In [ ]:
```
#Load statistical analysis
import pandas as pd
from scipy.stats import f_oneway
from statsmodels.stats.multicomp import pairwise_tukeyhsd
```

In [ ]:
```
anova_data = pd.read_csv('treatment1.csv')
anova_data
```

Out[ ]:

	Variables	PR1	PR2	PR3	DR1	DR2	DR3	MR1	MR2	MR3
0	CONTROL	18.98	17.21	19.04	432.0	441.0	426.1	124.8	124.38	119.25
1	NHT0254b	5.72	6.21	5.96	552.6	554.9	550.0	132.1	136.25	124.54
2	NHT0356b	4.41	4.56	4.87	571.0	572.0	570.0	116.1	110.24	121.24
3	NGB00699	0.04	0.05	0.04	622.0	618.0	626.0	127.2	135.04	126.58
4	NHT0206a	-10.04	-9.97	-10.11	681.8	697.0	665.0	131.8	141.60	121.77
5	NHT100	2.36	2.45	2.29	672.3	683.0	661.0	80.2	84.67	83.22
6	NHT0199c	-2.23	-2.22	-3.01	670.1	662.0	678.0	148.7	149.97	150.37
7	NGB00733	-6.91	-6.48	-7.16	448.3	441.0	455.0	187.3	198.44	185.07
8	NGB00739	-6.84	-7.11	-6.90	509.0	516.0	503.0	250.2	265.54	251.25
9	NHT034a	-4.37	-4.87	-4.55	527.1	532.0	522.0	231.5	247.88	232.30
10	NHT0226a	-0.34	-0.38	-0.42	858.3	857.0	859.0	275.1	259.23	270.83
11	NHT0339a	-0.76	-0.87	-0.72	551.7	552.0	549.0	104.9	106.26	102.91
12	NHT0366	2.60	2.99	2.41	539.4	533.1	542.6	251.6	235.57	249.43
13	NHT0216a	-2.37	-2.39	-2.36	546.7	549.3	556.2	455.0	458.44	478.92
14	NHT0355a	6.67	6.22	6.41	455.0	457.0	451.0	142.5	148.81	145.04
15	NHT0259a	0.41	0.42	0.44	1403.7	1413.2	1297.9	273.5	267.01	269.43
16	NGB00713	1.23	1.39	1.32	296.8	287.0	310.7	221.1	234.32	207.67

In [ ]:
```
# Reshape the data to long format for Data P
data_pt = anova_data.melt(id_vars='Variables', value_vars=['PR1', 'PR2', 'PR3'],
```

In [ ]:
```
# Group the data by 'PT' and collect all values into lists (for ANOVA)
grouped_data = data_pt.groupby('Variables')['Value'].apply(list)

# Perform one-way ANOVA
anova_result = f_oneway(*grouped_data)
anova_result
```

Out[ ]:
```
F_onewayResult(statistic=1222.0654819131378, pvalue=4.035409587598977e-42)
```

In [ ]:
```
# Perform Tukey's HSD test (ANOVA - POSTHOC)
tukey_result = pairwise_tukeyhsd(endog=data_pt['Value'], groups=data_pt['Variabl
print(tukey_result.summary())
```

