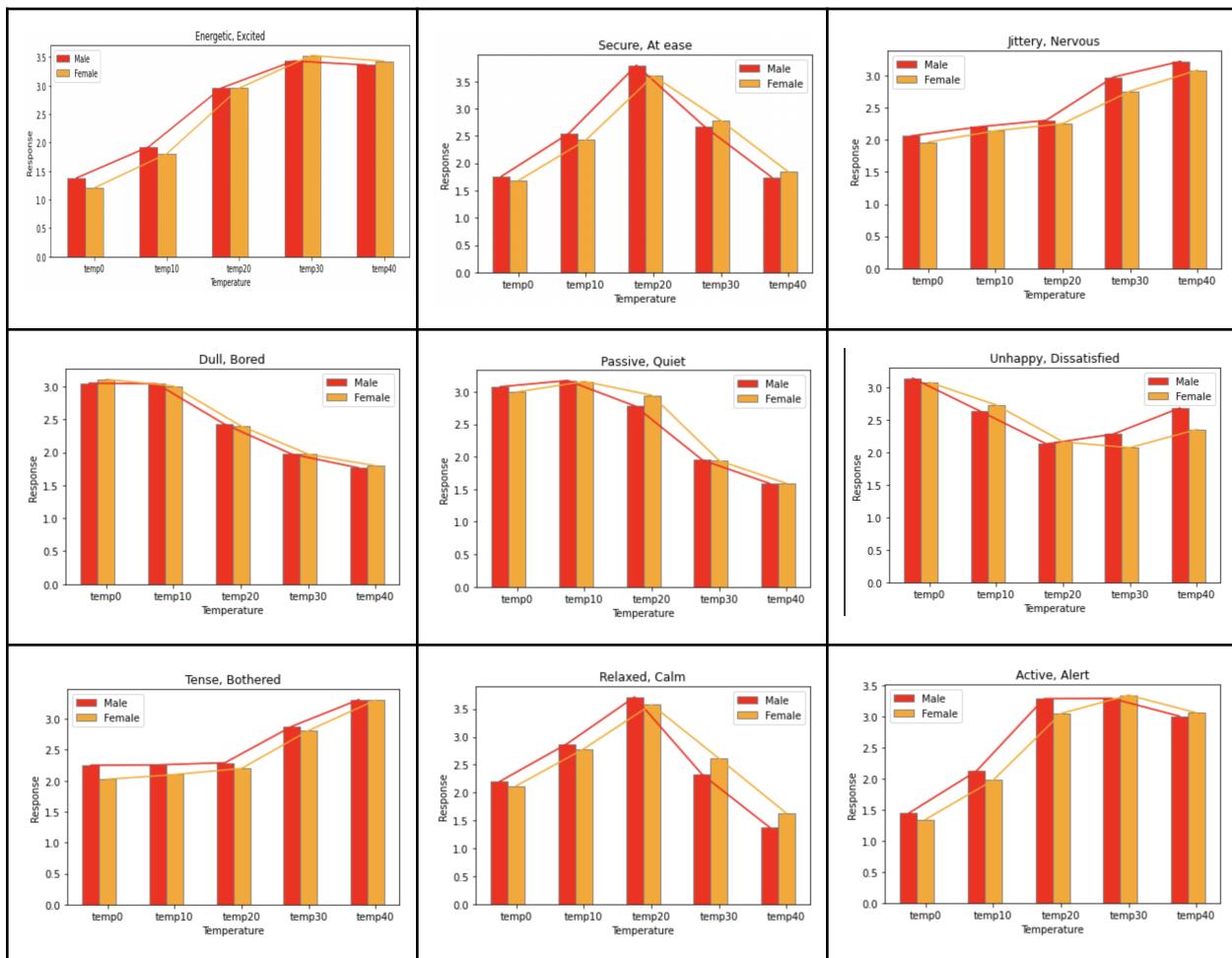
For example - The highest rating for Energetic, Excited is for temperature 30 for both the groups - 3.528 (Females) and 3.432161 (Males).

