

example_analysis

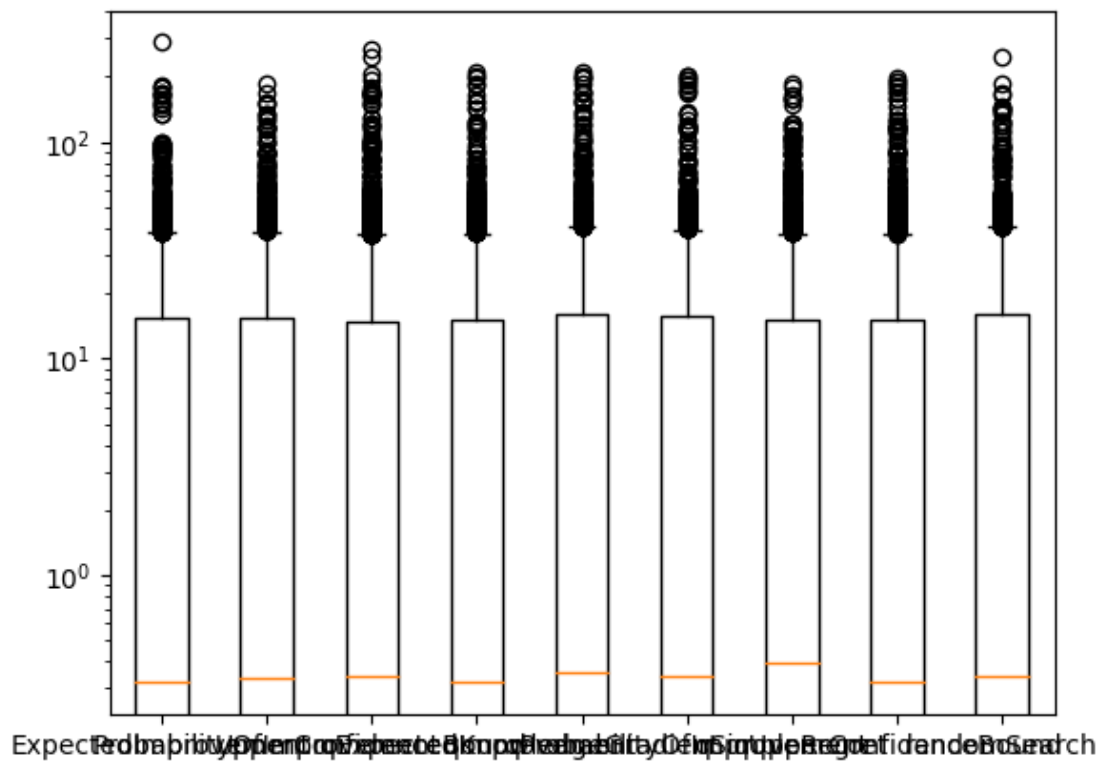
May 10, 2023

```
[ ]: import pandas as pd

from significance_analysis import conduct_analysis

# Load example dataset
data = pd.read_csv("./example_dataset.csv")
```

```
[ ]: # First Analysis: Analyse performance of acquisition functions over all
      ↪ benchmarks and training grounds
conduct_analysis(data, "mean", "acquisition", "benchmark")
```



P-value: 0.0

As the p-value 0.0 is smaller than 0.05, we can reject the Null-Hypothesis that the model that does not consider the acquisition describes the data as well as the one that does. Therefore there is significant difference within acquisition.

P-values adjusted by tukey method for family of 36 estimates

	acquisition	Estimate	2.5_ci	97.5_ci	SE	DF	
1	ExpectedImprovement	5.760	-7.732	19.251	4.88	4.044	
2	ProbabilityOfImprovement	6.097	-7.395	19.588	4.88	4.044	
3	UpperConfidenceBound	5.878	-7.613	19.370	4.88	4.044	
4	qExpectedImprovement	5.822	-7.670	19.313	4.88	4.044	
5	qKnowledgeGradient	6.255	-7.237	19.747	4.88	4.044	
6	qProbabilityOfImprovement	6.283	-7.209	19.775	4.88	4.044	
7	qSimpleRegret	5.856	-7.636	19.348	4.88	4.044	
8	qUpperConfidenceBound	5.912	-7.579	19.404	4.88	4.044	
9	randomSearch	6.652	-6.840	20.144	4.88	4.044	
	acquisition_1			acquisition_2	Estimate	2.5_ci	
	97.5_ci	SE	DF	T-stat	P-val	Sig	
1							ExpectedImprovement ProbabilityOfImprovement -0.337 -0.564
	-0.110	0.073	179996.0	-4.609	0.000	***	
2							ExpectedImprovement UpperConfidenceBound -0.119 -0.346
	0.108	0.073	179996.0	-1.624	0.792		
3							ExpectedImprovement qExpectedImprovement -0.062 -0.289
	0.165	0.073	179996.0	-0.846	0.995		
4							ExpectedImprovement qKnowledgeGradient -0.495 -0.722
	-0.268	0.073	179996.0	-6.773	0.000	***	
5							ExpectedImprovement qProbabilityOfImprovement -0.523 -0.750
	-0.296	0.073	179996.0	-7.155	0.000	***	
6							ExpectedImprovement qSimpleRegret -0.096 -0.323
	0.130	0.073	179996.0	-1.319	0.926		
7							ExpectedImprovement qUpperConfidenceBound -0.153 -0.380
	0.074	0.073	179996.0	-2.090	0.480		
8							ExpectedImprovement randomSearch -0.892 -1.119
	-0.665	0.073	179996.0	-12.202	0.000	***	
9							ProbabilityOfImprovement UpperConfidenceBound 0.218 -0.009
	0.445	0.073	179996.0	2.985	0.070	.	
10							ProbabilityOfImprovement qExpectedImprovement 0.275 0.048
	0.502	0.073	179996.0	3.762	0.005	**	
11							ProbabilityOfImprovement qKnowledgeGradient -0.158 -0.385
	0.069	0.073	179996.0	-2.164	0.429		
12							ProbabilityOfImprovement qProbabilityOfImprovement -0.186 -0.413
	0.041	0.073	179996.0	-2.546	0.210		
13							ProbabilityOfImprovement qSimpleRegret 0.241 0.014
	0.467	0.073	179996.0	3.290	0.028	*	
14							ProbabilityOfImprovement qUpperConfidenceBound 0.184 -0.043
	0.411	0.073	179996.0	2.519	0.223		
15							ProbabilityOfImprovement randomSearch -0.555 -0.782
	-0.328	0.073	179996.0	-7.593	0.000	***	
16							UpperConfidenceBound qExpectedImprovement 0.057 -0.170

