Pairwise Comparisons After ANOVA

Dependent variable: G3
Grouping factor: studytime

Workflow:
1. Run one-way ANOVA to test whether any group mean differs.
2. Use pairwise comparisons to identify which groups differ.
3. Compare raw LSD p-values with Bonferroni, Sidak, Holm, and BH/FDR adjustments.

Omnibus ANOVA p-value: 5.70573e-10
Decision at alpha=0.05: continue to post-hoc interpretation

ANOVA table:

source	sum_of_squares	df	mean_square	f_value	p_value
Between groups	465.077825	3	155.025942	15.876268	0.0
Within groups	6298.188739	645	9.764634	NaN	NaN
Total	6763.266564	648	NaN	NaN	NaN

Group summary:

group	n	mean	standard_deviation	variance	standard_error	minimum	maximum	mean_ci95_lower	mean_ci95_upper
1	212	10.8443	3.2186	10.3595	0.2211	0	18	10.4111	11.2776
2	305	12.0918	3.2431	10.5179	0.1857	0	19	11.7278	12.4558
3	97	13.2268	2.5021	6.2605	0.2541	8	18	12.7289	13.7247
4	35	13.0571	3.0384	9.2319	0.5136	6	19	12.0505	14.0638

Top pairwise comparisons by raw p-value:

group_1	group_2	mean_1	mean_2	mean_difference_group1_minus_group2	standard_error_pooled	df_within	t_value	p_unadjusted_lsd	ci95_lower_unadjusted	ci95_upper_unadjusted	p_bonferroni	p_sidak	p_holm	p_bh_fdr	significant_lsd_alpha_0_05	significant_bonferroni_alpha_0_05	significant_sidak_alpha_0_05	significant_holm_alpha_0_05	significant_bh_fdr_alpha_0_05
1	3	10.844340	13.226804	-2.382465	0.383048	645	-6.219751	0.000000	-3.134637	-1.630292	0.000000	0.000000	0.000000	0.000000	Yes	Yes	Yes	Yes	Yes
1	2	10.844340	12.091803	-1.247464	0.279419	645	-4.464497	0.000009	-1.796144	-0.698784	0.000057	0.000057	0.000047	0.000028	Yes	Yes	Yes	Yes	Yes
1	4	10.844340	13.057143	-2.212803	0.570131	645	-3.881220	0.000115	-3.332340	-1.093267	0.000688	0.000688	0.000458	0.000229	Yes	Yes	Yes	Yes	Yes
2	3	12.091803	13.226804	-1.135001	0.364255	645	-3.115953	0.001915	-1.850269	-0.419732	0.011489	0.011435	0.005745	0.002872	Yes	Yes	Yes	Yes	Yes
2	4	12.091803	13.057143	-0.965340	0.557678	645	-1.730998	0.083930	-2.060423	0.129744	0.503582	0.409022	0.167861	0.100716	No	No	No	No	No
3	4	13.226804	13.057143	0.169661	0.616162	645	0.275352	0.783134	-1.040265	1.379587	1.000000	0.999896	0.783134	0.783134	No	No	No	No	No

Compact letters based on Holm adjusted p-values:

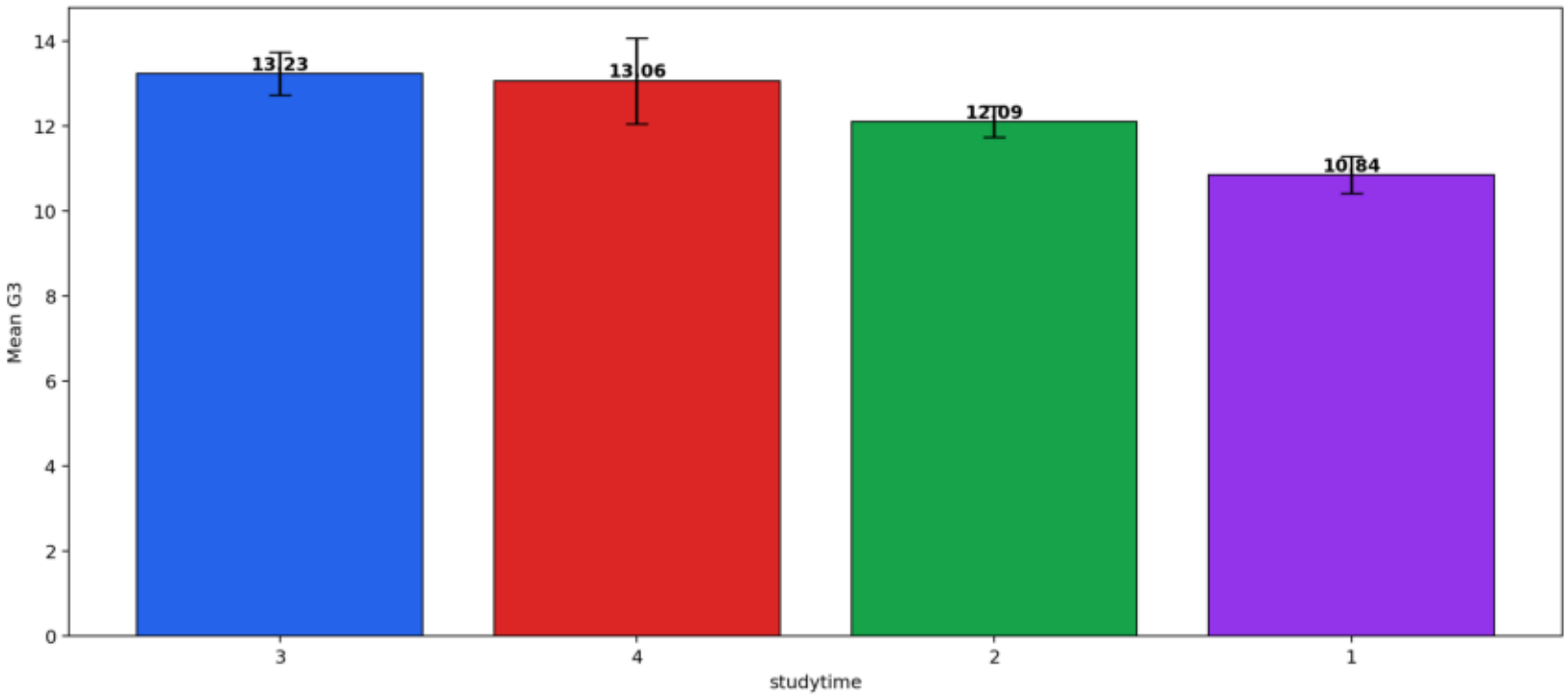
group	holm_based_compact_letters
3	A
4	A
2	B
1	C

Tukey HSD context

group1	group2	meandiff	p-adj	lower	upper	reject
1	2	1.2475	0.0001	0.5278	1.9672	True
1	3	2.3825	0.0000	1.3958	3.3691	True
1	4	2.2128	0.0007	0.7443	3.6813	True
2	3	1.1350	0.0103	0.1968	2.0732	True
2	4	0.9653	0.3084	-0.4711	2.4018	False
3	4	-0.1697	0.9927	-1.7567	1.4174	False