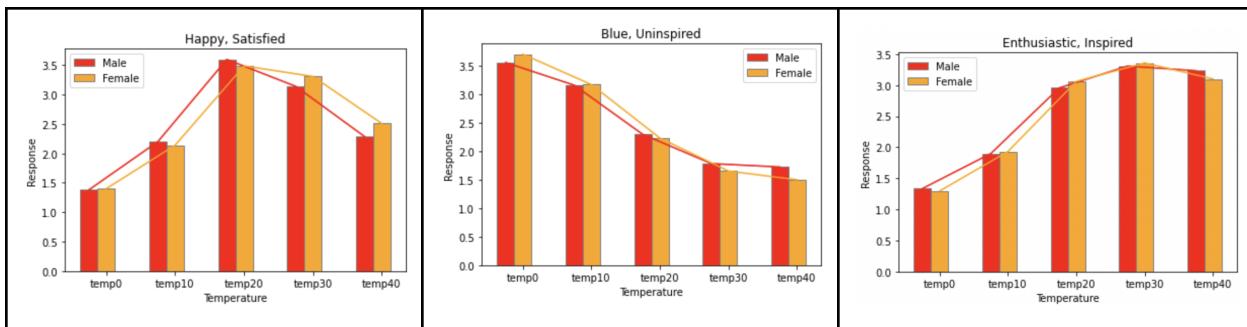
Similarly for all the other emotions, this trend continues implying that irrespective of gender, humans tend to associate the same temperature with the given emotion.

The same can be visualized by the heat maps for the association of all the temperatures for a particular emotion for both groups.



Next, we plotted the bar graphs and line graphs of the ratings provided for both the groups for every emotion separately to observe the trend.





2. Statistical Tests -

- Mann-Whitney Test -
 - Across all responses - There was an overall statistically significant difference found between the 2 groups ($p\text{-value} = 0.02$).
 - Across emotions - There was a statistically significant difference found between the 2 groups for the emotions like
 - Tense, Bothered ($p\text{-value} = 0.026$)
 - Jittery, Nervous ($p\text{-value} = 0.023$)
 - Unhappy, Dissatisfied ($p\text{-value} = 0.048$)
- 2 way ANOVA - There was no statistically significant interaction between Gender:Temperature ($p\text{-value} = 0.5011$) and Gender:Emotion ($p\text{-value} = 0.4353$)

3. Inferences -

- a. For the Tense, Bothered and Jittery, Nervous emotions male participants reported higher ratings as compared to female participants for all the five temperature values. For Unhappy, Dissatisfied emotions, a particular gender does not exceed the other one in all the cases.
- b. All three emotions have low valence and low arousal.
- c. The trend of the ratings represented by the line graphs almost matches for both the genders signifying there is not a very large difference between the association of emotions and temperature values.

Based on Country of Residence -

1. Visualization

	emotion	temp0	temp10	temp20	temp30	temp40
0	Energetic, Excited	1.340909	1.988636	3.159091	3.505682	3.255682
1	Secure, At ease	1.812500	2.607955	3.806818	2.750000	1.767045
2	Jittery, Nervous	1.977273	2.244318	2.352273	3.051136	3.375000
3	Dull, Bored	3.096591	2.982955	2.403409	2.085227	2.022727
4	Passive, Quiet	3.045455	3.125000	2.909091	2.045455	1.732955
5	Unhappy, Dissatisfied	3.232955	2.681818	2.085227	2.221591	2.710227
6	Tense, Bothered	2.323864	2.335227	2.312500	2.863636	3.113636
7	Relaxed, Calm	1.965909	2.767045	3.784091	2.534091	1.534091
8	Active, Alert	1.471591	2.250000	3.414773	3.250000	2.750000
9	Happy, Satisfied	1.392045	2.284091	3.687500	3.147727	2.363636
10	Blue, Uninspired	3.556818	3.113636	2.318182	1.892045	1.784091
11	Enthusiastic, Inspired	1.443182	2.062500	3.170455	3.250000	3.005682

Plotting the average ratings for every emotion for all the temperatures for both the groups, we found out that the temperature associated with the highest average rating for a particular emotion remains the same across both the groups but the values differed a bit.