0.284	0.073	179996.0	0.777	0.997			
17	UpperConfidenceBound		qKnowledgeGradient	-0.377	-0.603		
-0.150	0.073	179996.0	-5.149	0.000	***		
18	UpperConfidenceBound		qProbabilityOfImprovement	-0.404	-0.631		
-0.178	0.073	179996.0	-5.531	0.000	***		
19	UpperConfidenceBound		qSimpleRegret	0.022	-0.205		
0.249	0.073	179996.0	0.305	1.000			
20	UpperConfidenceBound		qUpperConfidenceBound	-0.034	-0.261		
0.193	0.073	179996.0	-0.466	1.000			
21	UpperConfidenceBound		randomSearch	-0.773	-1.000		
-0.547	0.073	179996.0	-10.578	0.000	***		
22	qExpectedImprovement		qKnowledgeGradient	-0.433	-0.660		
-0.207	0.073	179996.0	-5.927	0.000	***		
23	qExpectedImprovement		qProbabilityOfImprovement	-0.461	-0.688		
-0.234	0.073	179996.0	-6.308	0.000	***		
24	qExpectedImprovement		qSimpleRegret	-0.035	-0.261		
0.192	0.073	179996.0	-0.472	1.000			
25	qExpectedImprovement		qUpperConfidenceBound	-0.091	-0.318		
0.136	0.073	179996.0	-1.244	0.947			
26	qExpectedImprovement		randomSearch	-0.830	-1.057		
-0.604	0.073	179996.0	-11.356	0.000	***		
27	qKnowledgeGradient		qProbabilityOfImprovement	-0.028	-0.255		
0.199	0.073	179996.0	-0.381	1.000			
28	qKnowledgeGradient		qSimpleRegret	0.399	0.172		
0.626	0.073	179996.0	5.454	0.000	***		
29	qKnowledgeGradient		qUpperConfidenceBound	0.342	0.116		
0.569	0.073	179996.0	4.683	0.000	***		
30	qKnowledgeGradient		randomSearch	-0.397	-0.624		
-0.170	0.073	179996.0	-5.429	0.000	***		
31	qProbabilityOfImprovement		qSimpleRegret	0.427	0.200		
0.654	0.073	179996.0	5.836	0.000	***		
32	qProbabilityOfImprovement		qUpperConfidenceBound	0.370	0.144		
0.597	0.073	179996.0	5.065	0.000	***		
33	qProbabilityOfImprovement		randomSearch	-0.369	-0.596		
-0.142	0.073	179996.0	-5.047	0.000	***		
34	qSimpleRegret		qUpperConfidenceBound	-0.056	-0.283		
0.170	0.073	179996.0	-0.771	0.998			
35	qSimpleRegret		randomSearch	-0.796	-1.023		
-0.569	0.073	179996.0	-10.883	0.000	***		
36	qUpperConfidenceBound		randomSearch	-0.739	-0.966		
-0.513	0.073	179996.0	-10.112	0.000	***		

The best performing acquisition is ExpectedImprovement, but ['UpperConfidenceBound', 'qExpectedImprovement', 'qSimpleRegret', 'qUpperConfidenceBound'] are only insignificantly worse.

```
[ ]: ({'chi_square': 255.16374744055793, 'df': 8, 'p': 0.0},
(
    acquisition Estimate 2.5_ci 97.5_ci SE DF
1 ExpectedImprovement 5.760 -7.732 19.251 4.88 4.044
2 ProbabilityOfImprovement 6.097 -7.395 19.588 4.88 4.044
3 UpperConfidenceBound 5.878 -7.613 19.370 4.88 4.044
4 qExpectedImprovement 5.822 -7.670 19.313 4.88 4.044
5 qKnowledgeGradient 6.255 -7.237 19.747 4.88 4.044
6 qProbabilityOfImprovement 6.283 -7.209 19.775 4.88 4.044
7 qSimpleRegret 5.856 -7.636 19.348 4.88 4.044
8 qUpperConfidenceBound 5.912 -7.579 19.404 4.88 4.044
9 randomSearch 6.652 -6.840 20.144 4.88 4.044,
Contrast Estimate 2.5_ci
97.5_ci SE DF T-stat P-val Sig acquisition_1
acquisition_2
1 ExpectedImprovement - ProbabilityOfImprovement -0.337 -0.564
-0.110 0.073 179996.0 -4.609 0.000 *** ExpectedImprovement
ProbabilityOfImprovement
2 ExpectedImprovement - UpperConfidenceBound -0.119 -0.346
0.108 0.073 179996.0 -1.624 0.792 ExpectedImprovement
UpperConfidenceBound
3 ExpectedImprovement - qExpectedImprovement -0.062 -0.289
0.165 0.073 179996.0 -0.846 0.995 ExpectedImprovement
qExpectedImprovement
4 ExpectedImprovement - qKnowledgeGradient -0.495 -0.722
-0.268 0.073 179996.0 -6.773 0.000 *** ExpectedImprovement
qKnowledgeGradient
5 ExpectedImprovement - qProbabilityOfImprovement -0.523 -0.750
-0.296 0.073 179996.0 -7.155 0.000 *** ExpectedImprovement
qProbabilityOfImprovement
6 ExpectedImprovement - qSimpleRegret -0.096 -0.323
0.130 0.073 179996.0 -1.319 0.926 ExpectedImprovement
qSimpleRegret
7 ExpectedImprovement - qUpperConfidenceBound -0.153 -0.380
0.074 0.073 179996.0 -2.090 0.480 ExpectedImprovement
qUpperConfidenceBound
8 ExpectedImprovement - randomSearch -0.892 -1.119
-0.665 0.073 179996.0 -12.202 0.000 *** ExpectedImprovement
randomSearch
9 ProbabilityOfImprovement - UpperConfidenceBound 0.218 -0.009
0.445 0.073 179996.0 2.985 0.070 . ProbabilityOfImprovement
UpperConfidenceBound
10 ProbabilityOfImprovement - qExpectedImprovement 0.275 0.048
0.502 0.073 179996.0 3.762 0.005 ** ProbabilityOfImprovement
qExpectedImprovement
11 ProbabilityOfImprovement - qKnowledgeGradient -0.158 -0.385
0.069 0.073 179996.0 -2.164 0.429 ProbabilityOfImprovement
qKnowledgeGradient
```