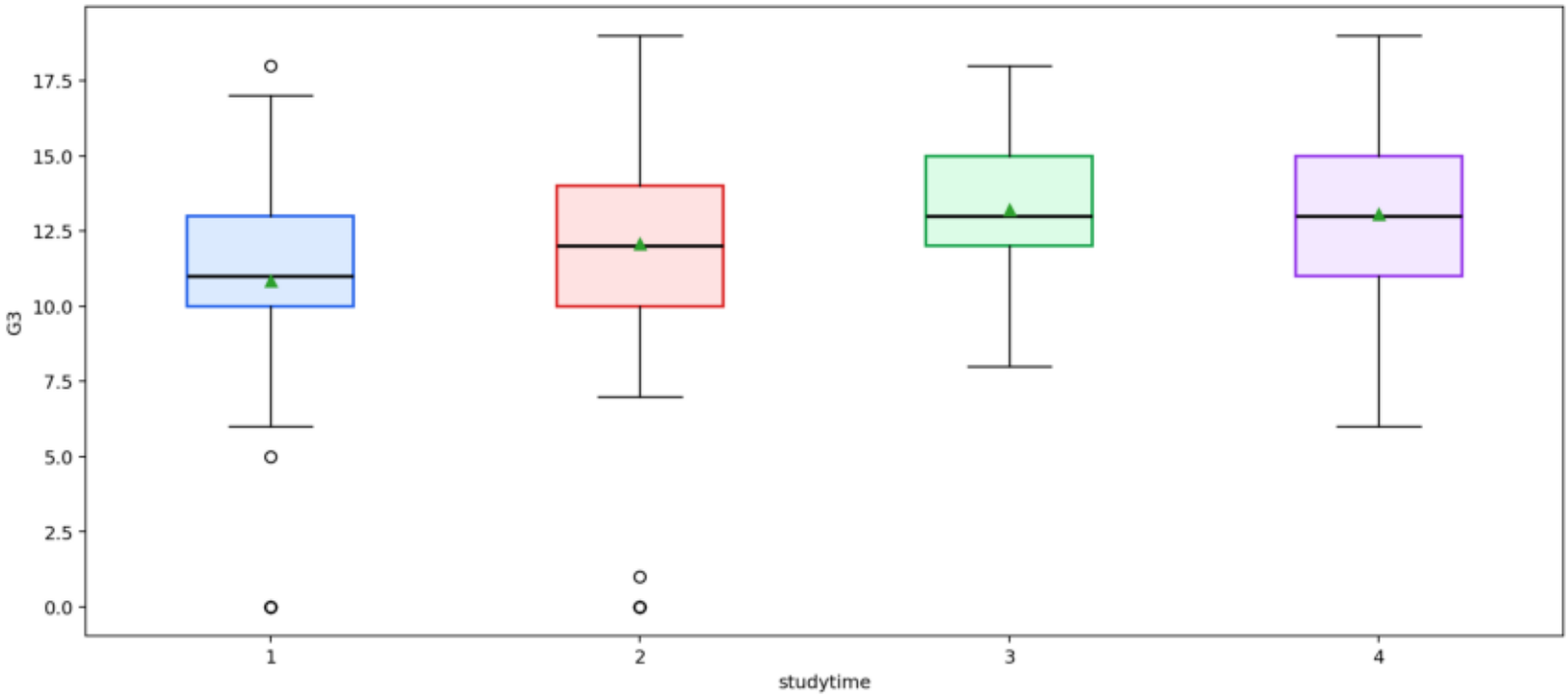
Pairwise After ANOVA: Group Means

Colorful 95% confidence intervals show which group means differ most before pairwise testing.



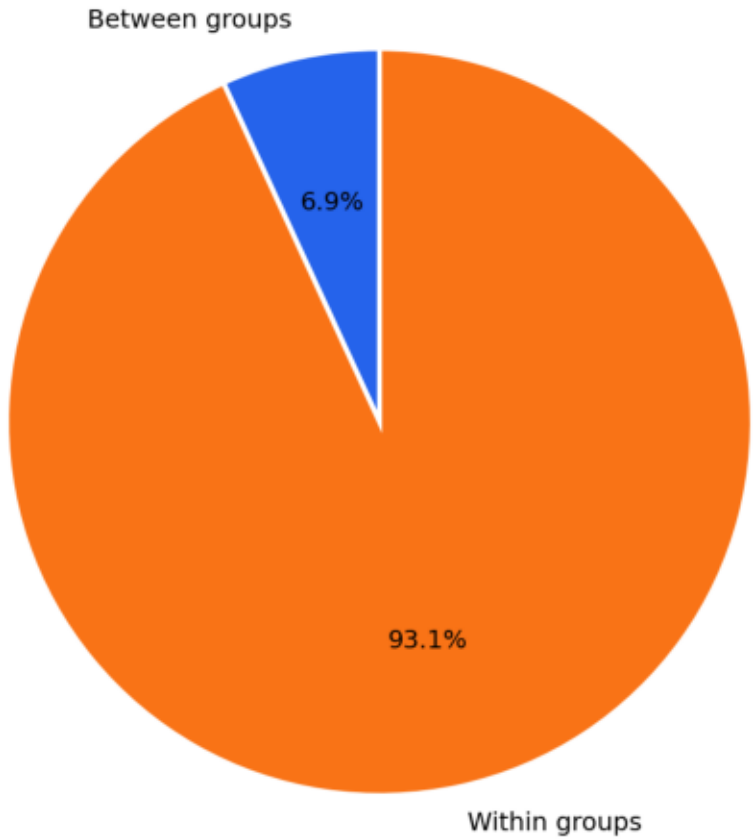
Pairwise After ANOVA: Group Distributions

