Results

Descriptive Statistics

Descriptive Statistics

		Valid	Missing	Mean	Std. Deviation	Shapiro-Wilk	P-value of Shapiro-Wilk	Minimum	Maximum
rank	abalone	10230	0	6.000	3.162	NaN	NaN	1.000	11.000
rank	adult	10230	0	5.839	3.234	NaN	NaN	1.000	11.000
rank	air_quality	10230	0	6.000	3.162	NaN	NaN	1.000	11.000
rank	bank	10230	0	6.000	3.162	NaN	NaN	1.000	11.000
rank	bike	10230	0	6.000	3.162	NaN	NaN	1.000	11.000
rank	car	10230	0	6.000	3.162	NaN	NaN	1.000	11.000
rank	diabetic	10230	0	6.000	3.162	NaN	NaN	1.000	11.000
rank	fish_toxicity	10230	0	6.000	3.162	NaN	NaN	1.000	11.000
rank	forest_fires	10230	0	6.000	3.162	NaN	NaN	1.000	11.000
rank	housing	10230	0	6.000	3.162	NaN	NaN	1.000	11.000
rank	iris	10230	0	6.000	3.162	NaN	NaN	1.000	11.000
rank	mushroom	10230	0	6.000	3.162	NaN	NaN	1.000	11.000
rank	parkinsons	10230	0	6.000	3.162	NaN	NaN	1.000	11.000
rank	student_performance	10230	0	6.000	3.162	NaN	NaN	1.000	11.000
rank	wine_quality	10230	0	6.000	3.162	NaN	NaN	1.000	11.000
test_loss	abalone	10230	0	2.522	0.527	NaN	NaN	1.888	6.404
test_loss	adult	10230	0	22.495	192.207	NaN	NaN	0.309	6186.153
test_loss	air_quality	10230	0	0.288	0.055	NaN	NaN	0.239	0.749
test_loss	bank	10230	0	0.279	0.147	NaN	NaN	0.196	2.002
test_loss	bike	10230	0	0.143	0.091	NaN	NaN	0.041	0.830
test_loss	car	10230	0	0.536	0.390	NaN	NaN	0.058	2.838
test_loss	diabetic	10230	0	0.965	0.315	NaN	NaN	0.874	19.008
test_loss	fish_toxicity	10230	0	0.123	0.045	NaN	NaN	0.079	0.534
test_loss	forest_fires	10230	0	0.146	0.140	NaN	NaN	0.009	0.888
test_loss	housing	10230	0	0.140	0.063	NaN	NaN	0.060	0.590
test_loss	iris	10230	0	0.448	0.511	NaN	NaN	3.576e−8	10.622
test_loss	mushroom	10230	0	0.234	0.919	NaN	NaN	0.000	60.909
test_loss	parkinsons	10230	0	0.085	0.060	NaN	NaN	0.051	0.665
test_loss	student_performance	10230	0	0.273	0.147	NaN	NaN	0.144	0.632
test_loss	wine_quality	10230	0	1.236	0.282	NaN	NaN	0.991	3.008

ANOVA

ANOVA - rank

Cases	Sum of Squares	df	Mean Square	F	p
dataset	248.990	14	17.785	6.515	< .001
heuristic	699163.514	10	69916.351	25612.484	< .001
dataset ✻ heuristic	421571.950	140	3011.228	1103.104	< .001
Residuals	418433.761	153285	2.730		