12	ProbabilityOfImprovement - qProbabilityOfImpro...	-0.186	-0.413
0.041	0.073 179996.0 -2.546 0.210	ProbabilityOfImprovement	
13	ProbabilityOfImprovement - qSimpleRegret	0.241	0.014
0.467	0.073 179996.0 3.290 0.028 *	ProbabilityOfImprovement	
	qSimpleRegret		
14	ProbabilityOfImprovement - qUpperConfidenceBound	0.184	-0.043
0.411	0.073 179996.0 2.519 0.223	ProbabilityOfImprovement	
	qUpperConfidenceBound		
15	ProbabilityOfImprovement - randomSearch	-0.555	-0.782
-0.328	0.073 179996.0 -7.593 0.000 ***	ProbabilityOfImprovement	
	randomSearch		
16	UpperConfidenceBound - qExpectedImprovement	0.057	-0.170
0.284	0.073 179996.0 0.777 0.997	UpperConfidenceBound	
	qExpectedImprovement		
17	UpperConfidenceBound - qKnowledgeGradient	-0.377	-0.603
-0.150	0.073 179996.0 -5.149 0.000 ***	UpperConfidenceBound	
	qKnowledgeGradient		
18	UpperConfidenceBound - qProbabilityOfImprovement	-0.404	-0.631
-0.178	0.073 179996.0 -5.531 0.000 ***	UpperConfidenceBound	
	qProbabilityOfImprovement		
19	UpperConfidenceBound - qSimpleRegret	0.022	-0.205
0.249	0.073 179996.0 0.305 1.000	UpperConfidenceBound	
	qSimpleRegret		
20	UpperConfidenceBound - qUpperConfidenceBound	-0.034	-0.261
0.193	0.073 179996.0 -0.466 1.000	UpperConfidenceBound	
	qUpperConfidenceBound		
21	UpperConfidenceBound - randomSearch	-0.773	-1.000
-0.547	0.073 179996.0 -10.578 0.000 ***	UpperConfidenceBound	
	randomSearch		
22	qExpectedImprovement - qKnowledgeGradient	-0.433	-0.660
-0.207	0.073 179996.0 -5.927 0.000 ***	qExpectedImprovement	
	qKnowledgeGradient		
23	qExpectedImprovement - qProbabilityOfImprovement	-0.461	-0.688
-0.234	0.073 179996.0 -6.308 0.000 ***	qExpectedImprovement	
	qProbabilityOfImprovement		
24	qExpectedImprovement - qSimpleRegret	-0.035	-0.261
0.192	0.073 179996.0 -0.472 1.000	qExpectedImprovement	
	qSimpleRegret		
25	qExpectedImprovement - qUpperConfidenceBound	-0.091	-0.318
0.136	0.073 179996.0 -1.244 0.947	qExpectedImprovement	
	qUpperConfidenceBound		
26	qExpectedImprovement - randomSearch	-0.830	-1.057
-0.604	0.073 179996.0 -11.356 0.000 ***	qExpectedImprovement	
	randomSearch		
27	qKnowledgeGradient - qProbabilityOfImprovement	-0.028	-0.255
0.199	0.073 179996.0 -0.381 1.000	qKnowledgeGradient	

```

qProbabilityOfImprovement
 28          qKnowledgeGradient - qSimpleRegret      0.399  0.172
0.626  0.073  179996.0   5.454  0.000  ***          qKnowledgeGradient
qSimpleRegret
 29          qKnowledgeGradient - qUpperConfidenceBound  0.342  0.116
0.569  0.073  179996.0   4.683  0.000  ***          qKnowledgeGradient
qUpperConfidenceBound
 30          qKnowledgeGradient - randomSearch      -0.397  -0.624
-0.170  0.073  179996.0  -5.429  0.000  ***          qKnowledgeGradient
randomSearch
 31          qProbabilityOfImprovement - qSimpleRegret   0.427  0.200
0.654  0.073  179996.0   5.836  0.000  *** qProbabilityOfImprovement
qSimpleRegret
 32 qProbabilityOfImprovement - qUpperConfidenceBound   0.370  0.144
0.597  0.073  179996.0   5.065  0.000  *** qProbabilityOfImprovement
qUpperConfidenceBound
 33          qProbabilityOfImprovement - randomSearch  -0.369  -0.596
-0.142  0.073  179996.0  -5.047  0.000  *** qProbabilityOfImprovement
randomSearch
 34          qSimpleRegret - qUpperConfidenceBound    -0.056  -0.283
0.170  0.073  179996.0  -0.771  0.998          qSimpleRegret
qUpperConfidenceBound
 35          qSimpleRegret - randomSearch      -0.796  -1.023
-0.569  0.073  179996.0 -10.883  0.000  ***          qSimpleRegret
randomSearch
 36          qUpperConfidenceBound - randomSearch  -0.739  -0.966
-0.513  0.073  179996.0 -10.112  0.000  ***          qUpperConfidenceBound
randomSearch))

```

```

[ ]: # Second Analysis: Analyse performance of acquisition functions over all
    ↪ benchmarks binned by training rounds,
    # i.e. performance in the first 8, the next 12, the next 15, the next 10 and
    ↪ the final 5 rounds.
    # Does not print the results, only shows plots.
conduct_analysis(
  data,
  "mean",
  "acquisition",
  "benchmark",
  bin_id="budget",
  bins=[9, 20, 35, 45],
  summarize=False,
)

```

P-value: 0.0

As the p-value 0.0 is smaller than 0.05, we can reject the Null-Hypothesis that the model that does not consider the acquisition and the budget describes the

data as well as the one that does. Therefore there is significant difference within acquisition and the budget.

P-values adjusted by tukey method for family of 36 estimates

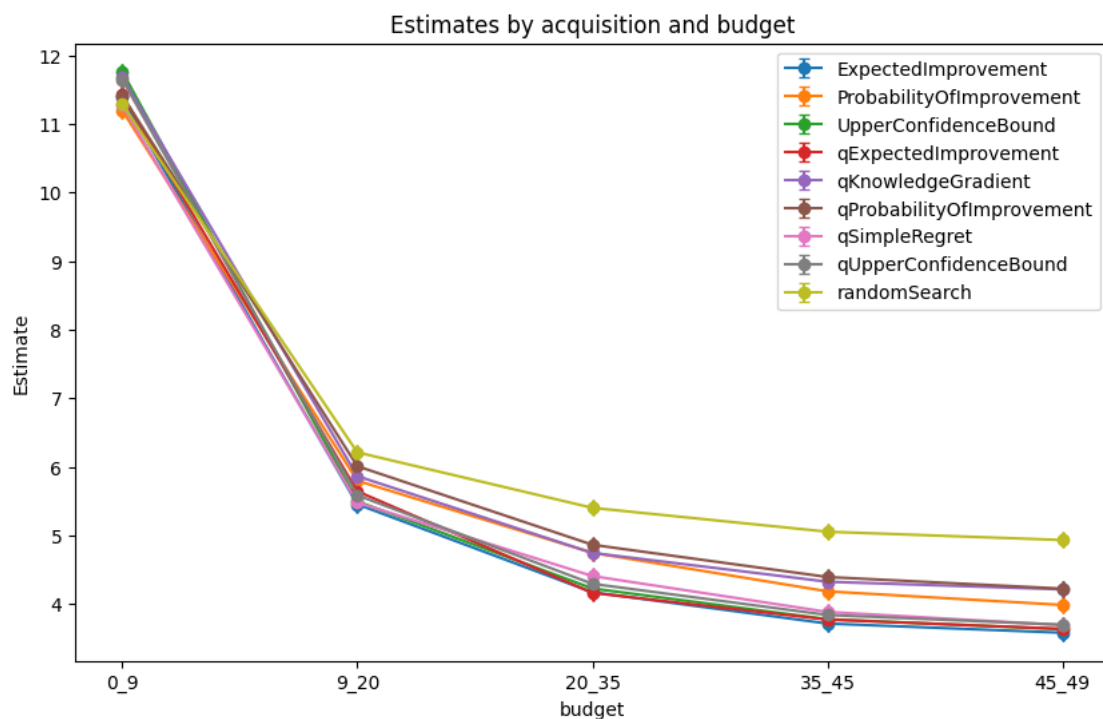
The best performing acquisition in budget-class 0_9 is ProbabilityOfImprovement, but ['ExpectedImprovement', 'qExpectedImprovement', 'qProbabilityOfImprovement', 'qSimpleRegret', 'qUpperConfidenceBound', 'randomSearch'] are only insignificantly worse.