Multiple Comparison of Means - Tukey HSD, FWER=0.05

group1	group2	meandiff	p-adj	lower	upper	reject
CONTROL	NGB00699	-18.3667	0.0	-19.3489	-17.3845	True
CONTROL	NGB00713	-17.0967	0.0	-18.0789	-16.1145	True
CONTROL	NGB00733	-25.26	0.0	-26.2422	-24.2778	True
CONTROL	NGB00739	-25.36	0.0	-26.3422	-24.3778	True
CONTROL	NHT0199c	-20.8967	0.0	-21.8789	-19.9145	True
CONTROL	NHT0206a	-28.45	0.0	-29.4322	-27.4678	True
CONTROL	NHT0216a	-20.7833	0.0	-21.7655	-19.8011	True
CONTROL	NHT0226a	-18.79	0.0	-19.7722	-17.8078	True
CONTROL	NHT0254b	-12.4467	0.0	-13.4289	-11.4645	True
CONTROL	NHT0259a	-17.9867	0.0	-18.9689	-17.0045	True
CONTROL	NHT0339a	-19.1933	0.0	-20.1755	-18.2111	True
CONTROL	NHT034a	-23.0067	0.0	-23.9889	-22.0245	True
CONTROL	NHT0355a	-11.9767	0.0	-12.9589	-10.9945	True
CONTROL	NHT0356b	-13.7967	0.0	-14.7789	-12.8145	True
CONTROL	NHT0366	-15.7433	0.0	-16.7255	-14.7611	True
CONTROL	NHT100	-16.0433	0.0	-17.0255	-15.0611	True
NGB00699	NGB00713	1.27	0.0028	0.2878	2.2522	True
NGB00699	NGB00733	-6.8933	0.0	-7.8755	-5.9111	True
NGB00699	NGB00739	-6.9933	0.0	-7.9755	-6.0111	True
NGB00699	NHT0199c	-2.53	0.0	-3.5122	-1.5478	True
NGB00699	NHT0206a	-10.0833	0.0	-11.0655	-9.1011	True
NGB00699	NHT0216a	-2.4167	0.0	-3.3989	-1.4345	True
NGB00699	NHT0226a	-0.4233	0.9643	-1.4055	0.5589	False
NGB00699	NHT0254b	5.92	0.0	4.9378	6.9022	True
NGB00699	NHT0259a	0.38	0.9863	-0.6022	1.3622	False
NGB00699	NHT0339a	-0.8267	0.1829	-1.8089	0.1555	False
NGB00699	NHT034a	-4.64	0.0	-5.6222	-3.6578	True
NGB00699	NHT0355a	6.39	0.0	5.4078	7.3722	True
NGB00699	NHT0356b	4.57	0.0	3.5878	5.5522	True
NGB00699	NHT0366	2.6233	0.0	1.6411	3.6055	True
NGB00699	NHT100	2.3233	0.0	1.3411	3.3055	True
NGB00713	NGB00733	-8.1633	0.0	-9.1455	-7.1811	True
NGB00713	NGB00739	-8.2633	0.0	-9.2455	-7.2811	True
NGB00713	NHT0199c	-3.8	0.0	-4.7822	-2.8178	True
NGB00713	NHT0206a	-11.3533	0.0	-12.3355	-10.3711	True
NGB00713	NHT0216a	-3.6867	0.0	-4.6689	-2.7045	True
NGB00713	NHT0226a	-1.6933	0.0	-2.6755	-0.7111	True
NGB00713	NHT0254b	4.65	0.0	3.6678	5.6322	True
NGB00713	NHT0259a	-0.89	0.1112	-1.8722	0.0922	False
NGB00713	NHT0339a	-2.0967	0.0	-3.0789	-1.1145	True
NGB00713	NHT034a	-5.91	0.0	-6.8922	-4.9278	True
NGB00713	NHT0355a	5.12	0.0	4.1378	6.1022	True
NGB00713	NHT0356b	3.3	0.0	2.3178	4.2822	True
NGB00713	NHT0366	1.3533	0.0012	0.3711	2.3355	True
NGB00713	NHT100	1.0533	0.0257	0.0711	2.0355	True
NGB00733	NGB00739	-0.1	1.0	-1.0822	0.8822	False
NGB00733	NHT0199c	4.3633	0.0	3.3811	5.3455	True
NGB00733	NHT0206a	-3.19	0.0	-4.1722	-2.2078	True
NGB00733	NHT0216a	4.4767	0.0	3.4945	5.4589	True
NGB00733	NHT0226a	6.47	0.0	5.4878	7.4522	True
NGB00733	NHT0254b	12.8133	0.0	11.8311	13.7955	True
NGB00733	NHT0259a	7.2733	0.0	6.2911	8.2555	True
NGB00733	NHT0339a	6.0667	0.0	5.0845	7.0489	True
NGB00733	NHT034a	2.2533	0.0	1.2711	3.2355	True
NGB00733	NHT0355a	13.2833	0.0	12.3011	14.2655	True
NGB00733	NHT0356b	11.4633	0.0	10.4811	12.4455	True

