Pokemon Stats Analysis

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1 INTRODUCTION

Our project aims to perform analysis of the statistics of Pokemon from the Pokemon Trading Card Game. Due to the high variety of Pokemon in this game, information about their statistics can help players become more informed and therefore develop better battle strategies. Our results can help players assess which Pokemon are worth it and which are considered more valuable based on their status (Legendary/non-Legendary) and type. Our project is divided into two parts: First, we analyse Legendary and non-Legendary Pokemon. Second, we compare different Pokemon based on their primary type.

Our main objectives are:

1.1 Conduct an exploratory analysis on Legendary and non-Legendary Pokemon.
1.2 Perform statistical inference on the results based on 1.1.
2.1 Find the most common Pokemon type.
2.2 Find the Pokemon type that has the highest overall statistics.

Our main hypotheses are:

1.1 Legendary Pokemon generally have superior statistics compared to non-Legendary Pokemon.
1.2 Some statistics can serve as a predictor for other statistics depending on the Legendary vs. non-Legendary status.
2.1 There are generally the same amount of Pokemon in each type.
2.2 Dragon-type Pokemon are stronger than other types.

2 DATA

Unfortunately, the dataset we initially downloaded from Kaggle on the 4th of February has been removed. This dataset was called ‘Pokemon’ and was made by ‘jaidalmotra’. This is the dataset we used to conduct our research. Figure 1 is a sample of the deleted dataset.

	number	name	type1	type2	total	hp	attack	defense	sp_attack	sp_defense	speed	generation	legendary
0	1	Bulbasaur	Grass	Poison	318	45	49	49	65	65	45	1	False
1	2	Ivysaur	Grass	Poison	405	60	62	63	80	80	60	1	False
2	3	Venusaur	Grass	Poison	525	80	82	83	100	100	80	1	False
3	3	Mega Venusaur	Grass	Poison	625	80	100	123	122	120	80	1	False
4	3	Gigantamax Venusaur	Grass	Poison	525	80	82	83	100	100	80	1	False

Figure 1 : Sample of dataset ‘Pokemon’

There are a total of 1072 Pokemon in this dataset, the possible bias from this dataset is that the data contains errors and is out of date. A dataset that is similar to ‘Pokemon’ and is still available for download is called ‘Pokemon with stats’ made by Barradas, A. It was downloaded from https://www.kaggle.com/ on the 30th of March 2025. Figure 2 is a sample of the alternative dataset.

‘Pokemon with stats’ is similar to ‘Pokemon’, however, there are less pokemons in this database (800 Pokemon as opposed to 1072 from the dataset we used).

#	Name	Type 1	Type 2	Total	HP	Attack	Defense	Sp. Atk	Sp. Def	Speed	Generation	Legendary
1	Bulbasaur	Grass	Poison	318	45	49	49	65	65	45	1	FALSE
2	Ivysaur	Grass	Poison	405	60	62	63	80	80	60	1	FALSE
3	Venusaur	Grass	Poison	525	80	82	83	100	100	80	1	FALSE
3	VenusaurMega Venusaur	Grass	Poison	625	80	100	123	122	120	80	1	FALSE
4	Charmander	Fire		309	39	52	43	60	50	65	1	FALSE
5	Charmeleon	Fire		405	58	64	58	80	65	80	1	FALSE

Figure 2 : Sample of dataset ‘Pokemon with stats’

The independent variables chosen for this project from the ‘Pokemon’ dataset are ‘legendary’ and ‘type1’. The dependent variables are ‘total’, ‘hp’, ‘attack’ ‘defence’ ‘ sp_attack’ and ‘speed’.

- Legendary Pokemon are more unique Pokemon who have a signature move or more exclusive ability as opposed to non-Legendary ones.
- Types represent elemental attributes that define a Pokemons’ abilities, strengths, and weaknesses in battle. Each Pokemon has one or two types, which influence how effective their moves are against other types, however, **type one is the dominant type and is therefore studied in this research**. There are 18 types of Pokemon in total.
- The stats represent a Pokemon’s attributes in battle, determining how strong, fast, or durable it is. The total stats is the summation of all types of stats, i.e.,‘hp’ + ‘attack’ + ‘defence’+ ‘ sp_attack’ + ‘speed’.