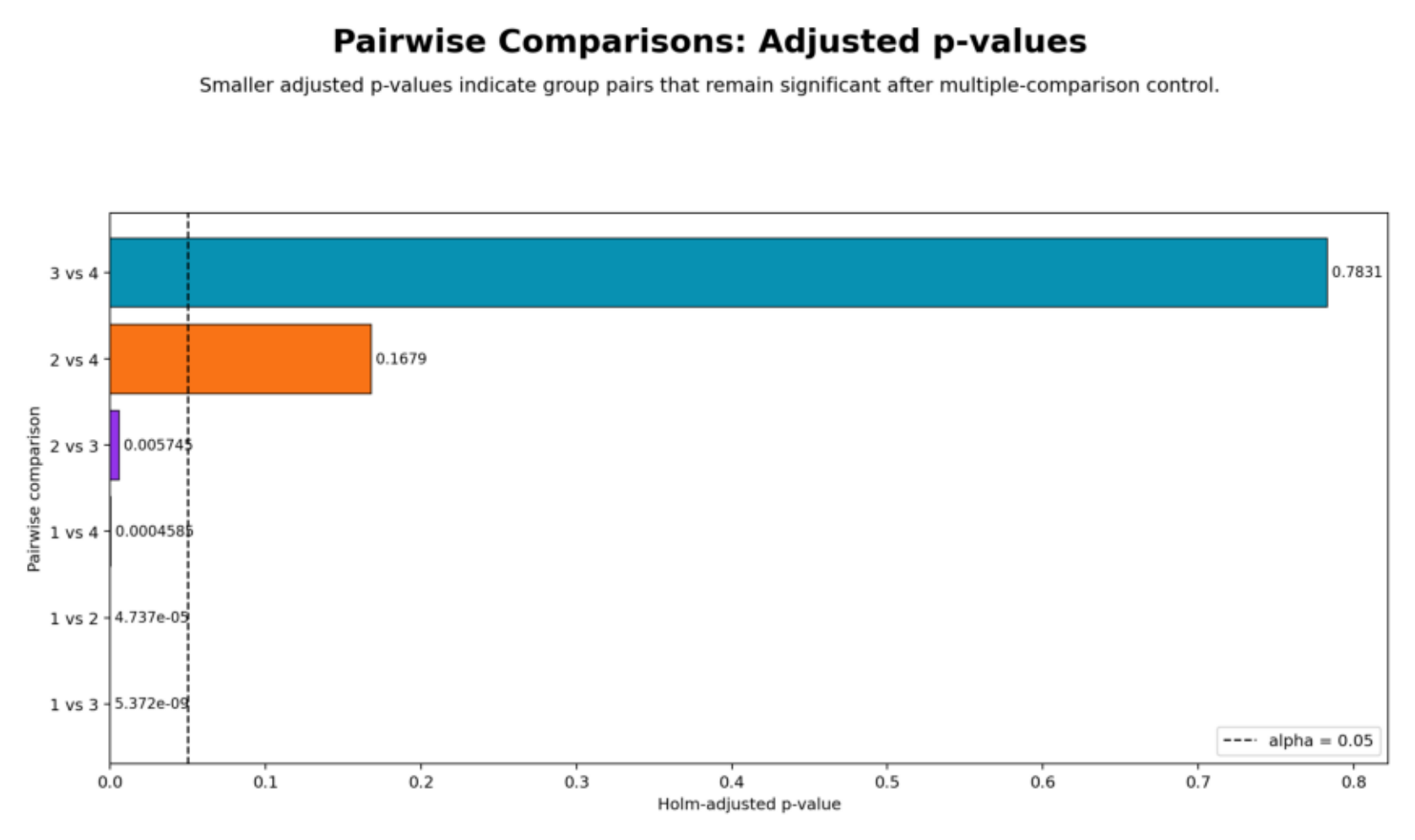
Boxplots check spread and overlap before interpreting post-hoc pairwise differences.