NGB00733	NHT0366	9.5167	0.0	8.5345	10.4989	True
NGB00733	NHT100	9.2167	0.0	8.2345	10.1989	True
NGB00739	NHT0199c	4.4633	0.0	3.4811	5.4455	True
NGB00739	NHT0206a	-3.09	0.0	-4.0722	-2.1078	True
NGB00739	NHT0216a	4.5767	0.0	3.5945	5.5589	True
NGB00739	NHT0226a	6.57	0.0	5.5878	7.5522	True
NGB00739	NHT0254b	12.9133	0.0	11.9311	13.8955	True
NGB00739	NHT0259a	7.3733	0.0	6.3911	8.3555	True
NGB00739	NHT0339a	6.1667	0.0	5.1845	7.1489	True
NGB00739	NHT034a	2.3533	0.0	1.3711	3.3355	True
NGB00739	NHT0355a	13.3833	0.0	12.4011	14.3655	True
NGB00739	NHT0356b	11.5633	0.0	10.5811	12.5455	True
NGB00739	NHT0366	9.6167	0.0	8.6345	10.5989	True
NGB00739	NHT100	9.3167	0.0	8.3345	10.2989	True
NHT0199c	NHT0206a	-7.5533	0.0	-8.5355	-6.5711	True
NHT0199c	NHT0216a	0.1133	1.0	-0.8689	1.0955	False
NHT0199c	NHT0226a	2.1067	0.0	1.1245	3.0889	True
NHT0199c	NHT0254b	8.45	0.0	7.4678	9.4322	True
NHT0199c	NHT0259a	2.91	0.0	1.9278	3.8922	True
NHT0199c	NHT0339a	1.7033	0.0	0.7211	2.6855	True
NHT0199c	NHT034a	-2.11	0.0	-3.0922	-1.1278	True
NHT0199c	NHT0355a	8.92	0.0	7.9378	9.9022	True
NHT0199c	NHT0356b	7.1	0.0	6.1178	8.0822	True
NHT0199c	NHT0366	5.1533	0.0	4.1711	6.1355	True
NHT0199c	NHT100	4.8533	0.0	3.8711	5.8355	True
NHT0206a	NHT0216a	7.6667	0.0	6.6845	8.6489	True
NHT0206a	NHT0226a	9.66	0.0	8.6778	10.6422	True
NHT0206a	NHT0254b	16.0033	0.0	15.0211	16.9855	True
NHT0206a	NHT0259a	10.4633	0.0	9.4811	11.4455	True
NHT0206a	NHT0339a	9.2567	0.0	8.2745	10.2389	True
NHT0206a	NHT034a	5.4433	0.0	4.4611	6.4255	True
NHT0206a	NHT0355a	16.4733	0.0	15.4911	17.4555	True
NHT0206a	NHT0356b	14.6533	0.0	13.6711	15.6355	True
NHT0206a	NHT0366	12.7067	0.0	11.7245	13.6889	True
NHT0206a	NHT100	12.4067	0.0	11.4245	13.3889	True
NHT0216a	NHT0226a	1.9933	0.0	1.0111	2.9755	True
NHT0216a	NHT0254b	8.3367	0.0	7.3545	9.3189	True
NHT0216a	NHT0259a	2.7967	0.0	1.8145	3.7789	True
NHT0216a	NHT0339a	1.59	0.0001	0.6078	2.5722	True
NHT0216a	NHT034a	-2.2233	0.0	-3.2055	-1.2411	True
NHT0216a	NHT0355a	8.8067	0.0	7.8245	9.7889	True
NHT0216a	NHT0356b	6.9867	0.0	6.0045	7.9689	True
NHT0216a	NHT0366	5.04	0.0	4.0578	6.0222	True
NHT0216a	NHT100	4.74	0.0	3.7578	5.7222	True
NHT0226a	NHT0254b	6.3433	0.0	5.3611	7.3255	True
NHT0226a	NHT0259a	0.8033	0.2169	-0.1789	1.7855	False
NHT0226a	NHT0339a	-0.4033	0.9764	-1.3855	0.5789	False
NHT0226a	NHT034a	-4.2167	0.0	-5.1989	-3.2345	True
NHT0226a	NHT0355a	6.8133	0.0	5.8311	7.7955	True
NHT0226a	NHT0356b	4.9933	0.0	4.0111	5.9755	True
NHT0226a	NHT0366	3.0467	0.0	2.0645	4.0289	True
NHT0226a	NHT100	2.7467	0.0	1.7645	3.7289	True
NHT0254b	NHT0259a	-5.54	0.0	-6.5222	-4.5578	True
NHT0254b	NHT0339a	-6.7467	0.0	-7.7289	-5.7645	True
NHT0254b	NHT034a	-10.56	0.0	-11.5422	-9.5778	True
NHT0254b	NHT0355a	0.47	0.9197	-0.5122	1.4522	False
NHT0254b	NHT0356b	-1.35	0.0012	-2.3322	-0.3678	True
NHT0254b	NHT0366	-3.2967	0.0	-4.2789	-2.3145	True
NHT0254b	NHT100	-3.5967	0.0	-4.5789	-2.6145	True
NHT0259a	NHT0339a	-1.2067	0.0055	-2.1889	-0.2245	True

```
NHT0259a  NHT034a    -5.02    0.0  -6.0022  -4.0378   True
NHT0259a NHT0355a     6.01    0.0   5.0278   6.9922   True
NHT0259a NHT0356b     4.19    0.0   3.2078   5.1722   True
NHT0259a  NHT0366   2.2433    0.0   1.2611   3.2255   True
NHT0259a   NHT100   1.9433    0.0   0.9611   2.9255   True
NHT0339a  NHT034a  -3.8133    0.0  -4.7955  -2.8311   True
NHT0339a NHT0355a   7.2167    0.0   6.2345   8.1989   True
NHT0339a NHT0356b   5.3967    0.0   4.4145   6.3789   True
NHT0339a  NHT0366     3.45    0.0   2.4678   4.4322   True
NHT0339a   NHT100     3.15    0.0   2.1678   4.1322   True
 NHT034a NHT0355a    11.03    0.0  10.0478  12.0122   True
 NHT034a NHT0356b     9.21    0.0   8.2278  10.1922   True
 NHT034a  NHT0366   7.2633    0.0   6.2811   8.2455   True
 NHT034a   NHT100   6.9633    0.0   5.9811   7.9455   True
NHT0355a NHT0356b    -1.82    0.0  -2.8022  -0.8378   True
NHT0355a  NHT0366  -3.7667    0.0  -4.7489  -2.7845   True
NHT0355a   NHT100  -4.0667    0.0  -5.0489  -3.0845   True
NHT0356b  NHT0366  -1.9467    0.0  -2.9289  -0.9645   True
NHT0356b   NHT100  -2.2467    0.0  -3.2289  -1.2645   True
 NHT0366   NHT100     -0.3 0.9988  -1.2822   0.6822  False
-----------------------------------------------------------
```

In [ ]:
```
# Reshape the data to long format for Data D
data_dt = anova_data.melt(id_vars='Variables', value_vars=['DR1', 'DR2', 'DR3'],
```