The best performing acquisition in budget-class 9_20 is ExpectedImprovement, but ['ProbabilityOfImprovement', 'UpperConfidenceBound', 'qExpectedImprovement', 'qKnowledgeGradient', 'qSimpleRegret', 'qUpperConfidenceBound'] are only insignificantly worse.

The best performing acquisition in budget-class 20_35 is qExpectedImprovement, but ['ExpectedImprovement', 'UpperConfidenceBound', 'qSimpleRegret', 'qUpperConfidenceBound'] are only insignificantly worse.

The best performing acquisition in budget-class 35_45 is ExpectedImprovement, but ['ProbabilityOfImprovement', 'UpperConfidenceBound', 'qExpectedImprovement', 'qSimpleRegret', 'qUpperConfidenceBound'] are only insignificantly worse.

The best performing acquisition in budget-class 45_49 is ExpectedImprovement, but ['ProbabilityOfImprovement', 'UpperConfidenceBound', 'qExpectedImprovement', 'qKnowledgeGradient', 'qProbabilityOfImprovement', 'qSimpleRegret', 'qUpperConfidenceBound'] are only insignificantly worse.



```
[ ]: ({'chi_square': 152.49639868503436, 'df': 32, 'p': 0.0},
      (
          acquisition budget_bins Estimate 2.5_ci 97.5_ci SE
DF
  1      ExpectedImprovement      0_9    11.384 -2.084 24.852 4.881
4.065
  2      ProbabilityOfImprovement      0_9    11.197 -2.271 24.666 4.881
4.065
  3      UpperConfidenceBound      0_9    11.763 -1.705 25.232 4.881
4.065
  4      qExpectedImprovement      0_9    11.418 -2.051 24.886 4.881
4.065
  5      qKnowledgeGradient      0_9    11.688 -1.780 25.156 4.881
4.065
  6      qProbabilityOfImprovement      0_9    11.416 -2.052 24.884 4.881
4.065
  7      qSimpleRegret      0_9    11.271 -2.197 24.740 4.881
4.065
  8      qUpperConfidenceBound      0_9    11.648 -1.821 25.116 4.881
4.065
  9      randomSearch      0_9    11.289 -2.180 24.757 4.881
4.065
 10      ExpectedImprovement      9_20     5.456 -8.013 18.924 4.881
4.064
 11      ProbabilityOfImprovement      9_20     5.799 -7.669 19.268 4.881
```


4.064						
12	UpperConfidenceBound	9_20	5.499	-7.969	18.968	4.881
4.064						
13	qExpectedImprovement	9_20	5.646	-7.822	19.115	4.881
4.064						
14	qKnowledgeGradient	9_20	5.866	-7.603	19.334	4.881
4.064						
15	qProbabilityOfImprovement	9_20	6.011	-7.457	19.480	4.881
4.064						
16	qSimpleRegret	9_20	5.481	-7.987	18.950	4.881
4.064						
17	qUpperConfidenceBound	9_20	5.588	-7.881	19.056	4.881
4.064						
18	randomSearch	9_20	6.213	-7.256	19.681	4.881
4.064						
19	ExpectedImprovement	20_35	4.174	-9.295	17.643	4.881
4.063						
20	ProbabilityOfImprovement	20_35	4.749	-8.720	18.218	4.881
4.063						
21	UpperConfidenceBound	20_35	4.229	-9.239	17.698	4.881
4.063						
22	qExpectedImprovement	20_35	4.165	-9.304	17.634	4.881
4.063						
23	qKnowledgeGradient	20_35	4.747	-8.722	18.216	4.881
4.063						
24	qProbabilityOfImprovement	20_35	4.866	-8.603	18.335	4.881
4.063						
25	qSimpleRegret	20_35	4.410	-9.059	17.879	4.881
4.063						
26	qUpperConfidenceBound	20_35	4.297	-9.172	17.766	4.881
4.063						
27	randomSearch	20_35	5.404	-8.065	18.873	4.881
4.063						
28	ExpectedImprovement	35_45	3.718	-9.750	17.186	4.881
4.065						
29	ProbabilityOfImprovement	35_45	4.187	-9.281	17.656	4.881
4.065						
30	UpperConfidenceBound	35_45	3.781	-9.687	17.250	4.881
4.065						
31	qExpectedImprovement	35_45	3.776	-9.693	17.244	4.881
4.065						
32	qKnowledgeGradient	35_45	4.327	-9.141	17.796	4.881
4.065						
33	qProbabilityOfImprovement	35_45	4.396	-9.073	17.864	4.881
4.065						
34	qSimpleRegret	35_45	3.887	-9.581	17.355	4.881
4.065						

35	qUpperConfidenceBound	35_45	3.843	-9.625	17.312	4.881
4.065						
36	randomSearch	35_45	5.056	-8.412	18.525	4.881
4.065						
37	ExpectedImprovement	45_49	3.584	-9.882	17.049	4.883
4.070						
38	ProbabilityOfImprovement	45_49	3.989	-9.476	17.455	4.883
4.070						
39	UpperConfidenceBound	45_49	3.635	-9.831	17.100	4.883
4.070						
40	qExpectedImprovement	45_49	3.640	-9.825	17.106	4.883
4.070						
41	qKnowledgeGradient	45_49	4.216	-9.249	17.682	4.883
4.070						
42	qProbabilityOfImprovement	45_49	4.226	-9.239	17.692	4.883
4.070						
43	qSimpleRegret	45_49	3.695	-9.771	17.161	4.883
4.070						
44	qUpperConfidenceBound	45_49	3.701	-9.765	17.166	4.883
4.070						
45	randomSearch	45_49	4.935	-8.531	18.401	4.883
4.070,						