3 DATA CLEANING AND PREPARATION

Overall, our data set was sufficient and clean. There were only a few typing mistakes.

We fixed 'Blastoise' and 'Graass'. Blastoise is the name of a Pokemon rather than the type, and Grass is simply mistyped. We changed ‘Blastoise' to the Water type and corrected the typo.

4. EXPLORATORY DATA ANALYSIS

4.1 Univariate analysis

4.1.1 Legendary vs. Non-Legendary Pokemon

First, we draw a histogram to depict exact amount of both Legendary and Non-Legendary Pokemon, the results are:

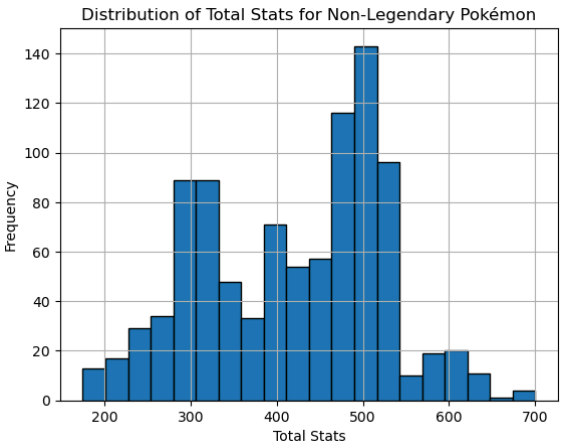
- 118 - Legendary Pokemons
- 954 Non-Legendary Pokemons

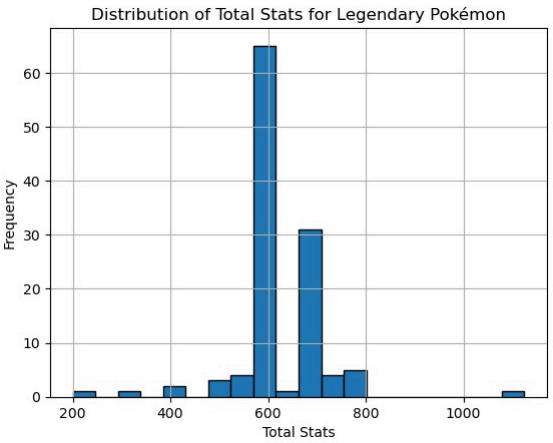
Then, we analyze both Legendary and Non-Legendary Pokemon separately using the describe() function:

```
count     118.000000
mean      618.796610
std        95.797825
min       200.000000
25%       580.000000
50%       600.000000
75%       680.000000
max      1125.000000
Name: total, dtype: float64
```

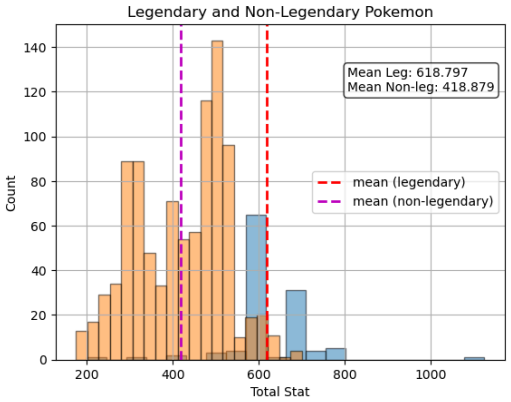
```
count    954.000000
mean     418.879455
std      105.006926
min      175.000000
25%      320.750000
50%      437.000000
75%      500.000000
max      700.000000
Name: total, dtype: float64
```

It is already clear that the mean of Legendary Pokemon Total Statistics is higher than the mean of Non-Legendary ones. To see the data visually we draw distributions separately:



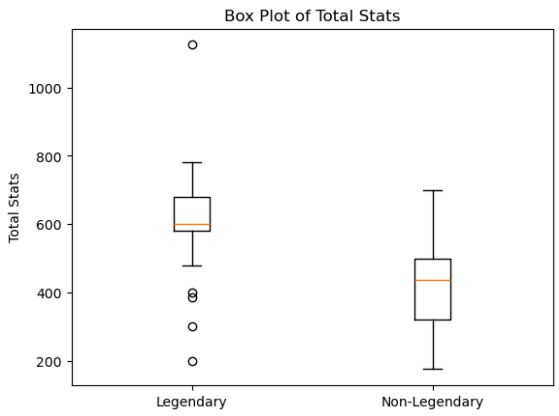


But first we decided to check the normality of distributions to see how exactly we can work with these distributions later. The Shapiro-Wilk Test was implemented. From the results, it can be seen that none of Legendary, Non-Legendary, and combined distributions are normal.



From the distribution it can be observed that non-Legendary Pokemon are mostly on the left side of the distribution, which shows that Non-Legendary Pokemon are generally weaker than Legendary. However, there are some clearly visible interesting characteristics: overlapping between two types of Pokemon, and one extremely huge value on the right – an outlier.

To interpret these features from the data we are analyzing the outliers.



It is visible that there are no outliers in Non-Legendary Pokemon and a few outliers in Legendary Pokemon distributions. Legendary Pokemon have some Pokemon that are extremely weak in comparison to the mean. Nevertheless, there is one that is extremely strong. To check which Pokemon it is, we are looking for the Pokemon who have Total Statistics greater than 900: The name of the Pokemon is *Eternamax Eternatus*. He has two types: type 1 - Poison and type 2 - Dragon.

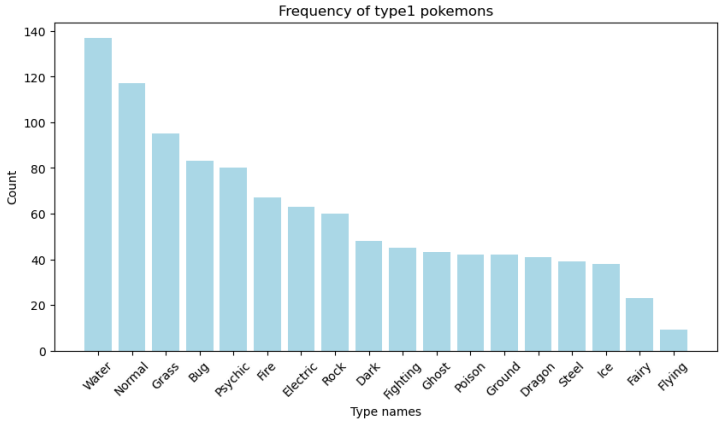
4.1.2 Analysis of the Pokemon with similar total statistics

As it was mentioned before, based on the common distribution we see a significant overlap in the total statistics around the value 600. There are in total 22 non-Legendary Pokemon who are approximately as strong as average Legendary ones.

4.1.3 Pokemon comparison based on type

In the Pokemon universe the types define the elemental nature of the Pokemon and influence their strengths and weaknesses in battles. Our second part of the research concentrates on comparing the types between each other.

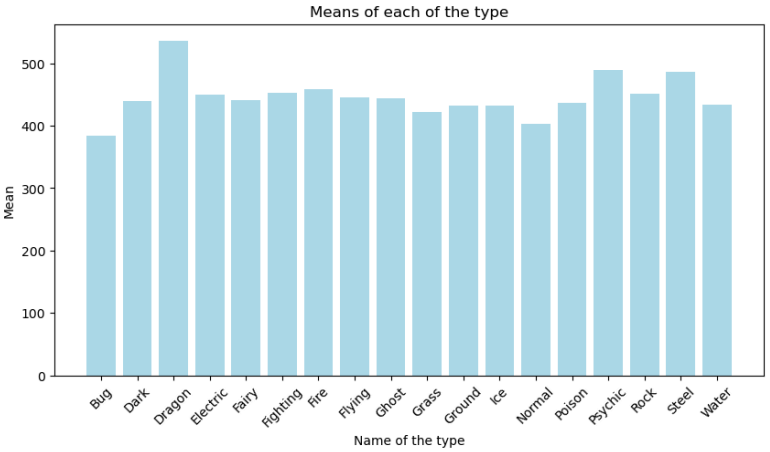
For the first question of the second part of the research, we plotted the frequency of Pokemon based on their primary type to determine which type is the most common one.