In [ ]:
```
# Group the data by 'DT' and collect all values into lists (for ANOVA)
grouped_data = data_dt.groupby('Variables')['Value'].apply(list)

# Perform one-way ANOVA
anova_result = f_oneway(*grouped_data)
anova_result
```

Out[ ]:
```
F_onewayResult(statistic=559.9403788059761, pvalue=2.2236079411906107e-36)
```

In [ ]:
```
# Perform Tukey's HSD test (ANOVA - POSTHOC)
tukey_result = pairwise_tukeyhsd(endog=data_dt['Value'], groups=data_dt['Variabl
print(tukey_result.summary())
```

Multiple Comparison of Means - Tukey HSD, FWER=0.05

group1	group2	meandiff	p-adj	lower	upper	reject
CONTROL	NGB00699	188.9667	0.0	137.076	240.8573	True
CONTROL	NGB00713	-134.8667	0.0	-186.7573	-82.976	True
CONTROL	NGB00733	15.0667	0.9994	-36.824	66.9573	False
CONTROL	NGB00739	76.3	0.0004	24.4094	128.1906	True
CONTROL	NHT0199c	237.0	0.0	185.1094	288.8906	True
CONTROL	NHT0206a	248.2333	0.0	196.3427	300.124	True
CONTROL	NHT0216a	117.7	0.0	65.8094	169.5906	True
CONTROL	NHT0226a	425.0667	0.0	373.176	476.9573	True
CONTROL	NHT0254b	119.4667	0.0	67.576	171.3573	True
CONTROL	NHT0259a	938.5667	0.0	886.676	990.4573	True
CONTROL	NHT0339a	117.8667	0.0	65.976	169.7573	True
CONTROL	NHT034a	94.0	0.0	42.1094	145.8906	True
CONTROL	NHT0355a	21.3	0.9765	-30.5906	73.1906	False
CONTROL	NHT0356b	137.9667	0.0	86.076	189.8573	True
CONTROL	NHT0366	105.3333	0.0	53.4427	157.224	True
CONTROL	NHT100	239.0667	0.0	187.176	290.9573	True
NGB00699	NGB00713	-323.8333	0.0	-375.724	-271.9427	True
NGB00699	NGB00733	-173.9	0.0	-225.7906	-122.0094	True
NGB00699	NGB00739	-112.6667	0.0	-164.5573	-60.776	True
NGB00699	NHT0199c	48.0333	0.0948	-3.8573	99.924	False
NGB00699	NHT0206a	59.2667	0.0131	7.376	111.1573	True
NGB00699	NHT0216a	-71.2667	0.0012	-123.1573	-19.376	True
NGB00699	NHT0226a	236.1	0.0	184.2094	287.9906	True
NGB00699	NHT0254b	-69.5	0.0017	-121.3906	-17.6094	True
NGB00699	NHT0259a	749.6	0.0	697.7094	801.4906	True
NGB00699	NHT0339a	-71.1	0.0013	-122.9906	-19.2094	True
NGB00699	NHT034a	-94.9667	0.0	-146.8573	-43.076	True
NGB00699	NHT0355a	-167.6667	0.0	-219.5573	-115.776	True
NGB00699	NHT0356b	-51.0	0.0582	-102.8906	0.8906	False
NGB00699	NHT0366	-83.6333	0.0001	-135.524	-31.7427	True
NGB00699	NHT100	50.1	0.0677	-1.7906	101.9906	False
NGB00713	NGB00733	149.9333	0.0	98.0427	201.824	True
NGB00713	NGB00739	211.1667	0.0	159.276	263.0573	True
NGB00713	NHT0199c	371.8667	0.0	319.976	423.7573	True
NGB00713	NHT0206a	383.1	0.0	331.2094	434.9906	True
NGB00713	NHT0216a	252.5667	0.0	200.676	304.4573	True
NGB00713	NHT0226a	559.9333	0.0	508.0427	611.824	True
NGB00713	NHT0254b	254.3333	0.0	202.4427	306.224	True
NGB00713	NHT0259a	1073.4333	0.0	1021.5427	1125.324	True
NGB00713	NHT0339a	252.7333	0.0	200.8427	304.624	True
NGB00713	NHT034a	228.8667	0.0	176.976	280.7573	True
NGB00713	NHT0355a	156.1667	0.0	104.276	208.0573	True
NGB00713	NHT0356b	272.8333	0.0	220.9427	324.724	True
NGB00713	NHT0366	240.2	0.0	188.3094	292.0906	True
NGB00713	NHT100	373.9333	0.0	322.0427	425.824	True
NGB00733	NGB00739	61.2333	0.009	9.3427	113.124	True
NGB00733	NHT0199c	221.9333	0.0	170.0427	273.824	True
NGB00733	NHT0206a	233.1667	0.0	181.276	285.0573	True
NGB00733	NHT0216a	102.6333	0.0	50.7427	154.524	True
NGB00733	NHT0226a	410.0	0.0	358.1094	461.8906	True
NGB00733	NHT0254b	104.4	0.0	52.5094	156.2906	True
NGB00733	NHT0259a	923.5	0.0	871.6094	975.3906	True
NGB00733	NHT0339a	102.8	0.0	50.9094	154.6906	True
NGB00733	NHT034a	78.9333	0.0002	27.0427	130.824	True
NGB00733	NHT0355a	6.2333	1.0	-45.6573	58.124	False
NGB00733	NHT0356b	122.9	0.0	71.0094	174.7906	True