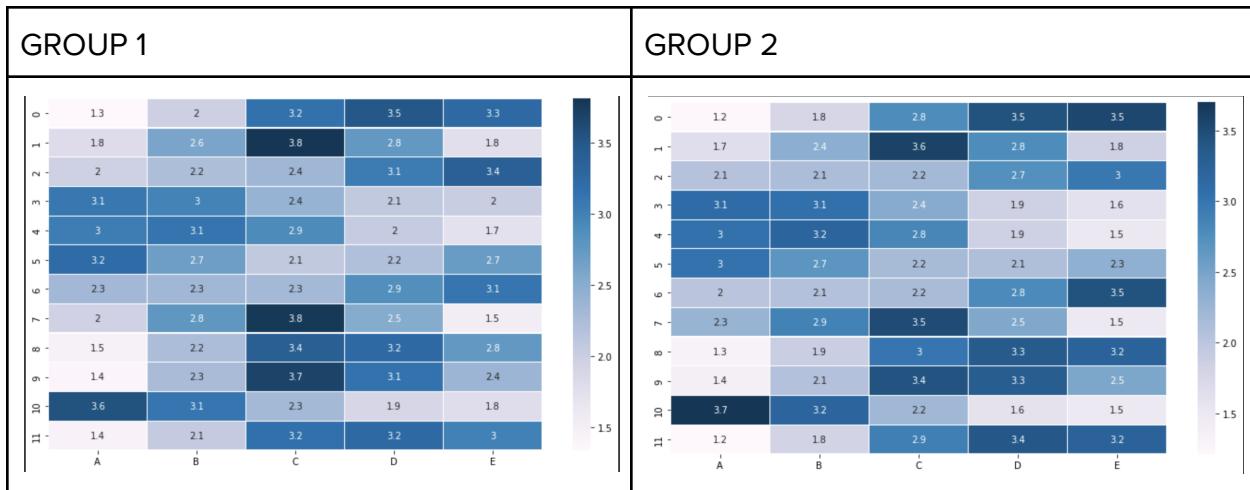
The first table is the average rating for group 1 ($YAT > 13$) while the second is for group 2 ($YAT < 13$).

	emotion	temp0	temp10	temp20	temp30	temp40
0	Energetic, Excited	1.223577	1.756098	2.780488	3.455285	3.544715
1	Secure, At ease	1.650407	2.365854	3.585366	2.776423	1.845528
2	Jittery, Nervous	2.052846	2.134146	2.195122	2.739837	2.983740
3	Dull, Bored	3.121951	3.056911	2.402439	1.857724	1.605691
4	Passive, Quiet	3.044715	3.195122	2.841463	1.857724	1.512195
5	Unhappy, Dissatisfied	3.036585	2.678862	2.166667	2.113821	2.333333
6	Tense, Bothered	2.024390	2.065041	2.162602	2.800813	3.451220
7	Relaxed, Calm	2.276423	2.873984	3.512195	2.455285	1.491870
8	Active, Alert	1.321138	1.886179	3.000000	3.349593	3.239837
9	Happy, Satisfied	1.378049	2.056911	3.430894	3.333333	2.467480
10	Blue, Uninspired	3.699187	3.203252	2.219512	1.593496	1.483740
11	Enthusiastic, Inspired	1.211382	1.808943	2.910569	3.394309	3.243902

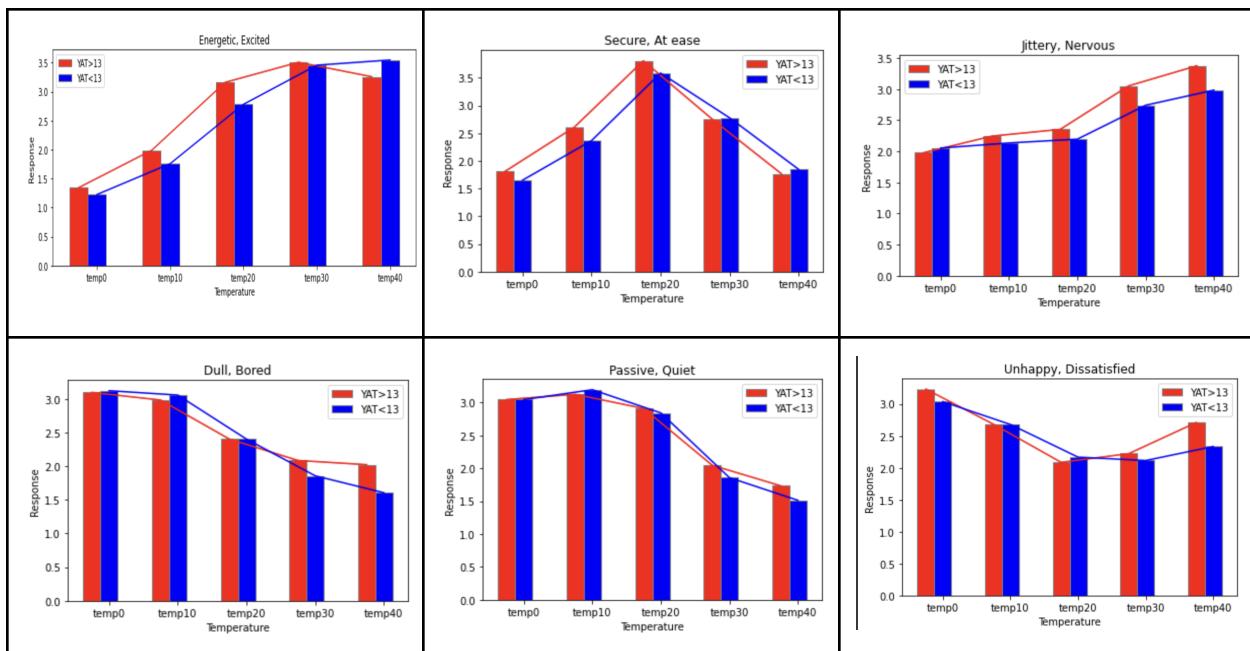
For example - The highest rating for Blue, Uninspired is for temperature 0 for both the groups - 3.556 (Group 1) and 3.699 (Group 2).