						Contrast	budget_bins	Estimate
2.5_ci	97.5_ci	SE	DF	T-stat	P-val	Sig		
1	ExpectedImprovement - ProbabilityOfImprovement						0_9	0.187
-0.283	0.656	0.151	179996.0	1.233	0.949			
2	ExpectedImprovement - UpperConfidenceBound						0_9	-0.380
-0.849	0.090	0.151	179996.0	-2.508	0.228			
3	ExpectedImprovement - qExpectedImprovement						0_9	-0.034
-0.503	0.436	0.151	179996.0	-0.223	1.000			
4	ExpectedImprovement - qKnowledgeGradient						0_9	-0.304
-0.774	0.165	0.151	179996.0	-2.010	0.536			
5	ExpectedImprovement - qProbabilityOfImprovement						0_9	-0.032
-0.502	0.437	0.151	179996.0	-0.212	1.000			
6	ExpectedImprovement - qSimpleRegret						0_9	0.112
-0.357	0.582	0.151	179996.0	0.743	0.998			
7	ExpectedImprovement - qUpperConfidenceBound						0_9	-0.264
-0.733	0.206	0.151	179996.0	-1.743	0.720			
8	ExpectedImprovement - randomSearch						0_9	0.095
-0.374	0.564	0.151	179996.0	0.628	0.999			
9	ProbabilityOfImprovement - UpperConfidenceBound						0_9	-0.566
-1.036	-0.097	0.151	179996.0	-3.742	0.006	**		
10	ProbabilityOfImprovement - qExpectedImprovement						0_9	-0.220
-0.690	0.249	0.151	179996.0	-1.457	0.875			
11	ProbabilityOfImprovement - qKnowledgeGradient						0_9	-0.491
-0.960	-0.021	0.151	179996.0	-3.244	0.032	*		
12	ProbabilityOfImprovement - qProbabilityOfImpro...						0_9	-0.219

-0.688	0.251	0.151	179996.0	-1.446	0.880		
13	ProbabilityOfImprovement - qSimpleRegret					0_9	-0.074
-0.544	0.395	0.151	179996.0	-0.490	1.000		
14	ProbabilityOfImprovement - qUpperConfidenceBound					0_9	-0.450
-0.920	0.019	0.151	179996.0	-2.977	0.072	.	
15	ProbabilityOfImprovement - randomSearch					0_9	-0.092
-0.561	0.378	0.151	179996.0	-0.605	1.000		
16	UpperConfidenceBound - qExpectedImprovement					0_9	0.346
-0.124	0.815	0.151	179996.0	2.285	0.351		
17	UpperConfidenceBound - qKnowledgeGradient					0_9	0.075
-0.394	0.545	0.151	179996.0	0.498	1.000		
18	UpperConfidenceBound - qProbabilityOfImprovement					0_9	0.347
-0.122	0.817	0.151	179996.0	2.296	0.345		
19	UpperConfidenceBound - qSimpleRegret					0_9	0.492
0.023	0.961	0.151	179996.0	3.252	0.032	*	
20	UpperConfidenceBound - qUpperConfidenceBound					0_9	0.116
-0.354	0.585	0.151	179996.0	0.765	0.998		
21	UpperConfidenceBound - randomSearch					0_9	0.475
0.005	0.944	0.151	179996.0	3.137	0.045	*	
22	qExpectedImprovement - qKnowledgeGradient					0_9	-0.270
-0.740	0.199	0.151	179996.0	-1.787	0.691		
23	qExpectedImprovement - qProbabilityOfImprovement					0_9	0.002
-0.468	0.471	0.151	179996.0	0.011	1.000		
24	qExpectedImprovement - qSimpleRegret					0_9	0.146
-0.323	0.616	0.151	179996.0	0.966	0.989		
25	qExpectedImprovement - qUpperConfidenceBound					0_9	-0.230
-0.699	0.239	0.151	179996.0	-1.520	0.846		
26	qExpectedImprovement - randomSearch					0_9	0.129
-0.341	0.598	0.151	179996.0	0.851	0.995		
27	qKnowledgeGradient - qProbabilityOfImprovement					0_9	0.272
-0.197	0.741	0.151	179996.0	1.798	0.684		
28	qKnowledgeGradient - qSimpleRegret					0_9	0.417
-0.053	0.886	0.151	179996.0	2.753	0.130		
29	qKnowledgeGradient - qUpperConfidenceBound					0_9	0.040
-0.429	0.510	0.151	179996.0	0.267	1.000		
30	qKnowledgeGradient - randomSearch					0_9	0.399
-0.070	0.869	0.151	179996.0	2.638	0.171		
31	qProbabilityOfImprovement - qSimpleRegret					0_9	0.145
-0.325	0.614	0.151	179996.0	0.956	0.990		
32	qProbabilityOfImprovement - qUpperConfidenceBound					0_9	-0.232
-0.701	0.238	0.151	179996.0	-1.531	0.841		
33	qProbabilityOfImprovement - randomSearch					0_9	0.127
-0.342	0.597	0.151	179996.0	0.841	0.996		
34	qSimpleRegret - qUpperConfidenceBound					0_9	-0.376
-0.846	0.093	0.151	179996.0	-2.487	0.238		
35	qSimpleRegret - randomSearch					0_9	-0.017
-0.487	0.452	0.151	179996.0	-0.115	1.000		

36	qUpperConfidenceBound - randomSearch					0_9	0.359
-0.110	0.828	0.151	179996.0	2.372	0.300		
37	ExpectedImprovement - ProbabilityOfImprovement					9_20	-0.344
-0.791	0.104	0.144	179996.0	-2.381	0.294		
38	ExpectedImprovement - UpperConfidenceBound					9_20	-0.043
-0.491	0.404	0.144	179996.0	-0.300	1.000		
39	ExpectedImprovement - qExpectedImprovement					9_20	-0.190
-0.638	0.257	0.144	179996.0	-1.318	0.926		
40	ExpectedImprovement - qKnowledgeGradient					9_20	-0.410
-0.857	0.038	0.144	179996.0	-2.839	0.104		
41	ExpectedImprovement - qProbabilityOfImprovement					9_20	-0.555
-1.003	-0.108	0.144	179996.0	-3.848	0.004	**	
42	ExpectedImprovement - qSimpleRegret					9_20	-0.025
-0.473	0.422	0.144	179996.0	-0.176	1.000		
43	ExpectedImprovement - qUpperConfidenceBound					9_20	-0.132
-0.579	0.316	0.144	179996.0	-0.912	0.992		
44	ExpectedImprovement - randomSearch					9_20	-0.757
-1.204	-0.309	0.144	179996.0	-5.246	0.000	***	
45	ProbabilityOfImprovement - UpperConfidenceBound					9_20	0.300
-0.147	0.748	0.144	179996.0	2.081	0.486		
46	ProbabilityOfImprovement - qExpectedImprovement					9_20	0.153
-0.294	0.601	0.144	179996.0	1.062	0.979		
47	ProbabilityOfImprovement - qKnowledgeGradient					9_20	-0.066
-0.514	0.381	0.144	179996.0	-0.458	1.000		
48	ProbabilityOfImprovement - qProbabilityOfImpro...					9_20	-0.212
-0.659	0.236	0.144	179996.0	-1.467	0.871		
49	ProbabilityOfImprovement - qSimpleRegret					9_20	0.318
-0.129	0.766	0.144	179996.0	2.205	0.402		
50	ProbabilityOfImprovement - qUpperConfidenceBound					9_20	0.212
-0.236	0.659	0.144	179996.0	1.469	0.870		
51	ProbabilityOfImprovement - randomSearch					9_20	-0.413
-0.861	0.034	0.144	179996.0	-2.866	0.097	.	
52	UpperConfidenceBound - qExpectedImprovement					9_20	-0.147
-0.594	0.301	0.144	179996.0	-1.019	0.984		
53	UpperConfidenceBound - qKnowledgeGradient					9_20	-0.366
-0.814	0.081	0.144	179996.0	-2.539	0.213		
54	UpperConfidenceBound - qProbabilityOfImprovement					9_20	-0.512
-0.959	-0.064	0.144	179996.0	-3.548	0.012	*	
55	UpperConfidenceBound - qSimpleRegret					9_20	0.018
-0.430	0.465	0.144	179996.0	0.124	1.000		
56	UpperConfidenceBound - qUpperConfidenceBound					9_20	-0.088
-0.536	0.359	0.144	179996.0	-0.612	1.000		
57	UpperConfidenceBound - randomSearch					9_20	-0.714
-1.161	-0.266	0.144	179996.0	-4.947	0.000	***	
58	qExpectedImprovement - qKnowledgeGradient					9_20	-0.219
-0.667	0.228	0.144	179996.0	-1.521	0.846		
59	qExpectedImprovement - qProbabilityOfImprovement					9_20	-0.365