NGB00733	NHT0366	90.2667	0.0	38.376	142.1573	True
NGB00733	NHT100	224.0	0.0	172.1094	275.8906	True
NGB00739	NHT0199c	160.7	0.0	108.8094	212.5906	True
NGB00739	NHT0206a	171.9333	0.0	120.0427	223.824	True
NGB00739	NHT0216a	41.4	0.249	-10.4906	93.2906	False
NGB00739	NHT0226a	348.7667	0.0	296.876	400.6573	True
NGB00739	NHT0254b	43.1667	0.1963	-8.724	95.0573	False
NGB00739	NHT0259a	862.2667	0.0	810.376	914.1573	True
NGB00739	NHT0339a	41.5667	0.2437	-10.324	93.4573	False
NGB00739	NHT034a	17.7	0.9961	-34.1906	69.5906	False
NGB00739	NHT0355a	-55.0	0.0289	-106.8906	-3.1094	True
NGB00739	NHT0356b	61.6667	0.0083	9.776	113.5573	True
NGB00739	NHT0366	29.0333	0.7842	-22.8573	80.924	False
NGB00739	NHT100	162.7667	0.0	110.876	214.6573	True
NHT0199c	NHT0206a	11.2333	1.0	-40.6573	63.124	False
NHT0199c	NHT0216a	-119.3	0.0	-171.1906	-67.4094	True
NHT0199c	NHT0226a	188.0667	0.0	136.176	239.9573	True
NHT0199c	NHT0254b	-117.5333	0.0	-169.424	-65.6427	True
NHT0199c	NHT0259a	701.5667	0.0	649.676	753.4573	True
NHT0199c	NHT0339a	-119.1333	0.0	-171.024	-67.2427	True
NHT0199c	NHT034a	-143.0	0.0	-194.8906	-91.1094	True
NHT0199c	NHT0355a	-215.7	0.0	-267.5906	-163.8094	True
NHT0199c	NHT0356b	-99.0333	0.0	-150.924	-47.1427	True
NHT0199c	NHT0366	-131.6667	0.0	-183.5573	-79.776	True
NHT0199c	NHT100	2.0667	1.0	-49.824	53.9573	False
NHT0206a	NHT0216a	-130.5333	0.0	-182.424	-78.6427	True
NHT0206a	NHT0226a	176.8333	0.0	124.9427	228.724	True
NHT0206a	NHT0254b	-128.7667	0.0	-180.6573	-76.876	True
NHT0206a	NHT0259a	690.3333	0.0	638.4427	742.224	True
NHT0206a	NHT0339a	-130.3667	0.0	-182.2573	-78.476	True
NHT0206a	NHT034a	-154.2333	0.0	-206.124	-102.3427	True
NHT0206a	NHT0355a	-226.9333	0.0	-278.824	-175.0427	True
NHT0206a	NHT0356b	-110.2667	0.0	-162.1573	-58.376	True
NHT0206a	NHT0366	-142.9	0.0	-194.7906	-91.0094	True
NHT0206a	NHT100	-9.1667	1.0	-61.0573	42.724	False
NHT0216a	NHT0226a	307.3667	0.0	255.476	359.2573	True
NHT0216a	NHT0254b	1.7667	1.0	-50.124	53.6573	False
NHT0216a	NHT0259a	820.8667	0.0	768.976	872.7573	True
NHT0216a	NHT0339a	0.1667	1.0	-51.724	52.0573	False
NHT0216a	NHT034a	-23.7	0.9432	-75.5906	28.1906	False
NHT0216a	NHT0355a	-96.4	0.0	-148.2906	-44.5094	True
NHT0216a	NHT0356b	20.2667	0.985	-31.624	72.1573	False
NHT0216a	NHT0366	-12.3667	0.9999	-64.2573	39.524	False
NHT0216a	NHT100	121.3667	0.0	69.476	173.2573	True
NHT0226a	NHT0254b	-305.6	0.0	-357.4906	-253.7094	True
NHT0226a	NHT0259a	513.5	0.0	461.6094	565.3906	True
NHT0226a	NHT0339a	-307.2	0.0	-359.0906	-255.3094	True
NHT0226a	NHT034a	-331.0667	0.0	-382.9573	-279.176	True
NHT0226a	NHT0355a	-403.7667	0.0	-455.6573	-351.876	True
NHT0226a	NHT0356b	-287.1	0.0	-338.9906	-235.2094	True
NHT0226a	NHT0366	-319.7333	0.0	-371.624	-267.8427	True
NHT0226a	NHT100	-186.0	0.0	-237.8906	-134.1094	True
NHT0254b	NHT0259a	819.1	0.0	767.2094	870.9906	True
NHT0254b	NHT0339a	-1.6	1.0	-53.4906	50.2906	False
NHT0254b	NHT034a	-25.4667	0.904	-77.3573	26.424	False
NHT0254b	NHT0355a	-98.1667	0.0	-150.0573	-46.276	True
NHT0254b	NHT0356b	18.5	0.9938	-33.3906	70.3906	False
NHT0254b	NHT0366	-14.1333	0.9997	-66.024	37.7573	False
NHT0254b	NHT100	119.6	0.0	67.7094	171.4906	True
NHT0259a	NHT0339a	-820.7	0.0	-872.5906	-768.8094	True

```
NHT0259a  NHT034a -844.5667    0.0 -896.4573  -792.676   True
NHT0259a NHT0355a -917.2667    0.0 -969.1573  -865.376   True
NHT0259a NHT0356b    -800.6    0.0 -852.4906 -748.7094   True
NHT0259a  NHT0366 -833.2333    0.0  -885.124 -781.3427   True
NHT0259a   NHT100    -699.5    0.0 -751.3906 -647.6094   True
NHT0339a  NHT034a  -23.8667 0.9401  -75.7573    28.024  False
NHT0339a NHT0355a  -96.5667    0.0 -148.4573   -44.676   True
NHT0339a NHT0356b      20.1 0.9861  -31.7906   71.9906  False
NHT0339a  NHT0366  -12.5333 0.9999   -64.424   39.3573  False
NHT0339a   NHT100     121.2    0.0   69.3094  173.0906   True
 NHT034a NHT0355a     -72.7 0.0009 -124.5906  -20.8094   True
 NHT034a NHT0356b   43.9667 0.1754    -7.924   95.8573  False
 NHT034a  NHT0366   11.3333    1.0  -40.5573    63.224  False
 NHT034a   NHT100  145.0667    0.0    93.176  196.9573   True
NHT0355a NHT0356b  116.6667    0.0    64.776  168.5573   True
NHT0355a  NHT0366   84.0333 0.0001   32.1427   135.924   True
NHT0355a   NHT100  217.7667    0.0   165.876  269.6573   True
NHT0356b  NHT0366  -32.6333  0.623   -84.524   19.2573  False
NHT0356b   NHT100     101.1    0.0   49.2094  152.9906   True
 NHT0366   NHT100  133.7333    0.0   81.8427   185.624   True
-----------------------------------------------------------------
```