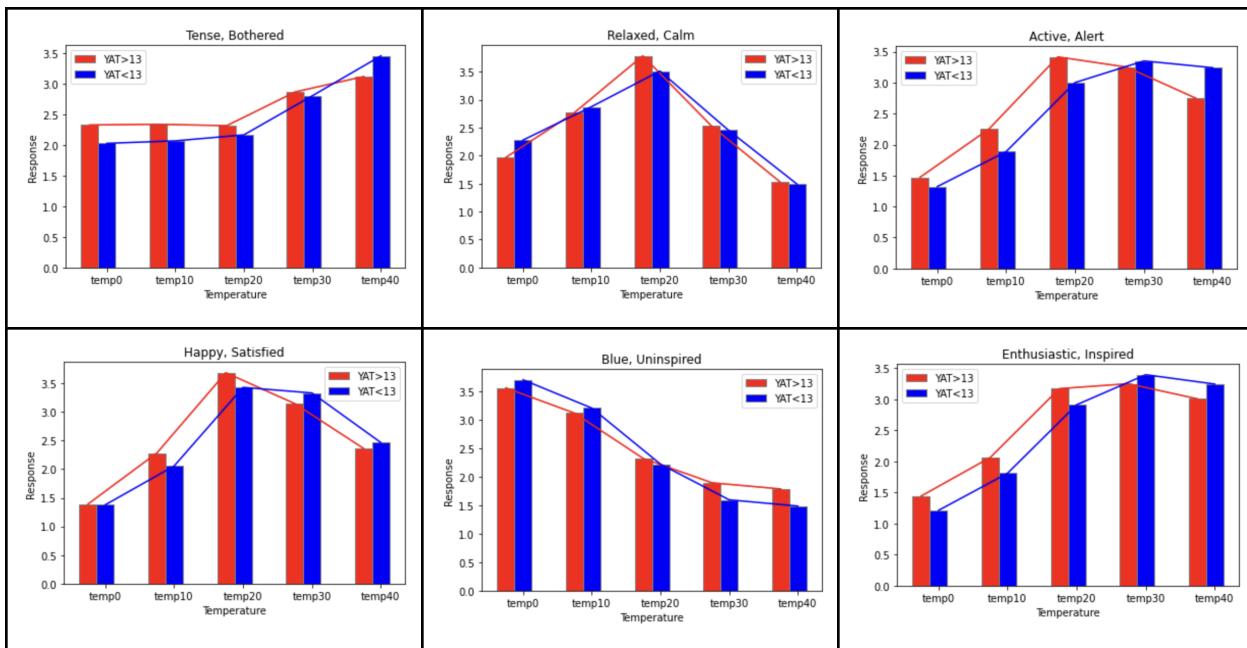
Similarly for all the other emotions, this trend continues implying that irrespective of the country of residence, humans tend to associate the same temperature with the given emotion.

The same can be visualized by the heat maps for the association of all the temperatures for a particular emotion for both groups.



Next, we plotted the bar graphs and line graphs of the ratings provided for both the groups for every emotion separately to observe the trend.