Overall, there are 18 types of Pokemon. It can be concluded from the figure that water Pokemon are the most common and flying Pokemon are the most rare. Furthermore, we found that there are a total of 137 water Pokemon and 9 flying ones.

For the second question of the second part of the research (determining the strongest type) , we used df.describe() to get an overview of the 'total' stats for each type of Pokemon. To interpret the results further, we extracted and plotted the means.

type1	count	mean	std	min	25%	50%	75%	max
Bug	83.0	384.746988	119.336156	180.0	287.5	395.0	490.00	600.0
Dark	48.0	439.562500	116.193329	220.0	346.0	450.5	510.00	680.0
Dragon	41.0	536.365854	147.306442	270.0	420.0	600.0	680.00	780.0
Electric	63.0	450.333333	103.315208	205.0	385.0	481.0	520.00	610.0
Fairy	23.0	441.695652	139.086446	218.0	332.0	462.0	510.00	720.0
Fighting	45.0	452.311111	112.359978	210.0	377.0	470.0	510.00	720.0
Fire	67.0	458.582090	104.926403	250.0	375.5	484.0	534.00	680.0
Flying	9.0	446.111111	130.785554	245.0	365.0	495.0	535.00	580.0
Ghost	43.0	444.674419	103.846434	275.0	335.0	476.0	500.00	680.0
Grass	95.0	421.842105	108.381450	180.0	318.0	450.0	512.50	630.0
Ground	42.0	432.547619	116.695811	265.0	328.5	440.0	509.50	770.0
Ice	38.0	432.947368	108.339793	185.0	307.5	470.0	518.50	580.0
Normal	117.0	403.333333	114.144041	190.0	300.0	418.0	485.00	720.0
Poison	42.0	436.190476	146.612188	245.0	326.0	462.5	493.00	1125.0
Psychic	80.0	488.987500	142.418397	198.0	370.0	490.0	600.00	780.0
Rock	60.0	451.850000	104.828160	240.0	362.0	487.0	511.25	700.0
Steel	39.0	486.358974	114.380134	290.0	425.0	500.0	580.00	700.0
Water	137.0	434.000000	113.698841	175.0	330.0	460.0	510.00	770.0

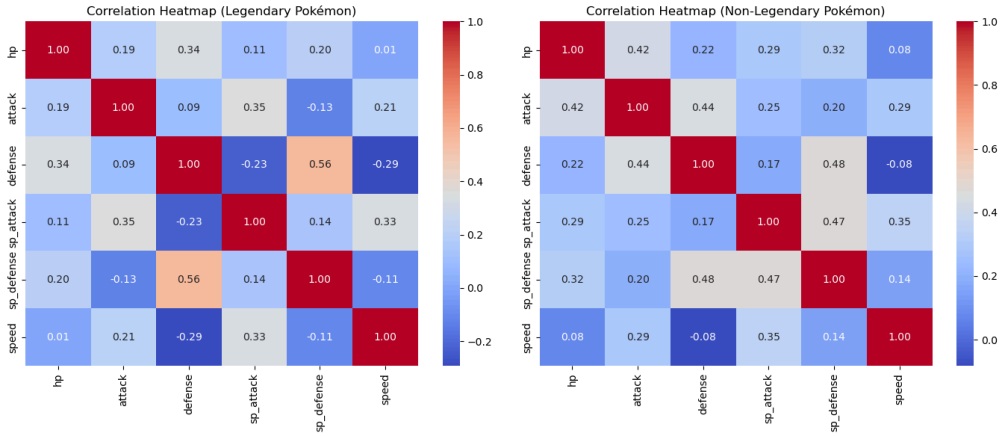


From the mean distribution it is noticeable that dragon type has larger total statistics than all other types, this is the base for our further hypothesis testing (see section 5).