In [ ]:
```
# Reshape the data to long format for Data M
data_mt = anova_data.melt(id_vars='Variables', value_vars=['MR1', 'MR2', 'MR3'],
```

In [ ]:
```
# Group the data by 'DT' and collect all values into lists (for ANOVA)
grouped_data = data_mt.groupby('Variables')['Value'].apply(list)

# Perform one-way ANOVA
anova_result = f_oneway(*grouped_data)
anova_result
```

Out[ ]:
```
F_onewayResult(statistic=487.3239911336594, pvalue=2.326973292243675e-35)
```

In [ ]:
```
# Perform Tukey's HSD test (ANOVA - POSTHOC)
tukey_result = pairwise_tukeyhsd(endog=data_mt['Value'], groups=data_mt['Variabl
print(tukey_result.summary())
```

Multiple Comparison of Means - Tukey HSD, FWER=0.05

group1	group2	meandiff	p-adj	lower	upper	reject
CONTROL	NGB00699	6.7967	0.9989	-15.6451	29.2385	False
CONTROL	NGB00713	98.22	0.0	75.7782	120.6618	True
CONTROL	NGB00733	67.46	0.0	45.0182	89.9018	True
CONTROL	NGB00739	132.8533	0.0	110.4115	155.2951	True
CONTROL	NHT0199c	26.87	0.0076	4.4282	49.3118	True
CONTROL	NHT0206a	8.9133	0.9825	-13.5285	31.3551	False
CONTROL	NHT0216a	341.31	0.0	318.8682	363.7518	True
CONTROL	NHT0226a	145.5767	0.0	123.1349	168.0185	True
CONTROL	NHT0254b	8.1533	0.9926	-14.2885	30.5951	False
CONTROL	NHT0259a	147.17	0.0	124.7282	169.6118	True
CONTROL	NHT0339a	-18.12	0.2333	-40.5618	4.3218	False
CONTROL	NHT034a	114.4167	0.0	91.9749	136.8585	True
CONTROL	NHT0355a	22.64	0.0462	0.1982	45.0818	True
CONTROL	NHT0356b	-6.95	0.9986	-29.3918	15.4918	False
CONTROL	NHT0366	122.7233	0.0	100.2815	145.1651	True
CONTROL	NHT100	-40.1133	0.0	-62.5551	-17.6715	True
NGB00699	NGB00713	91.4233	0.0	68.9815	113.8651	True
NGB00699	NGB00733	60.6633	0.0	38.2215	83.1051	True
NGB00699	NGB00739	126.0567	0.0	103.6149	148.4985	True
NGB00699	NHT0199c	20.0733	0.1221	-2.3685	42.5151	False
NGB00699	NHT0206a	2.1167	1.0	-20.3251	24.5585	False
NGB00699	NHT0216a	334.5133	0.0	312.0715	356.9551	True
NGB00699	NHT0226a	138.78	0.0	116.3382	161.2218	True
NGB00699	NHT0254b	1.3567	1.0	-21.0851	23.7985	False
NGB00699	NHT0259a	140.3733	0.0	117.9315	162.8151	True
NGB00699	NHT0339a	-24.9167	0.0179	-47.3585	-2.4749	True
NGB00699	NHT034a	107.62	0.0	85.1782	130.0618	True
NGB00699	NHT0355a	15.8433	0.4349	-6.5985	38.2851	False
NGB00699	NHT0356b	-13.7467	0.663	-36.1885	8.6951	False
NGB00699	NHT0366	115.9267	0.0	93.4849	138.3685	True
NGB00699	NHT100	-46.91	0.0	-69.3518	-24.4682	True
NGB00713	NGB00733	-30.76	0.0013	-53.2018	-8.3182	True
NGB00713	NGB00739	34.6333	0.0002	12.1915	57.0751	True
NGB00713	NHT0199c	-71.35	0.0	-93.7918	-48.9082	True
NGB00713	NHT0206a	-89.3067	0.0	-111.7485	-66.8649	True
NGB00713	NHT0216a	243.09	0.0	220.6482	265.5318	True
NGB00713	NHT0226a	47.3567	0.0	24.9149	69.7985	True
NGB00713	NHT0254b	-90.0667	0.0	-112.5085	-67.6249	True
NGB00713	NHT0259a	48.95	0.0	26.5082	71.3918	True
NGB00713	NHT0339a	-116.34	0.0	-138.7818	-93.8982	True
NGB00713	NHT034a	16.1967	0.399	-6.2451	38.6385	False
NGB00713	NHT0355a	-75.58	0.0	-98.0218	-53.1382	True
NGB00713	NHT0356b	-105.17	0.0	-127.6118	-82.7282	True
NGB00713	NHT0366	24.5033	0.0214	2.0615	46.9451	True
NGB00713	NHT100	-138.3333	0.0	-160.7751	-115.8915	True
NGB00733	NGB00739	65.3933	0.0	42.9515	87.8351	True
NGB00733	NHT0199c	-40.59	0.0	-63.0318	-18.1482	True
NGB00733	NHT0206a	-58.5467	0.0	-80.9885	-36.1049	True
NGB00733	NHT0216a	273.85	0.0	251.4082	296.2918	True
NGB00733	NHT0226a	78.1167	0.0	55.6749	100.5585	True
NGB00733	NHT0254b	-59.3067	0.0	-81.7485	-36.8649	True
NGB00733	NHT0259a	79.71	0.0	57.2682	102.1518	True
NGB00733	NHT0339a	-85.58	0.0	-108.0218	-63.1382	True
NGB00733	NHT034a	46.9567	0.0	24.5149	69.3985	True
NGB00733	NHT0355a	-44.82	0.0	-67.2618	-22.3782	True
NGB00733	NHT0356b	-74.41	0.0	-96.8518	-51.9682	True