ANOVA Variance Breakdown

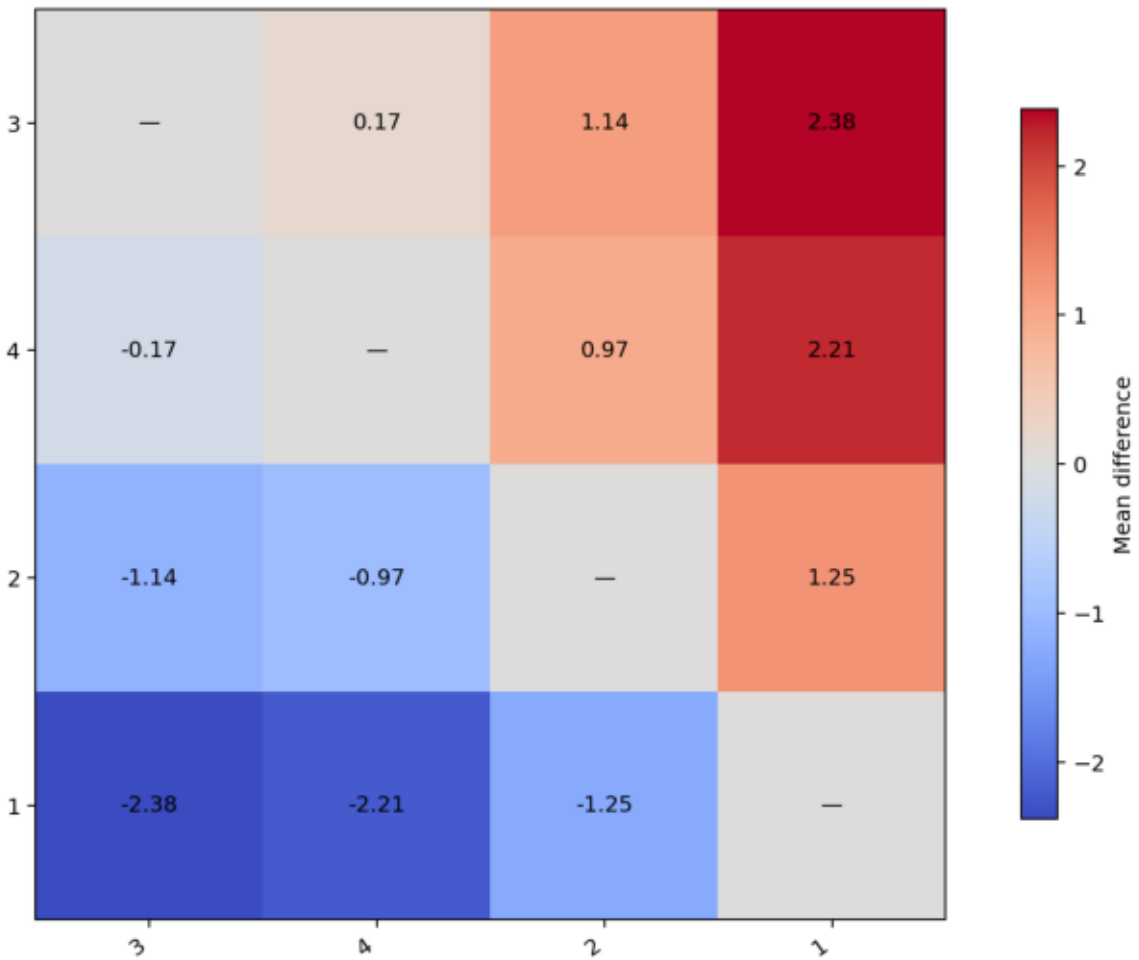
Post-hoc comparisons are meaningful after checking the omnibus between-group evidence.