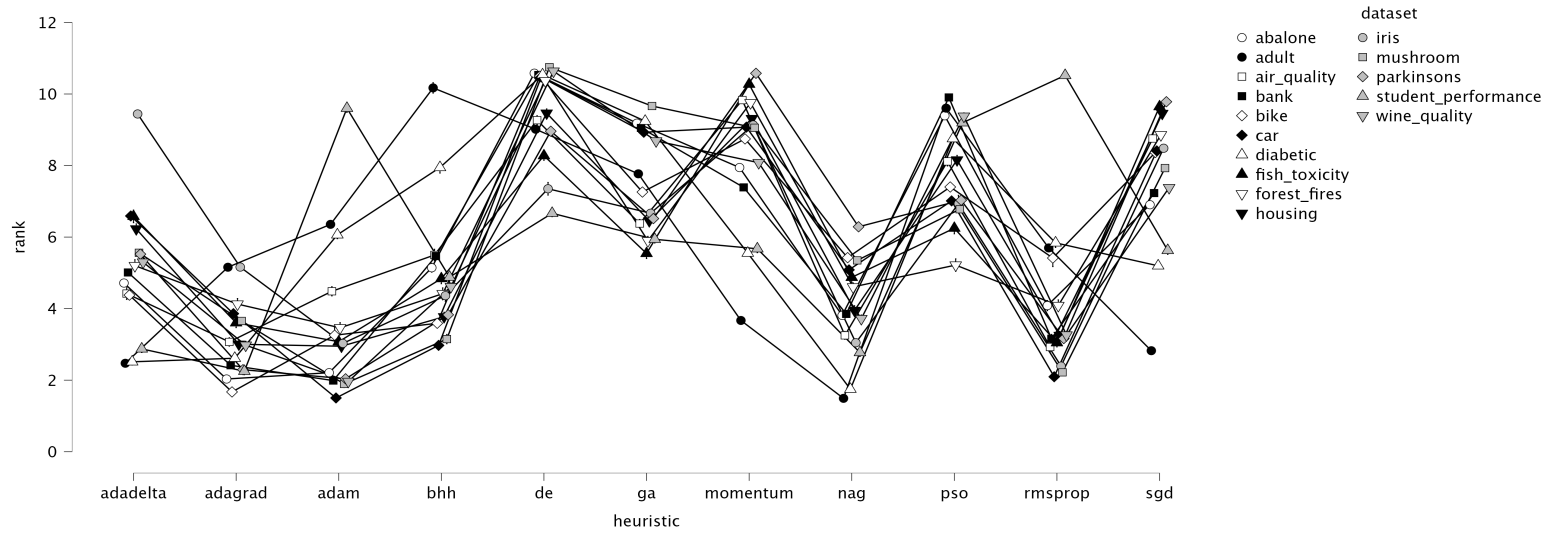
Note. Type III Sum of Squares

Descriptives

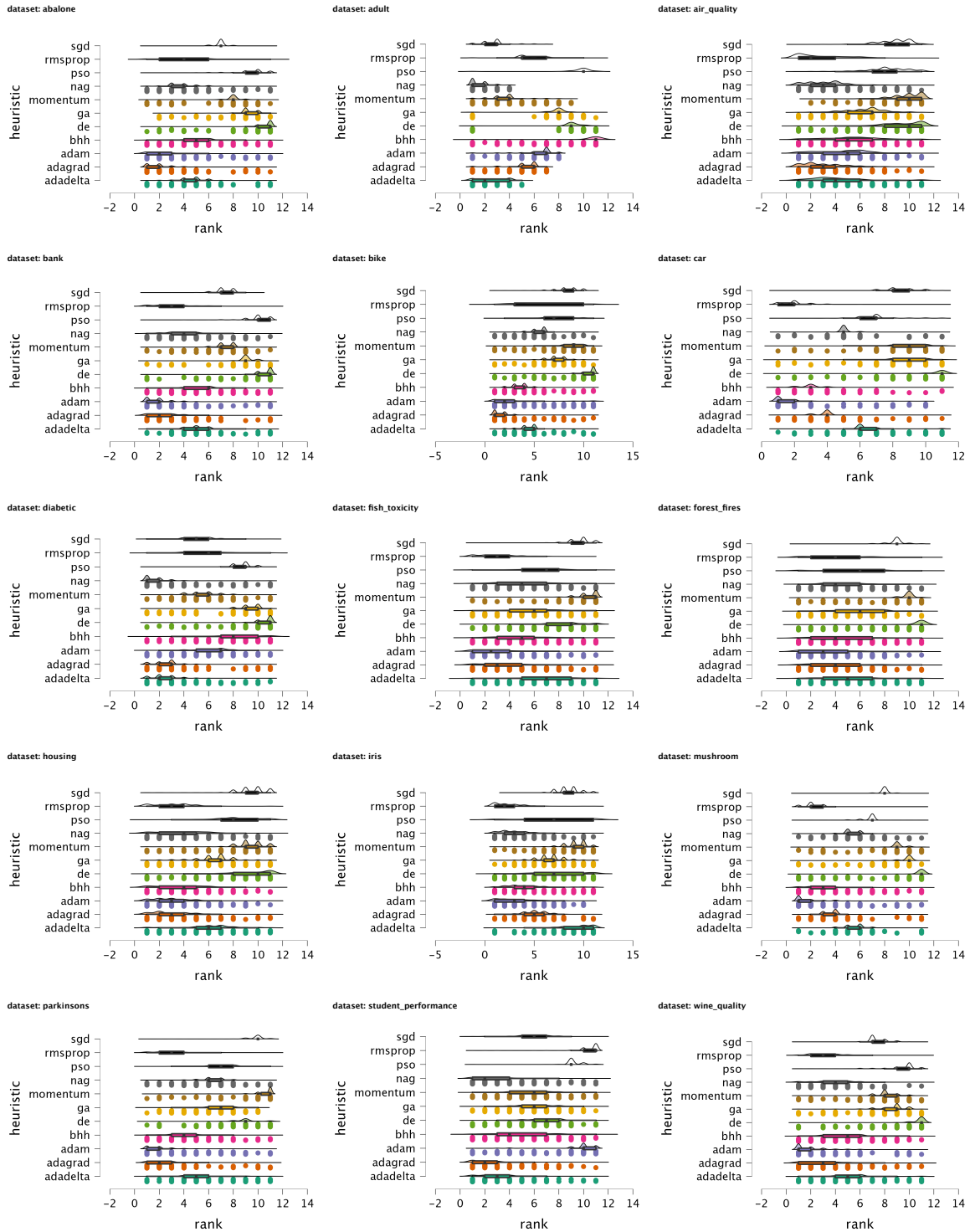
Descriptives - rank

dataset	heuristic	Mean	SD	N
abalone	adadelta	4.715	1.167	930
	adagrad	2.032	1.344	930
	adam	2.209	1.567	930
	bhh	5.143	1.933	930
	de	10.582	1.129	930
	ga	9.184	0.903	930
	momentum	7.944	0.972	930
	nag	3.811	1.276	930
	pso	9.391	1.527	930
	rmsprop	4.085	2.209	930
	sgd	6.904	0.774	930
adult	adadelta	2.472	1.297	930
	adagrad	5.157	1.284	930
	adam	6.356	1.482	930
	bhh	10.171	2.269	930
	de	9.014	1.561	930
	ga	7.769	1.346	930
	momentum	3.669	1.383	930
	nag	1.491	0.687	930
	pso	9.604	1.672	930
	rmsprop	5.697	1.401	930
	sgd	2.824	1.199	930
air_quality	adadelta	4.420	2.558	930
	adagrad	3.069	1.815	930
	adam	4.485	2.009	930
	bhh	5.499	2.502	930
	de	9.269	1.958	930
	ga	6.378	1.771	930
	momentum	9.830	1.305	930
	nag	3.253	1.727	930
	pso	8.115	1.977	930
	rmsprop	2.927	2.047	930
	sgd	8.755	1.407	930
bank	adadelta	5.011	0.986	930
	adagrad	2.416	1.387	930
	adam	1.988	1.398	930
	bhh	5.469	1.749	930
	de	10.531	1.045	930
	ga	9.051	0.995	930
	momentum	7.389	0.891	930
	nag	3.852	1.406	930
	pso	9.904	1.237	930
	rmsprop	3.159	1.865	930
	sgd	7.230	0.914	930
bike	adadelta	4.377	1.068	930
	adagrad	1.671	1.185	930
	adam	3.256	3.258	930
	bhh	3.590	1.053	930
	de	10.498	1.272	930
	ga	7.259	1.099	930