NGB00733	NHT0366	55.2633	0.0	32.8215	77.7051	True
NGB00733	NHT100	-107.5733	0.0	-130.0151	-85.1315	True
NGB00739	NHT0199c	-105.9833	0.0	-128.4251	-83.5415	True
NGB00739	NHT0206a	-123.94	0.0	-146.3818	-101.4982	True
NGB00739	NHT0216a	208.4567	0.0	186.0149	230.8985	True
NGB00739	NHT0226a	12.7233	0.7684	-9.7185	35.1651	False
NGB00739	NHT0254b	-124.7	0.0	-147.1418	-102.2582	True
NGB00739	NHT0259a	14.3167	0.6005	-8.1251	36.7585	False
NGB00739	NHT0339a	-150.9733	0.0	-173.4151	-128.5315	True
NGB00739	NHT034a	-18.4367	0.2114	-40.8785	4.0051	False
NGB00739	NHT0355a	-110.2133	0.0	-132.6551	-87.7715	True
NGB00739	NHT0356b	-139.8033	0.0	-162.2451	-117.3615	True
NGB00739	NHT0366	-10.13	0.9482	-32.5718	12.3118	False
NGB00739	NHT100	-172.9667	0.0	-195.4085	-150.5249	True
NHT0199c	NHT0206a	-17.9567	0.2452	-40.3985	4.4851	False
NHT0199c	NHT0216a	314.44	0.0	291.9982	336.8818	True
NHT0199c	NHT0226a	118.7067	0.0	96.2649	141.1485	True
NHT0199c	NHT0254b	-18.7167	0.1933	-41.1585	3.7251	False
NHT0199c	NHT0259a	120.3	0.0	97.8582	142.7418	True
NHT0199c	NHT0339a	-44.99	0.0	-67.4318	-22.5482	True
NHT0199c	NHT034a	87.5467	0.0	65.1049	109.9885	True
NHT0199c	NHT0355a	-4.23	1.0	-26.6718	18.2118	False
NHT0199c	NHT0356b	-33.82	0.0003	-56.2618	-11.3782	True
NHT0199c	NHT0366	95.8533	0.0	73.4115	118.2951	True
NHT0199c	NHT100	-66.9833	0.0	-89.4251	-44.5415	True
NHT0206a	NHT0216a	332.3967	0.0	309.9549	354.8385	True
NHT0206a	NHT0226a	136.6633	0.0	114.2215	159.1051	True
NHT0206a	NHT0254b	-0.76	1.0	-23.2018	21.6818	False
NHT0206a	NHT0259a	138.2567	0.0	115.8149	160.6985	True
NHT0206a	NHT0339a	-27.0333	0.007	-49.4751	-4.5915	True
NHT0206a	NHT034a	105.5033	0.0	83.0615	127.9451	True
NHT0206a	NHT0355a	13.7267	0.6652	-8.7151	36.1685	False
NHT0206a	NHT0356b	-15.8633	0.4328	-38.3051	6.5785	False
NHT0206a	NHT0366	113.81	0.0	91.3682	136.2518	True
NHT0206a	NHT100	-49.0267	0.0	-71.4685	-26.5849	True
NHT0216a	NHT0226a	-195.7333	0.0	-218.1751	-173.2915	True
NHT0216a	NHT0254b	-333.1567	0.0	-355.5985	-310.7149	True
NHT0216a	NHT0259a	-194.14	0.0	-216.5818	-171.6982	True
NHT0216a	NHT0339a	-359.43	0.0	-381.8718	-336.9882	True
NHT0216a	NHT034a	-226.8933	0.0	-249.3351	-204.4515	True