-0.813	0.083	0.144	179996.0	-2.530	0.218		
60			qExpectedImprovement - qSimpleRegret	9_20	0.165		
-0.283	0.612	0.144	179996.0	1.142	0.968		
61			qExpectedImprovement - qUpperConfidenceBound	9_20	0.059		
-0.389	0.506	0.144	179996.0	0.407	1.000		
62			qExpectedImprovement - randomSearch	9_20	-0.567		
-1.014	-0.119	0.144	179996.0	-3.928	0.003	**	
63			qKnowledgeGradient - qProbabilityOfImprovement	9_20	-0.146		
-0.593	0.302	0.144	179996.0	-1.009	0.985		
64			qKnowledgeGradient - qSimpleRegret	9_20	0.384		
-0.063	0.832	0.144	179996.0	2.663	0.161		
65			qKnowledgeGradient - qUpperConfidenceBound	9_20	0.278		
-0.169	0.726	0.144	179996.0	1.927	0.595		
66			qKnowledgeGradient - randomSearch	9_20	-0.347		
-0.795	0.100	0.144	179996.0	-2.407	0.280		
67			qProbabilityOfImprovement - qSimpleRegret	9_20	0.530		
0.082	0.977	0.144	179996.0	3.672	0.007	**	
68			qProbabilityOfImprovement - qUpperConfidenceBound	9_20	0.424		
-0.024	0.871	0.144	179996.0	2.936	0.080	.	
69			qProbabilityOfImprovement - randomSearch	9_20	-0.202		
-0.649	0.246	0.144	179996.0	-1.398	0.899		
70			qSimpleRegret - qUpperConfidenceBound	9_20	-0.106		
-0.554	0.341	0.144	179996.0	-0.736	0.998		
71			qSimpleRegret - randomSearch	9_20	-0.732		
-1.179	-0.284	0.144	179996.0	-5.070	0.000	***	
72			qUpperConfidenceBound - randomSearch	9_20	-0.625		
-1.073	-0.178	0.144	179996.0	-4.335	0.000	***	
73			ExpectedImprovement - ProbabilityOfImprovement	20_35	-0.575		
-0.958	-0.192	0.124	179996.0	-4.652	0.000	***	
74			ExpectedImprovement - UpperConfidenceBound	20_35	-0.055		
-0.439	0.328	0.124	179996.0	-0.448	1.000		
75			ExpectedImprovement - qExpectedImprovement	20_35	0.009		
-0.374	0.392	0.124	179996.0	0.074	1.000		
76			ExpectedImprovement - qKnowledgeGradient	20_35	-0.573		
-0.956	-0.190	0.124	179996.0	-4.636	0.000	***	
77			ExpectedImprovement - qProbabilityOfImprovement	20_35	-0.692		
-1.075	-0.309	0.124	179996.0	-5.603	0.000	***	
78			ExpectedImprovement - qSimpleRegret	20_35	-0.236		
-0.619	0.148	0.124	179996.0	-1.907	0.609		
79			ExpectedImprovement - qUpperConfidenceBound	20_35	-0.123		
-0.506	0.261	0.124	179996.0	-0.992	0.987		
80			ExpectedImprovement - randomSearch	20_35	-1.230		
-1.613	-0.847	0.124	179996.0	-9.954	0.000	***	
81			ProbabilityOfImprovement - UpperConfidenceBound	20_35	0.519		
0.136	0.903	0.124	179996.0	4.204	0.001	***	
82			ProbabilityOfImprovement - qExpectedImprovement	20_35	0.584		
0.201	0.967	0.124	179996.0	4.726	0.000	***	

83	ProbabilityOfImprovement - qKnowledgeGradient					20_35	0.002
-0.381	0.385	0.124	179996.0	0.016	1.000		
84	ProbabilityOfImprovement - qProbabilityOfImpro...					20_35	-0.117
-0.501	0.266	0.124	179996.0	-0.951	0.990		
85	ProbabilityOfImprovement - qSimpleRegret					20_35	0.339
-0.044	0.722	0.124	179996.0	2.745	0.132		
86	ProbabilityOfImprovement - qUpperConfidenceBound					20_35	0.452
0.069	0.835	0.124	179996.0	3.660	0.008	**	
87	ProbabilityOfImprovement - randomSearch					20_35	-0.655
-1.038	-0.272	0.124	179996.0	-5.302	0.000	***	
88	UpperConfidenceBound - qExpectedImprovement					20_35	0.065
-0.319	0.448	0.124	179996.0	0.522	1.000		
89	UpperConfidenceBound - qKnowledgeGradient					20_35	-0.517
-0.901	-0.134	0.124	179996.0	-4.188	0.001	***	
90	UpperConfidenceBound - qProbabilityOfImprovement					20_35	-0.637
-1.020	-0.254	0.124	179996.0	-5.154	0.000	***	
91	UpperConfidenceBound - qSimpleRegret					20_35	-0.180
-0.563	0.203	0.124	179996.0	-1.459	0.874		
92	UpperConfidenceBound - qUpperConfidenceBound					20_35	-0.067
-0.450	0.316	0.124	179996.0	-0.544	1.000		
93	UpperConfidenceBound - randomSearch					20_35	-1.174
-1.558	-0.791	0.124	179996.0	-9.506	0.000	***	
94	qExpectedImprovement - qKnowledgeGradient					20_35	-0.582
-0.965	-0.199	0.124	179996.0	-4.710	0.000	***	
95	qExpectedImprovement - qProbabilityOfImprovement					20_35	-0.701
-1.085	-0.318	0.124	179996.0	-5.677	0.000	***	
96	qExpectedImprovement - qSimpleRegret					20_35	-0.245
-0.628	0.138	0.124	179996.0	-1.981	0.557		
97	qExpectedImprovement - qUpperConfidenceBound					20_35	-0.132
-0.515	0.251	0.124	179996.0	-1.066	0.979		
98	qExpectedImprovement - randomSearch					20_35	-1.239
-1.622	-0.856	0.124	179996.0	-10.028	0.000	***	
99	qKnowledgeGradient - qProbabilityOfImprovement					20_35	-0.119
-0.503	0.264	0.124	179996.0	-0.967	0.989		
100	qKnowledgeGradient - qSimpleRegret					20_35	0.337
-0.046	0.720	0.124	179996.0	2.729	0.138		
101	qKnowledgeGradient - qUpperConfidenceBound					20_35	0.450
0.067	0.833	0.124	179996.0	3.644	0.008	**	
102	qKnowledgeGradient - randomSearch					20_35	-0.657
-1.040	-0.274	0.124	179996.0	-5.318	0.000	***	
103	qProbabilityOfImprovement - qSimpleRegret					20_35	0.457
0.073	0.840	0.124	179996.0	3.695	0.007	**	
104	qProbabilityOfImprovement - qUpperConfidenceBound					20_35	0.570
0.186	0.953	0.124	179996.0	4.611	0.000	***	
105	qProbabilityOfImprovement - randomSearch					20_35	-0.538
-0.921	-0.154	0.124	179996.0	-4.351	0.000	***	
106	qSimpleRegret - qUpperConfidenceBound					20_35	0.113