4.2 Bivariate analysis

4.2.1 Legendary vs. non-Legendary Pokemon

In order to assess if certain statistics can serve as a predictor for other statistics depending on the status of a Pokemon, we decided to create two heatmaps.



Heatmap of the correlation matrices between each type of stats.

The following observations can be inferred from the heat map:

For Legendary Pokemon:

- Weaker correlations between stats compared to non-Legendary Pokemon.
- Defense & Sp. Defense (0.56): The strongest positive correlation. This means that for Legendary Pokemon, those with high Defense tend to have high Special Defense as well.
- Defense & Sp. Attack (-0.23): Negative correlation, meaning Legendary Pokemon with high Defense tend to have lower Sp. Attack.

For non-Legendary Pokemon:

- Stronger correlations between stats compared to Legendary Pokémon.
- HP & Attack (0.42): Non-Legendary Pokémon with higher HP tend to have higher Attack.
- Sp. Attack & Sp. Defense (0.47): Pokémon with higher Sp. Attack also tend to have higher Sp. Defense.
- Speed & Defense (-0.08): Weak negative correlation, meaning Pokémon with higher Speed tend to have slightly lower Defense.

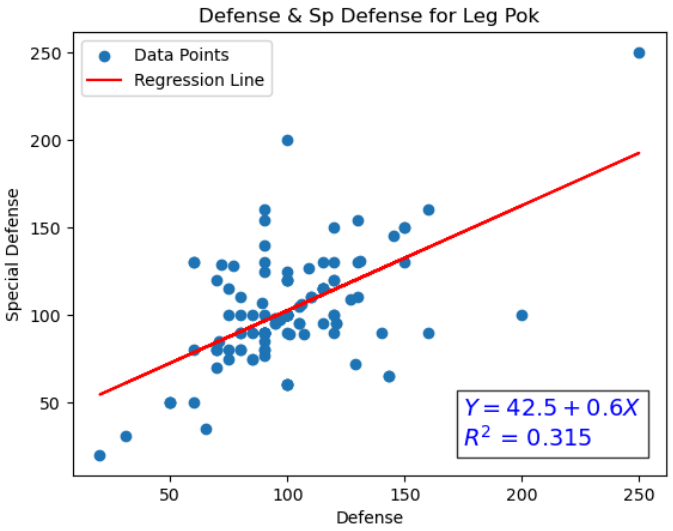
Interpretation

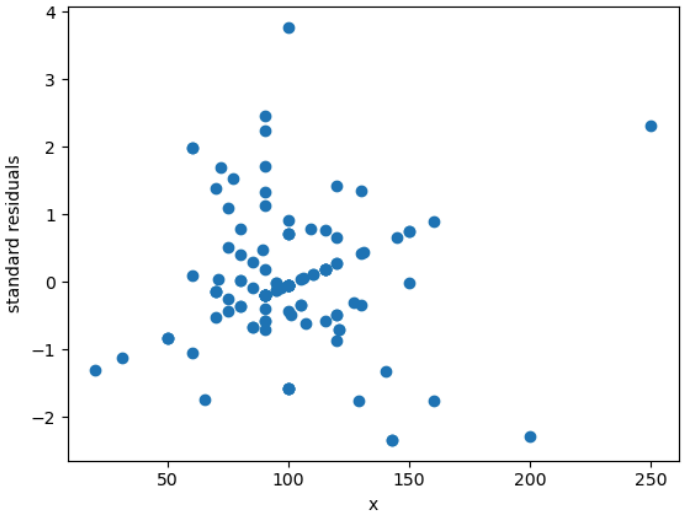
- Legendary Pokemon's stats are more independent from each other compared to non-Legendary ones, meaning they might be more balanced or unique in distribution.
- Non-Legendary Pokemon show stronger correlations, meaning their stats might follow clearer patterns (e.g., high hp Pokemon often have high attack).

4.2.2 Simple linear regression

Our correlation of determination (C.o.D) is approximately 32%. That means that approximately 32% of variation in y can be explained by x.