2. Statistical Tests -

- Mann-Whitney Test -
 - Across all responses - There was an overall statistically significant difference found between the 2 groups ($p\text{-value} << 0.05$).
 - Across emotions - There was a statistically significant difference found between the 2 groups for the emotions like
 - Energetic, Excited ($p\text{-value} = 0.042$)
 - Secure, At ease ($p\text{-value} = 0.047$)
 - Jittery, Nervous ($p\text{-value} = 0.001$)
 - Dull, Bored ($p\text{-value} = 0.022$)
 - Unhappy, Dissatisfied ($p\text{-value} = 0.025$)
 - Tense, Bothered ($p\text{-value} = 0.049$)
 - Blue, Uninspired ($p\text{-value} = 0.038$)
- 2 way ANOVA - There was no statistically significant interaction between Country:Temperature ($p\text{-value} = 0.0965$) and Country:Emotion ($p\text{-value} = 0.8350$)

3. Inferences -

- a. The emotions are a mix of low valence and arousal as well as high valence and arousal.
- b. There is not a clear distinction between the ratings provided by the residents of the two groups, i.e. a single group does not always have a higher rating compared to the other group.
- c. The line graphs are almost matched for both groups across different emotions signifying that the overall trend of rating is the same for the two groups.

Based on Age -

1. Visualization

	emotion	temp0	temp10	temp20	temp30	temp40
0	Energetic, Excited	1.179487	1.730769	3.006410	3.679487	3.519231
1	Secure, At ease	1.737179	2.596154	3.730769	2.717949	1.685897
2	Jittery, Nervous	2.307692	2.397436	2.282051	2.826923	3.128205
3	Dull, Bored	3.250000	3.089744	2.301282	1.980769	1.814103
4	Passive, Quiet	3.166667	3.371795	2.935897	1.833333	1.407669
5	Unhappy, Dissatisfied	3.429487	2.865385	2.192308	2.134615	2.397436
6	Tense, Bothered	2.269231	2.160256	2.102564	3.032051	3.602564
7	Relaxed, Calm	2.320513	2.993590	3.628205	2.493590	1.378205
8	Active, Alert	1.294872	2.000000	3.064103	3.525641	3.301282
9	Happy, Satisfied	1.339744	2.096154	3.596154	3.320513	2.333333
10	Blue, Uninspired	3.846154	3.288462	2.173077	1.666667	1.576923
11	Enthusiastic, Inspired	1.256410	1.865385	3.141026	3.371795	3.025641

	emotion	temp0	temp10	temp20	temp30	temp40
0	Energetic, Excited	1.347826	1.968944	2.987578	3.453416	3.310559
1	Secure, At ease	1.683230	2.409938	3.571429	2.757764	1.950311
2	Jittery, Nervous	1.931677	2.074534	2.291925	2.875776	3.136648
3	Dull, Bored	3.260870	3.012422	2.397516	1.962733	1.751553
4	Passive, Quiet	2.956522	3.068323	2.838509	1.956522	1.565217
5	Unhappy, Dissatisfied	2.944099	2.552795	2.074534	2.118012	2.459627
6	Tense, Bothered	2.024845	2.016834	2.273292	2.819876	3.322981
7	Relaxed, Calm	2.198758	2.795031	3.565217	2.428571	1.571429
8	Active, Alert	1.459627	2.080745	3.068323	3.236025	3.024845
9	Happy, Satisfied	1.478261	2.260870	3.515528	3.236025	2.496894
10	Blue, Uninspired	3.726708	3.074534	2.142857	1.658385	1.590062
11	Enthusiastic, Inspired	1.385093	1.937888	2.981366	3.285714	3.204969

	emotion	temp0	temp10	temp20	temp30	temp40
0	Energetic, Excited	1.313433	1.865672	2.858209	3.276119	3.335821
1	Secure, At ease	1.716418	2.417910	3.776119	2.716418	1.731343
2	Jittery, Nervous	1.738806	2.022388	2.238806	2.843284	3.156716
3	Dull, Bored	2.671642	2.932833	2.552239	1.977612	1.791045
4	Passive, Quiet	2.947761	3.037313	2.828358	2.052239	1.731343
5	Unhappy, Dissatisfied	2.895522	2.619403	2.149254	2.246269	2.649254
6	Tense, Bothered	2.097015	2.365672	2.343284	2.649254	2.970149
7	Relaxed, Calm	1.895522	2.664179	3.731343	2.529951	1.604478
8	Active, Alert	1.402985	2.052239	3.380597	3.164179	2.716418
9	Happy, Satisfied	1.343284	2.141791	3.507483	3.111940	2.380597
10	Blue, Uninspired	3.305970	3.126866	2.485075	1.820896	1.634328
11	Enthusiastic, Inspired	1.298507	1.955224	2.895522	3.320696	3.223881

Plotting the average ratings for every emotion for all the temperatures for all the groups, we found out that the temperature associated with the highest average rating for a particular emotion remains the same across the groups but the values differed a bit.