-0.270	0.496	0.124	179996.0	0.915	0.992		
107			qSimpleRegret - randomSearch			20_35	-0.994
-1.377	-0.611	0.124	179996.0	-8.047	0.000	***	
108			qUpperConfidenceBound - randomSearch			20_35	-1.107
-1.491	-0.724	0.124	179996.0	-8.962	0.000	***	
109			ExpectedImprovement - ProbabilityOfImprovement			35_45	-0.469
-0.939	0.000	0.151	179996.0	-3.101	0.050	.	
110			ExpectedImprovement - UpperConfidenceBound			35_45	-0.063
-0.532	0.406	0.151	179996.0	-0.417	1.000		
111			ExpectedImprovement - qExpectedImprovement			35_45	-0.058
-0.527	0.412	0.151	179996.0	-0.381	1.000		
112			ExpectedImprovement - qKnowledgeGradient			35_45	-0.609
-1.079	-0.140	0.151	179996.0	-4.026	0.002	**	
113			ExpectedImprovement - qProbabilityOfImprovement			35_45	-0.677
-1.147	-0.208	0.151	179996.0	-4.477	0.000	***	
114			ExpectedImprovement - qSimpleRegret			35_45	-0.169
-0.638	0.301	0.151	179996.0	-1.116	0.972		
115			ExpectedImprovement - qUpperConfidenceBound			35_45	-0.125
-0.594	0.344	0.151	179996.0	-0.826	0.996		
116			ExpectedImprovement - randomSearch			35_45	-1.338
-1.808	-0.869	0.151	179996.0	-8.844	0.000	***	
117			ProbabilityOfImprovement - UpperConfidenceBound			35_45	0.406
-0.063	0.876	0.151	179996.0	2.684	0.153		
118			ProbabilityOfImprovement - qExpectedImprovement			35_45	0.412
-0.058	0.881	0.151	179996.0	2.721	0.140		
119			ProbabilityOfImprovement - qKnowledgeGradient			35_45	-0.140
-0.609	0.329	0.151	179996.0	-0.925	0.992		
120			ProbabilityOfImprovement - qProbabilityOfImpro...			35_45	-0.208
-0.678	0.261	0.151	179996.0	-1.376	0.907		
121			ProbabilityOfImprovement - qSimpleRegret			35_45	0.300
-0.169	0.770	0.151	179996.0	1.986	0.553		
122			ProbabilityOfImprovement - qUpperConfidenceBound			35_45	0.344
-0.125	0.814	0.151	179996.0	2.275	0.357		
123			ProbabilityOfImprovement - randomSearch			35_45	-0.869
-1.338	-0.400	0.151	179996.0	-5.743	0.000	***	
124			UpperConfidenceBound - qExpectedImprovement			35_45	0.005
-0.464	0.475	0.151	179996.0	0.036	1.000		
125			UpperConfidenceBound - qKnowledgeGradient			35_45	-0.546
-1.015	-0.077	0.151	179996.0	-3.609	0.009	**	
126			UpperConfidenceBound - qProbabilityOfImprovement			35_45	-0.614
-1.084	-0.145	0.151	179996.0	-4.060	0.002	**	
127			UpperConfidenceBound - qSimpleRegret			35_45	-0.106
-0.575	0.364	0.151	179996.0	-0.699	0.999		
128			UpperConfidenceBound - qUpperConfidenceBound			35_45	-0.062
-0.531	0.407	0.151	179996.0	-0.409	1.000		
129			UpperConfidenceBound - randomSearch			35_45	-1.275
-1.745	-0.806	0.151	179996.0	-8.427	0.000	***	

130	qExpectedImprovement - qKnowledgeGradient					35_45	-0.552
-1.021	-0.082	0.151	179996.0	-3.645	0.008	**	
131	qExpectedImprovement - qProbabilityOfImprovement					35_45	-0.620
-1.089	-0.151	0.151	179996.0	-4.096	0.001	**	
132	qExpectedImprovement - qSimpleRegret					35_45	-0.111
-0.581	0.358	0.151	179996.0	-0.735	0.998		
133	qExpectedImprovement - qUpperConfidenceBound					35_45	-0.067
-0.537	0.402	0.151	179996.0	-0.446	1.000		
134	qExpectedImprovement - randomSearch					35_45	-1.281
-1.750	-0.811	0.151	179996.0	-8.463	0.000	***	
135	qKnowledgeGradient - qProbabilityOfImprovement					35_45	-0.068
-0.538	0.401	0.151	179996.0	-0.451	1.000		
136	qKnowledgeGradient - qSimpleRegret					35_45	0.440
-0.029	0.910	0.151	179996.0	2.910	0.086	.	
137	qKnowledgeGradient - qUpperConfidenceBound					35_45	0.484
0.015	0.954	0.151	179996.0	3.200	0.037	*	
138	qKnowledgeGradient - randomSearch					35_45	-0.729
-1.198	-0.260	0.151	179996.0	-4.818	0.000	***	
139	qProbabilityOfImprovement - qSimpleRegret					35_45	0.509
0.039	0.978	0.151	179996.0	3.361	0.022	*	
140	qProbabilityOfImprovement - qUpperConfidenceBound					35_45	0.552
0.083	1.022	0.151	179996.0	3.651	0.008	**	
141	qProbabilityOfImprovement - randomSearch					35_45	-0.661
-1.130	-0.191	0.151	179996.0	-4.367	0.000	***	
142	qSimpleRegret - qUpperConfidenceBound					35_45	0.044
-0.426	0.513	0.151	179996.0	0.289	1.000		
143	qSimpleRegret - randomSearch					35_45	-1.169
-1.639	-0.700	0.151	179996.0	-7.728	0.000	***	
144	qUpperConfidenceBound - randomSearch					35_45	-1.213
-1.683	-0.744	0.151	179996.0	-8.018	0.000	***	
145	ExpectedImprovement - ProbabilityOfImprovement					45_49	-0.406
-1.148	0.336	0.239	179996.0	-1.696	0.749		
146	ExpectedImprovement - UpperConfidenceBound					45_49	-0.051
-0.793	0.691	0.239	179996.0	-0.213	1.000		
147	ExpectedImprovement - qExpectedImprovement					45_49	-0.056
-0.799	0.686	0.239	179996.0	-0.236	1.000		
148	ExpectedImprovement - qKnowledgeGradient					45_49	-0.633
-1.375	0.109	0.239	179996.0	-2.645	0.168		
149	ExpectedImprovement - qProbabilityOfImprovement					45_49	-0.643
-1.385	0.099	0.239	179996.0	-2.686	0.153		
150	ExpectedImprovement - qSimpleRegret					45_49	-0.111
-0.853	0.631	0.239	179996.0	-0.464	1.000		
151	ExpectedImprovement - qUpperConfidenceBound					45_49	-0.117
-0.859	0.625	0.239	179996.0	-0.488	1.000		
152	ExpectedImprovement - randomSearch					45_49	-1.351
-2.093	-0.609	0.239	179996.0	-5.647	0.000	***	
153	ProbabilityOfImprovement - UpperConfidenceBound					45_49	0.355