NHT0216a	NHT0355a	-318.67	0.0	-341.1118	-296.2282	True
NHT0216a	NHT0356b	-348.26	0.0	-370.7018	-325.8182	True
NHT0216a	NHT0366	-218.5867	0.0	-241.0285	-196.1449	True
NHT0216a	NHT100	-381.4233	0.0	-403.8651	-358.9815	True
NHT0226a	NHT0254b	-137.4233	0.0	-159.8651	-114.9815	True
NHT0226a	NHT0259a	1.5933	1.0	-20.8485	24.0351	False
NHT0226a	NHT0339a	-163.6967	0.0	-186.1385	-141.2549	True
NHT0226a	NHT034a	-31.16	0.001	-53.6018	-8.7182	True
NHT0226a	NHT0355a	-122.9367	0.0	-145.3785	-100.4949	True
NHT0226a	NHT0356b	-152.5267	0.0	-174.9685	-130.0849	True
NHT0226a	NHT0366	-22.8533	0.0424	-45.2951	-0.4115	True
NHT0226a	NHT100	-185.69	0.0	-208.1318	-163.2482	True
NHT0254b	NHT0259a	139.0167	0.0	116.5749	161.4585	True
NHT0254b	NHT0339a	-26.2733	0.0099	-48.7151	-3.8315	True
NHT0254b	NHT034a	106.2633	0.0	83.8215	128.7051	True
NHT0254b	NHT0355a	14.4867	0.5817	-7.9551	36.9285	False
NHT0254b	NHT0356b	-15.1033	0.5137	-37.5451	7.3385	False
NHT0254b	NHT0366	114.57	0.0	92.1282	137.0118	True
NHT0254b	NHT100	-48.2667	0.0	-70.7085	-25.8249	True
NHT0259a	NHT0339a	-165.29	0.0	-187.7318	-142.8482	True

NHT0259a	NHT034a	-32.7533	0.0005	-55.1951	-10.3115	True
NHT0259a	NHT0355a	-124.53	0.0	-146.9718	-102.0882	True
NHT0259a	NHT0356b	-154.12	0.0	-176.5618	-131.6782	True
NHT0259a	NHT0366	-24.4467	0.0219	-46.8885	-2.0049	True
NHT0259a	NHT100	-187.2833	0.0	-209.7251	-164.8415	True
NHT0339a	NHT034a	132.5367	0.0	110.0949	154.9785	True
NHT0339a	NHT0355a	40.76	0.0	18.3182	63.2018	True
NHT0339a	NHT0356b	11.17	0.8943	-11.2718	33.6118	False
NHT0339a	NHT0366	140.8433	0.0	118.4015	163.2851	True
NHT0339a	NHT100	-21.9933	0.0597	-44.4351	0.4485	False
NHT034a	NHT0355a	-91.7767	0.0	-114.2185	-69.3349	True
NHT034a	NHT0356b	-121.3667	0.0	-143.8085	-98.9249	True
NHT034a	NHT0366	8.3067	0.991	-14.1351	30.7485	False
NHT034a	NHT100	-154.53	0.0	-176.9718	-132.0882	True
NHT0355a	NHT0356b	-29.59	0.0022	-52.0318	-7.1482	True
NHT0355a	NHT0366	100.0833	0.0	77.6415	122.5251	True
NHT0355a	NHT100	-62.7533	0.0	-85.1951	-40.3115	True
NHT0356b	NHT0366	129.6733	0.0	107.2315	152.1151	True
NHT0356b	NHT100	-33.1633	0.0004	-55.6051	-10.7215	True
NHT0366	NHT100	-162.8367	0.0	-185.2785	-140.3949	True