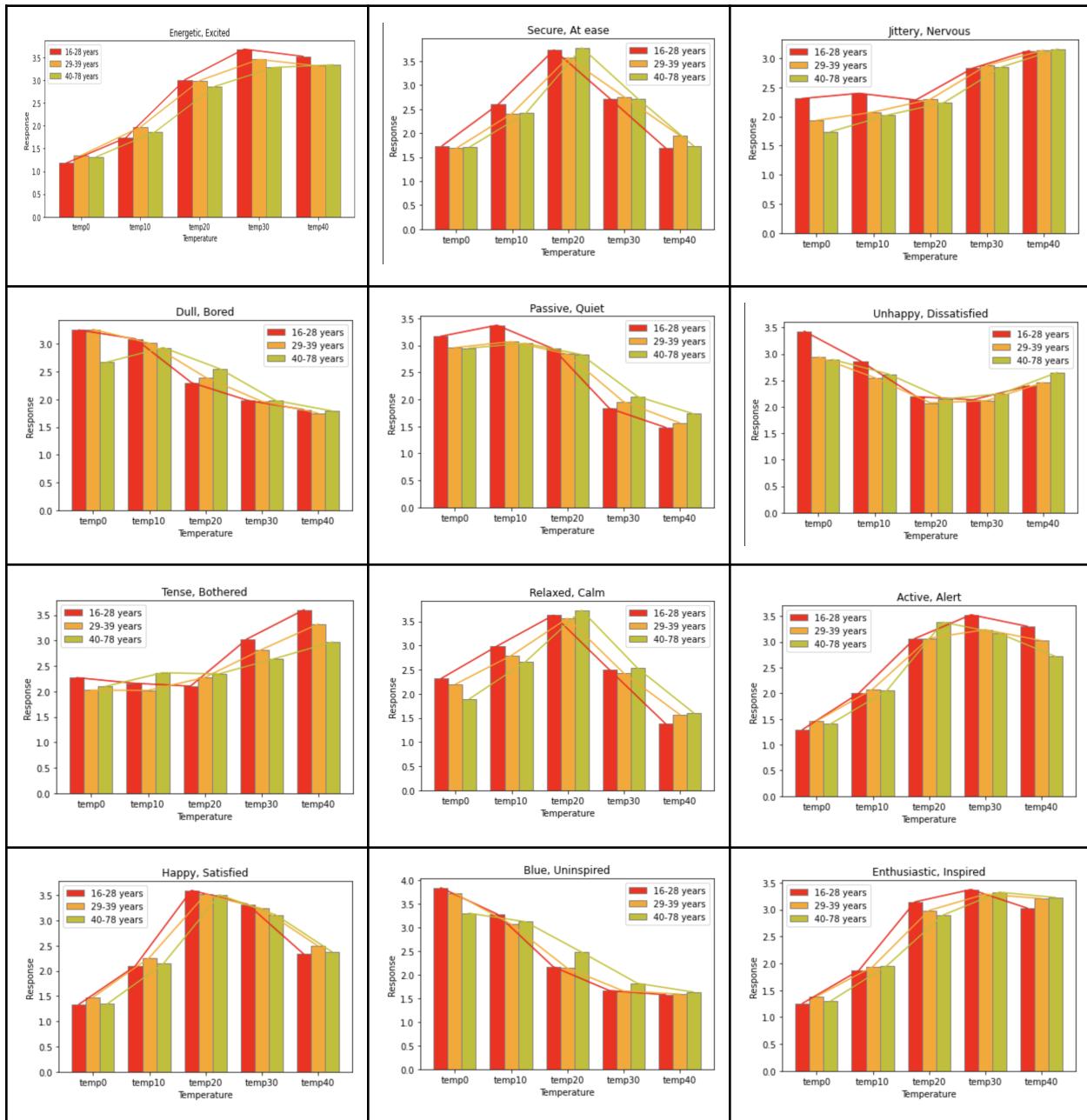
The first table is the average rating for group 1 ($16 \leq \text{age} \leq 28$) while the second is for group 2 ($29 \leq \text{age} \leq 39$) and the third is for group 3 ($40 \leq \text{age}$).

For example - The highest rating for Jittery, Nervous is for a temperature of 40 for all the groups - 3.128 (Group 1), 3.136 (Group 2) and 3.156 (Group 3). Similarly for all the other emotions, this trend continues implying that irrespective of age, humans tend to associate the same temperature with the given emotion.