Pairwise Comparisons: Adjusted p-values
Smaller adjusted p-values indicate group pairs that remain significant after multiple-comparison control.
3 vs 4
2 vs 4
2 vs 3
1 vs 4
1 vs 2
1 vs 3
Pairwise comparison
0.7831
0.1679
0.005745
0.0004585
4.737e-05
5.372e-09
alpha = 0.05
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Holm-adjusted p-value

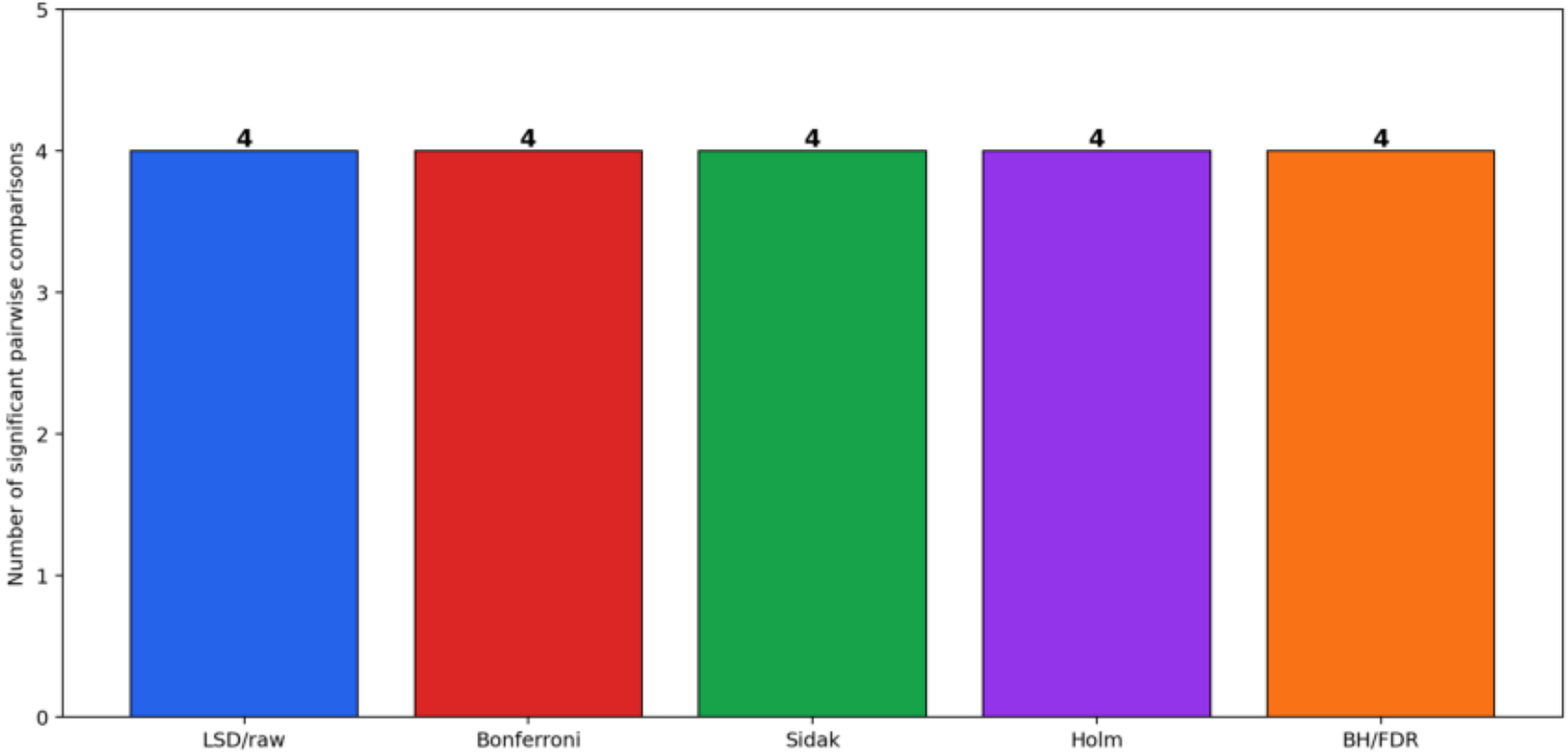
Pairwise Mean Difference Heatmap

Positive values show how much the row group mean exceeds the column group mean.