	momentum	8.744	1.275	930
	nag	5.425	0.931	930
	pso	7.400	1.604	930
	rmsprop	5.414	3.723	930
	sgd	8.366	1.316	930
car	adadelta	6.590	1.444	930
	adagrad	3.859	0.805	930
	adam	1.502	1.160	930
	bhh	2.972	1.015	930
	de	10.472	1.292	930
	ga	8.930	1.288	930
	momentum	9.073	1.174	930
	nag	5.084	0.692	930
	pso	7.012	1.297	930
	rmsprop	2.095	1.110	930
	sgd	8.411	1.233	930
diabetic	adadelta	2.513	1.384	930
	adagrad	2.613	1.391	930
	adam	6.063	1.694	930
	bhh	7.945	2.414	930
	de	10.538	1.061	930
	ga	9.241	1.221	930
	momentum	5.552	1.302	930
	nag	1.747	1.249	930
	pso	8.753	0.942	930
	rmsprop	5.839	2.013	930
	sgd	5.197	1.271	930
fish_toxicity	adadelta	6.578	2.739	930
	adagrad	3.603	2.100	930
	adam	3.074	2.046	930
	bhh	4.839	2.214	930
	de	8.275	2.008	930
	ga	5.542	2.203	930
	momentum	10.273	1.196	930
	nag	4.874	2.213	930
	pso	6.248	2.436	930
	rmsprop	3.046	1.816	930
	sgd	9.646	1.273	930
forest_fires	adadelta	5.201	2.592	930
	adagrad	4.127	2.417	930
	adam	3.463	2.258	930
	bhh	4.417	2.530	930
	de	10.370	1.788	930
	ga	5.898	1.901	930
	momentum	9.754	1.095	930
	nag	4.608	1.733	930
	pso	5.217	2.692	930
	rmsprop	4.086	2.458	930
	sgd	8.859	1.007	930
housing	adadelta	6.229	2.173	930
	adagrad	3.004	1.688	930
	adam	2.948	1.572	930
	bhh	3.772	1.977	930
	de	9.465	1.846	930
	ga	6.454	1.657	930
	momentum	9.314	1.354	930
	nag	3.949	2.069	930
	pso	8.157	1.982	930