The same can be visualized by the heat maps for the association of all the temperatures for a particular emotion for both groups.



Next, we plotted the bar graphs and line graphs of the ratings provided for all the groups for every emotion separately to observe the trend.



2. Statistical Tests -

- 1 way Anova -
 - Across all responses - There is a significant difference between the groups (p-value = 0.01)
 - Across emotions - The emotions that show a statistically significant difference are
 - Jittery, Nervous (p-value = 0.022)
 - Unhappy, Dissatisfied (p-value = 0.042)
- 2 way ANOVA - There was statistically significant interaction between Age:Temp(p-value = 0.0005) and Temp:Emotion (p-value << 0.05) but not between Age:Emotion (p-value = 0.8283)
- Post-Hoc Test - There is a significant difference between group 1 and 3 (p-value = 0.0010) and between group 1 and 2 (p-value = 0.0174) but not between group 2 and 3 (p-value = 0.5245). Also, the mean difference between these groups indicates that group 3 and 2 has higher ratings than group 1 for corresponding temperatures and emotions.

3. Inferences -

- a. For the Jittery, Nervous and Unhappy, Dissatisfied emotions, a particular age group does not have higher ratings for all the temperatures, the group with the highest ratings is different for different age groups.
- b. The line graphs show a similar trend of rating across all age groups for the 12 emotions.

Hypothesis Testing 2

Based on Gender -

- **Dataset Division** - The dataset was divided into 2 groups
 - Group 1 valence - Females - 32 participants
 - Group 1 arousal - Females - 34 participants
 - Group 2 valence - Males - 19 participants
 - Group 2 arousal - Males - 16 participants
- **Null Hypothesis** - There is no significant effect of the gender of participants on the reaction times and accuracy provided for valence and arousal emotions separately.
- **Alternate Hypothesis** - There is some significant effect of the gender of participants on the reaction times and accuracy provided for valence and arousal emotions separately.
- **Statistical Method:** Mann-Whitney Test for reaction times and D-Prime Values for accuracy.

Based on Age -

- **Dataset Division** - The dataset was divided into 2 groups
 - Group 1 valence - $19 \leq \text{age} \leq 30$ - 29 participants
 - Group 1 arousal - $19 \leq \text{age} \leq 30$ - 22 participants
 - Group 2 valence - $31 \leq \text{age}$ - 22 participants
 - Group 2 arousal - $31 \leq \text{age}$ - 28 participants
- **Null Hypothesis** - There is no significant effect of the age of participants on the reaction times and accuracy provided for valence and arousal emotions separately.
- **Alternate Hypothesis** - There is some significant effect of the age of participants on the reaction times and accuracy provided for valence and arousal emotions separately.
- **Statistical Method:** Mann-Whitney Test for reaction times and D-Prime Values for accuracy.

Results for Experiment 2

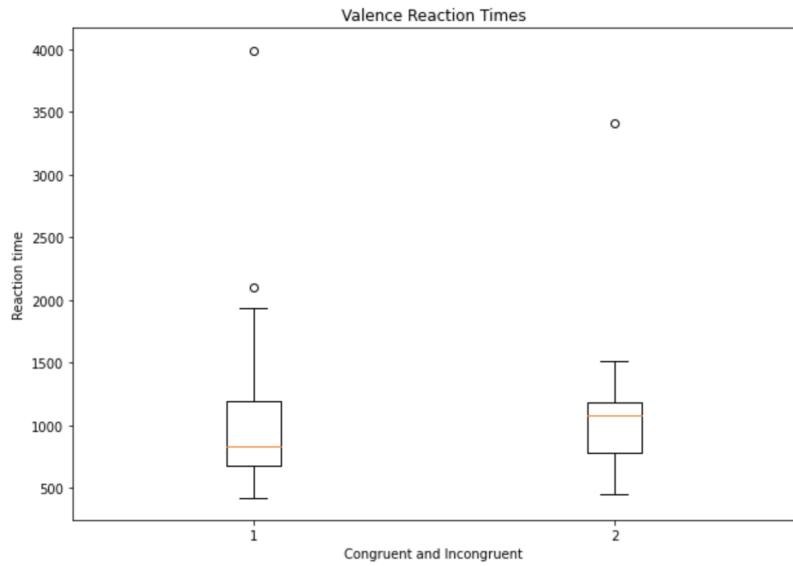
Based on Gender -

1. Valence -
 - a. Reaction time: No statistically significant difference (p-value = 0.06)
 - b. Accuracy: D-prime value -> 2.636 (Females), 2.5042 (Males)
2. Arousal -
 - a. Reaction time: Statistically significant difference (p-value = 0.04)
 - b. Accuracy: D-prime value -> 1.8578 (Females), 6.1805 (Males)