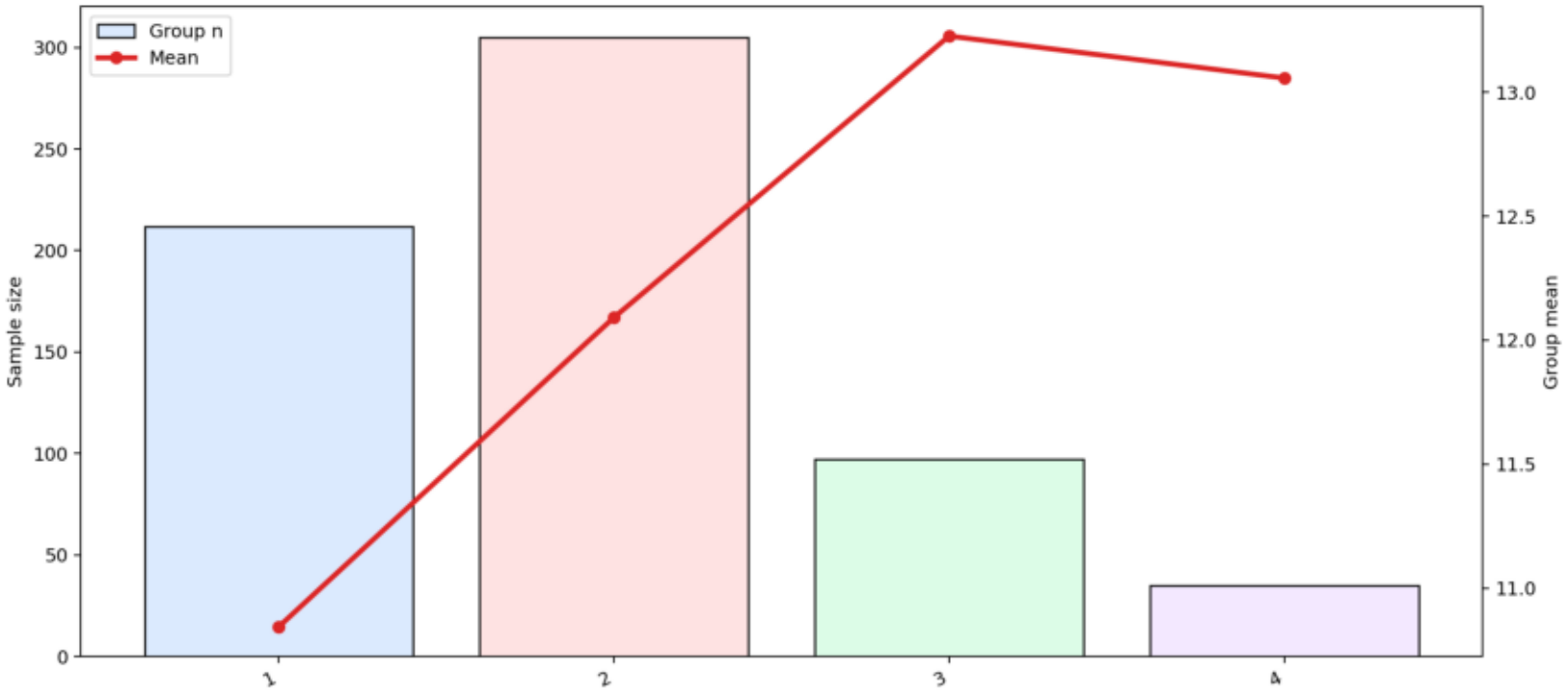
Multiple-Comparison Methods Compared

Strict corrections usually reduce the number of significant post-hoc findings.



Group Sample Size and Mean

Unequal group sizes can influence standard errors and post-hoc interpretation.



Pairwise After ANOVA: Overlaid Histograms

Colored histograms show whether group distributions overlap strongly or separate clearly.