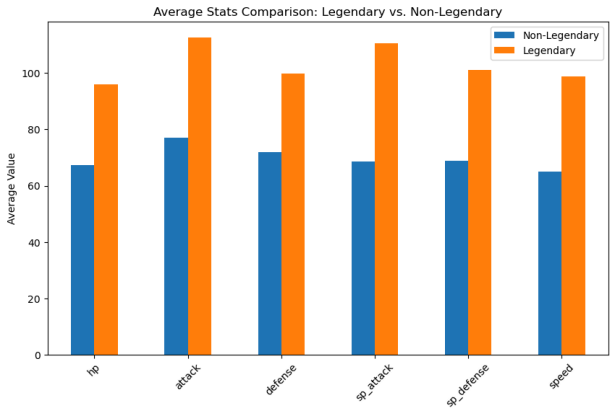
The linear regression is given by: $Y = 42.5 + 0.6x$

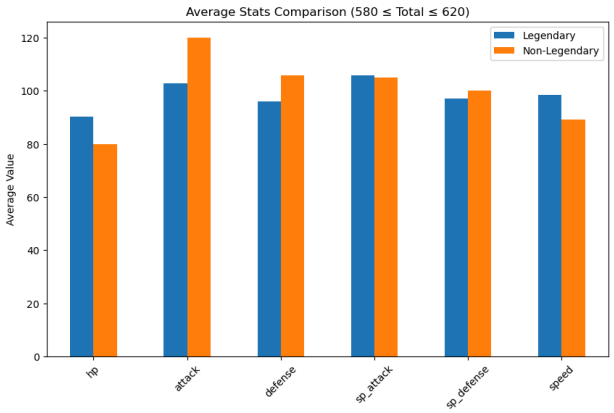




This can be interpreted as follows: if we take two Legendary Pokemon, and one of them has 'defence' which is 1 point higher, we would expect that that Pokemon, approximately, on average, will have 0.6 higher 'sp_defence'. However, since the C.o.D is 0.32, this is only a weak predictor — other factors also influence special defense. Analysis of the residuals has further concluded that approximately 94.1% of the standardized residuals fall within [-2, 2].

4.2.3. Plotting the stat difference between Legendary and non-Legendary Pokemon





The first plot shows that, on average, Legendary Pokemon have higher statistics in each category. However, if we limit the 'total' statistic to be around the overlap (where Legendary and non-Legendary share the 'total' value), the difference is somewhat still present but not that significant.

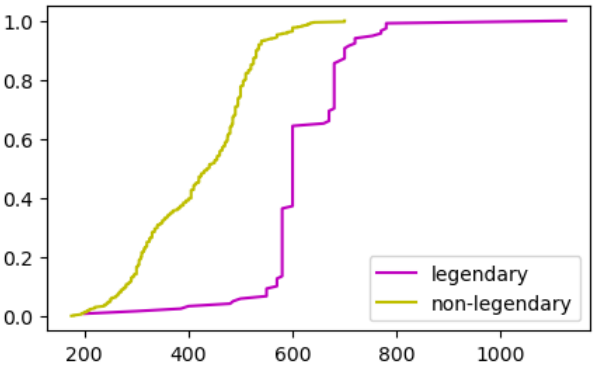
5 HYPOTHESIS TESTING
5.1 Legendary vs. non-Legendary Pokemon

5.1.1 Comparing the stat 'total'
Null Hypothesis (H_0) = the total stats of Legendary Pokemon are less than or equal to that of non-Legendary.

Mathematically: H_0: $\mu\_legendary <= \mu\_non\_legendary$

Alternative Hypothesis (H_1) = the total stats of Legendary Pokemon are greater than that of non-Legendary Pokemon.

Mathematically: H_1: $\mu\_legendary > \mu\_non\_legendary$



In order to identify what test is appropriate for comparing the Pokemon, it is crucial to understand whether the graphs are normally distributed, therefore we conduct the Shapiro-Wilk test. Both p-values are extremely small, therefore the null hypotheses are rejected, meaning the distributions are not normal. Therefore, we have to use the one-sided K-S test.

The results of the K-S test are:
- K-S Statistic: 0.875
- P-value: 0.00000
- Reject H_0: Legendary Pokemon have significantly higher total stats than Non-Legendary Pokemon.