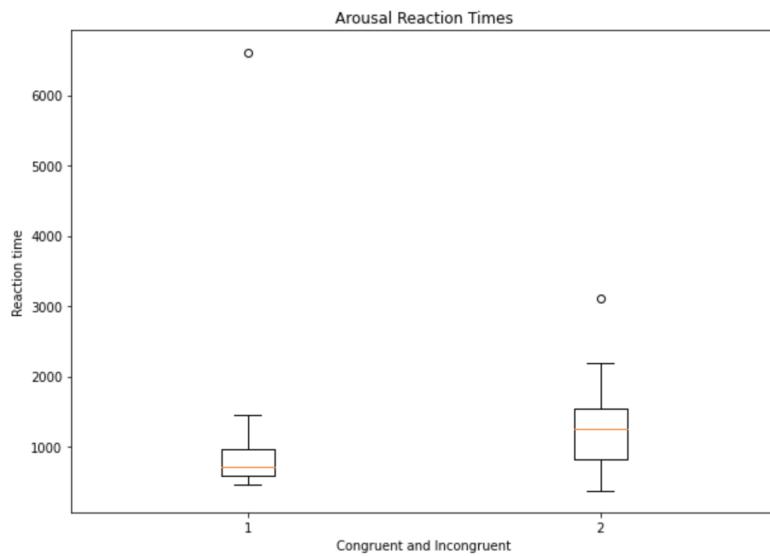
Based on Age Group-

1. Valence -
 - a. Reaction time: No statistically significant difference (p-value = 0.14)
 - b. Accuracy: D-prime value -> 1.9348 (Group 1), 2.8522 (Group 2)
2. Arousal -
 - a. Reaction time: No statistically significant difference (p-value = 0.21)
 - b. Accuracy: D-prime value -> 1.8169 (Group 1), 2.9305 (Group 2)

Visualization of Box plots -



Observations - The orange-coloured line in the boxplot denotes the median of the data distribution. Comparing the results for congruent and incongruent groups, the reaction time is reported to be more for the incongruent condition for both valence and arousal conditions.



Code -

https://colab.research.google.com/drive/1ZNRkrKcmtElr1Jp6HvN1qq2kGt_kWEkb?usp=sharing#scrollTo=VhqhdOmwmq5t

Final Inferences -

Experiment 1

Grouping the data based on Gender, Age and place of residence, the main effect was observed for all the 3 factors. (Based on p-value < 0.05)

All the emotions do not show statistically significant rating differences corresponding to the demographic factors.

Analysing the interactions between temperature, emotions and the above 3 factors, statistically significant interaction was found between Age-Temperature and Temperature-emotion.

The bar graphs and line graphs show the variation in ratings based on the demographic factors and the trend of ratings for the emotion-temperature association.

Experiment 2

For valence, No statistically significant difference was observed between reaction times for both gender wise grouping and agewise grouping. A slightly higher accuracy value was observed for females as compared to males and group 2 as compared to group 1.

For Arousal, a statistically significant difference was observed for Genderwise grouping. A higher accuracy value was observed for Males as compared to females and Group 2 as compared to Group 1.

Conclusions -

Based on age group - People in the different age groups rate the intensity of association between an emotion and a temperature value differently, this could be attributed to the changes in thermal sensitivity with ageing.

Based on country of residence - The ratings provided by residents of cold countries and hot countries differ significantly. This is because the climatic conditions of the place of residence could be playing a role in temperature sensation.

Based on Gender - A distinction was observed between the ratings provided by Females and Males. This could be attributed to the intensity with which both the genders perceive emotions and the difference in thermal sensitivity.

Finally, the difference in the perception of an association between emotions and temperatures for the considered demographic factors could be helpful in effectively capturing the variation in perceived intensity of temperature-emotion association across a diverse population.

Limitations -

The paper has no details on the environmental conditions around the participants while collecting the data which could have affected their responses.

Contribution -

1. Core Analysis - Tanvi (60%) and Pragya (40%)
2. Report + Presentation - Tanvi (35%) and Pragya (65%)
3. Other analysis - Tanvi (55%) and Pragya (45%)

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