	rmsprop	3.251	1.779	930
	sgd	9.457	1.365	930
iris	adadelta	9.442	1.621	930
	adagrad	5.161	1.263	930
	adam	3.027	1.906	930
	bhh	4.362	2.440	930
	de	7.351	2.749	930
	ga	6.667	1.470	930
	momentum	9.134	1.282	930
	nag	3.046	1.683	930
	pso	6.933	3.637	930
	rmsprop	2.392	1.557	930
	sgd	8.484	1.201	930
mushroom	adadelta	5.561	0.991	930
	adagrad	3.655	0.885	930
	adam	1.894	1.557	930
	bhh	3.148	2.024	930
	de	10.749	1.251	930
	ga	9.663	0.968	930
	momentum	9.056	0.920	930
	nag	5.348	0.815	930
	pso	6.777	0.783	930
	rmsprop	2.218	1.159	930
	sgd	7.929	0.837	930
parkinsons	adadelta	5.523	1.889	930
	adagrad	2.292	1.286	930
	adam	2.038	1.410	930
	bhh	3.827	1.468	930
	de	8.959	1.139	930
	ga	6.517	1.346	930
	momentum	10.578	1.149	930
	nag	6.288	1.134	930
	pso	7.030	1.477	930
	rmsprop	3.163	1.980	930
	sgd	9.784	0.974	930
student_performance	adadelta	2.874	1.561	930
	adagrad	2.249	1.517	930
	adam	9.602	1.814	930
	bhh	4.881	2.554	930
	de	6.666	1.481	930
	ga	5.938	1.594	930
	momentum	5.673	1.700	930
	nag	2.773	1.725	930
	pso	9.196	0.881	930
	rmsprop	10.520	1.129	930
	sgd	5.628	1.735	930
wine_quality	adadelta	5.299	1.974	930
	adagrad	2.977	1.719	930
	adam	1.963	1.449	930
	bhh	4.614	1.599	930
	de	10.638	1.136	930
	ga	8.688	1.273	930
	momentum	8.080	1.067	930
	nag	3.719	1.607	930
	pso	9.378	1.441	930
	rmsprop	3.262	1.422	930
	sgd	7.381	0.931	930