5.1.2 Comparing overall stats (from 4.2.3)
Null Hypothesis (H_0): There is no difference between the stats of Legendary and non-Legendary Pokemon. Specifically, the mean stat values of Legendary Pokemon are equal to those of non-Legendary Pokemon.

Mathematically: H_0: $\mu\_legendary = \mu\_non\_legendary$

Alternative Hypothesis (H_1): There is a significant difference between the stats of Legendary and non-Legendary Pokemon. This can either be that one is higher than the other (which is why we check the p-value for significance).

Mathematically: H_1: $\mu\_legendary \neq \mu\_non\_legendary$

H_0 was tested by conducting a Welch's t-test. The following are the results:

```
Stat: hp
  t-statistic: 9.9554
  p-value: 0.0000
  → Significant difference (reject H0 ✅)
----------------------------------------

Stat: attack
  t-statistic: 11.8156
  p-value: 0.0000
  → Significant difference (reject H0 ✅)
----------------------------------------
```

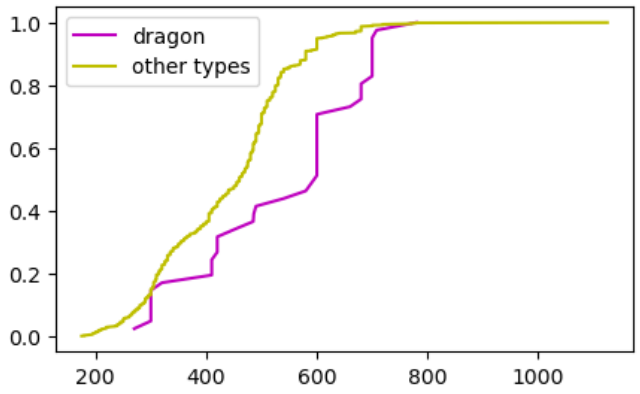
```
Stat: speed
  t-statistic: 12.1133
  p-value: 0.0000
  → Significant difference (reject H0 ✅)
----------------------------------------

Stat: defense
  t-statistic: 9.5202
  p-value: 0.0000
  → Significant difference (reject H0 ✅)
----------------------------------------
```

It was concluded that there is a significant difference between the stats of Legendary and non-Legendary Pokemon.

5.2 Total stats based on Pokemon type (from 4.1.3)

H_0: Dragon-type Pokemon are not stronger than other types (the mean total stats of Dragon-type Pokemon are less than or equal to the mean of other types).

H_1: Dragon-type Pokemon are stronger than other types (the mean total stats of Dragon-type Pokemon are greater than those of other types).



$$H_0 = \mu_{dragon\ pokemons} \leq \mu_{non-dragon\ pokemons}$$
$$H_1 = \mu_{dragon\ pokemons} > \mu_{non-dragon\ pokemons}$$

```
K-S Statistic: 0.445
P-value: 0.00000
Reject H₀: Dragon Pokemon have significantly higher total stats than Non-Dragon Pokemon
```

The data set was divided by Dragon-type vs. all other types of Pokemon. Graphs were plotted to see how they are distributed. By performing a KS test we concluded that the Dragon-type is stronger than other types of Pokemon.

6 CONCLUSION

- There is a significant difference between the stats of Legendary and non-Legendary Pokemon.
- There are some non-Legendary Pokemon that are stronger than an average Legendary Pokemon (or at least as strong as).
- There is a significant difference between the stats of Legendary and non-Legendary Pokemon. Specifically, the mean stat values of Legendary Pokemon are higher than those of non-Legendary Pokemon.
- There is some correlation between special defence and defence statistics within the Legendary Pokemon population.
- Water-type Pokemons are the most common type of Pokemon.
- It can be concluded with 99% confidence that Dragon-type Pokemon have higher total stats, therefore are stronger than other types.

Our further idea was to check whether the distribution and mean of Dragon type would change if we eliminate the outlier from task 1 - Eternamax Eternatus. Nevertheless, we realized that its primary type is Poison, and only the second type is Dragon. Our analysis was based on the first type of Pokemon, so even if we eliminate the outlier, it will not influence the results.