Descriptives plots



Raincloud plots



Assumption Checks

Test for Equality of Variances (Levene's)

F	df1	df2	p
247.532	164.000	153285.000	< .001

Contrast Tables

Simple Contrast - heuristic

Comparison	Estimate	SE	df	t	p
adagrad - adadelta	−1.928	0.020	153285	−97.455	< .001
adam - adadelta	−1.529	0.020	153285	−77.298	< .001
bhh - adadelta	−0.144	0.020	153285	−7.269	< .001
de - adadelta	4.438	0.020	153285	224.330	< .001
ga - adadelta	2.425	0.020	153285	122.570	< .001
momentum - adadelta	3.150	0.020	153285	159.251	< .001
nag - adadelta	−1.169	0.020	153285	−59.100	< .001
pso - adadelta	2.821	0.020	153285	142.583	< .001
rmsprop - adadelta	−1.043	0.020	153285	−52.744	< .001
sgd - adadelta	2.536	0.020	153285	128.216	< .001

Post Hoc Tests

Standard

Post Hoc Comparisons - heuristic

			95% CI for Mean Difference				
		Mean Difference	Lower	Upper	SE	t	P_{tukey}
adadelta	adagrad	1.928	1.864	1.992	0.020	97.455	< .001***
	adam	1.529	1.466	1.593	0.020	77.298	< .001***
	bhh	0.144	0.080	0.207	0.020	7.269	< .001***
	de	−4.438	−4.502	−4.374	0.020	−224.330	< .001***
	ga	−2.425	−2.488	−2.361	0.020	−122.570	< .001***
	momentum	−3.150	−3.214	−3.087	0.020	−159.251	< .001***
	nag	1.169	1.106	1.233	0.020	59.100	< .001***
	pso	−2.821	−2.884	−2.757	0.020	−142.583	< .001***
	rmsprop	1.043	0.980	1.107	0.020	52.744	< .001***
	sgd	−2.536	−2.600	−2.473	0.020	−128.216	< .001***
adagrad	adam	−0.399	−0.462	−0.335	0.020	−20.158	< .001***
	bhh	−1.784	−1.848	−1.720	0.020	−90.187	< .001***
	de	−6.366	−6.430	−6.302	0.020	−321.786	< .001***
	ga	−4.353	−4.416	−4.289	0.020	−220.026	< .001***
	momentum	−5.078	−5.142	−5.015	0.020	−256.707	< .001***
	nag	−0.759	−0.822	−0.695	0.020	−38.355	< .001***
	pso	−4.749	−4.812	−4.685	0.020	−240.039	< .001***
	rmsprop	−0.885	−0.948	−0.821	0.020	−44.711	< .001***
	sgd	−4.464	−4.528	−4.401	0.020	−225.671	< .001***
adam	bhh	−1.385	−1.449	−1.322	0.020	−70.029	< .001***
	de	−5.967	−6.031	−5.903	0.020	−301.628	< .001***
	ga	−3.954	−4.018	−3.890	0.020	−199.868	< .001***
	momentum	−4.680	−4.743	−4.616	0.020	−236.549	< .001***
	nag	−0.360	−0.424	−0.296	0.020	−18.197	< .001***
	pso	−4.350	−4.414	−4.286	0.020	−219.881	< .001***
	rmsprop	−0.486	−0.549	−0.422	0.020	−24.553	< .001***
	sgd	−4.066	−4.129	−4.002	0.020	−205.513	< .001***
bhh	de	−4.582	−4.645	−4.518	0.020	−231.599	< .001***
	ga	−2.569	−2.632	−2.505	0.020	−129.839	< .001***
	momentum	−3.294	−3.358	−3.231	0.020	−166.520	< .001***
	nag	1.025	0.962	1.089	0.020	51.831	< .001***
	pso	−2.965	−3.028	−2.901	0.020	−149.852	< .001***
	rmsprop	0.900	0.836	0.963	0.020	45.476	< .001***
	sgd	−2.680	−2.744	−2.617	0.020	−135.485	< .001***
de	ga	2.013	1.949	2.077	0.020	101.760	< .001***
	momentum	1.287	1.224	1.351	0.020	65.079	< .001***
	nag	5.607	5.543	5.671	0.020	283.431	< .001***
	pso	1.617	1.554	1.681	0.020	81.747	< .001***
	rmsprop	5.481	5.418	5.545	0.020	277.075	< .001***
	sgd	1.901	1.838	1.965	0.020	96.115	< .001***
ga	momentum	−0.726	−0.789	−0.662	0.020	−36.681	< .001***
	nag	3.594	3.530	3.658	0.020	181.670	< .001***
	pso	−0.396	−0.460	−0.332	0.020	−20.013	< .001***
	rmsprop	3.468	3.405	3.532	0.020	175.315	< .001***
	sgd	−0.112	−0.175	−0.048	0.020	−5.645	< .001***
momentum	nag	4.320	4.256	4.383	0.020	218.352	< .001***
	pso	0.330	0.266	0.393	0.020	16.668	< .001***
	rmsprop	4.194	4.130	4.258	0.020	211.996	< .001***
	sgd	0.614	0.550	0.678	0.020	31.036	< .001***
nag	pso	−3.990	−4.054	−3.926	0.020	−201.683	< .001***
	rmsprop	−0.126	−0.189	−0.062	0.020	−6.356	< .001***
	sgd	−3.706	−3.769	−3.642	0.020	−187.316	< .001***
pso	rmsprop	3.864	3.800	3.928	0.020	195.328	< .001***
	sgd	0.284	0.221	0.348	0.020	14.367	< .001***
rmsprop	sgd	−3.580	−3.644	−3.516	0.020	−180.960	< .001***

Note. Results are averaged over the levels of: dataset
Note. P-value and confidence intervals adjusted for comparing a family of 11 estimates (confidence intervals corrected using the tukey method).
*** p < .001

Kruskal-Wallis Test

Kruskal-Wallis Test

Factor	Statistic	df	p
heuristic	69680.264	10	< .001