-0.387	1.097	0.239	179996.0	1.483	0.864		
154	ProbabilityOfImprovement - qExpectedImprovement			45_49	0.349		
-0.393	1.091	0.239	179996.0	1.460	0.874		
155	ProbabilityOfImprovement - qKnowledgeGradient			45_49	-0.227		
-0.969	0.515	0.239	179996.0	-0.949	0.990		
156	ProbabilityOfImprovement - qProbabilityOfImpro...			45_49	-0.237		
-0.979	0.505	0.239	179996.0	-0.991	0.987		
157	ProbabilityOfImprovement - qSimpleRegret			45_49	0.295		
-0.447	1.037	0.239	179996.0	1.231	0.950		
158	ProbabilityOfImprovement - qUpperConfidenceBound			45_49	0.289		
-0.453	1.031	0.239	179996.0	1.208	0.955		
159	ProbabilityOfImprovement - randomSearch			45_49	-0.945		
-1.687	-0.203	0.239	179996.0	-3.951	0.003	**	
160	UpperConfidenceBound - qExpectedImprovement			45_49	-0.006		
-0.748	0.737	0.239	179996.0	-0.023	1.000		
161	UpperConfidenceBound - qKnowledgeGradient			45_49	-0.582		
-1.324	0.160	0.239	179996.0	-2.432	0.267		
162	UpperConfidenceBound - qProbabilityOfImprovement			45_49	-0.592		
-1.334	0.150	0.239	179996.0	-2.474	0.245		
163	UpperConfidenceBound - qSimpleRegret			45_49	-0.060		
-0.802	0.682	0.239	179996.0	-0.252	1.000		
164	UpperConfidenceBound - qUpperConfidenceBound			45_49	-0.066		
-0.808	0.676	0.239	179996.0	-0.275	1.000		
165	UpperConfidenceBound - randomSearch			45_49	-1.300		
-2.042	-0.558	0.239	179996.0	-5.434	0.000	***	
166	qExpectedImprovement - qKnowledgeGradient			45_49	-0.576		
-1.318	0.166	0.239	179996.0	-2.408	0.279		
167	qExpectedImprovement - qProbabilityOfImprovement			45_49	-0.586		
-1.328	0.156	0.239	179996.0	-2.450	0.257		
168	qExpectedImprovement - qSimpleRegret			45_49	-0.055		
-0.797	0.688	0.239	179996.0	-0.228	1.000		
169	qExpectedImprovement - qUpperConfidenceBound			45_49	-0.060		
-0.802	0.682	0.239	179996.0	-0.252	1.000		
170	qExpectedImprovement - randomSearch			45_49	-1.295		
-2.037	-0.552	0.239	179996.0	-5.411	0.000	***	
171	qKnowledgeGradient - qProbabilityOfImprovement			45_49	-0.010		
-0.752	0.732	0.239	179996.0	-0.042	1.000		
172	qKnowledgeGradient - qSimpleRegret			45_49	0.522		
-0.221	1.264	0.239	179996.0	2.180	0.419		
173	qKnowledgeGradient - qUpperConfidenceBound			45_49	0.516		
-0.226	1.258	0.239	179996.0	2.156	0.435		
174	qKnowledgeGradient - randomSearch			45_49	-0.718		
-1.460	0.024	0.239	179996.0	-3.002	0.067	.	
175	qProbabilityOfImprovement - qSimpleRegret			45_49	0.532		
-0.210	1.274	0.239	179996.0	2.222	0.391		
176	qProbabilityOfImprovement - qUpperConfidenceBound			45_49	0.526		
-0.216	1.268	0.239	179996.0	2.198	0.407		

```

177          qProbabilityOfImprovement - randomSearch      45_49      -0.708
-1.450    0.034  0.239 179996.0 -2.961  0.075      .
178          qSimpleRegret - qUpperConfidenceBound      45_49      -0.006
-0.748    0.736  0.239 179996.0 -0.024  1.000
179          qSimpleRegret - randomSearch      45_49      -1.240
-1.982   -0.498  0.239 179996.0 -5.182  0.000 ***
180          qUpperConfidenceBound - randomSearch      45_49      -1.234
-1.976   -0.492  0.239 179996.0 -5.159  0.000 ***)

```

```

[ ]: # Third Analysis: Analyse performance of acquisition functions on each
      ↪ benchmark seperately over all training grounds
      # without showing plots.
conduct_analysis(
  data,
  "mean",
  "acquisition",
  "benchmark",
  subset=("benchmark", "all"),
  show_plots=False,
)

```

Analysis for Branin

boundary (singular) fit: see help('isSingular')

boundary (singular) fit: see help('isSingular')

P-value: 2.2334027233172904e-06

As the p-value 2.2334027233172904e-06 is smaller than 0.05, we can reject the Null-Hypothesis that the model that does not consider the acquisition describes the data as well as the one that does. Therefore there is significant difference within acquisition.

P-values adjusted by tukey method for family of 36 estimates

	acquisition	Estimate	2.5_ci	97.5_ci	SE	DF
1	ExpectedImprovement	3.562	3.215	3.908	0.177	45000.0
2	ProbabilityOfImprovement	3.361	3.014	3.707	0.177	45000.0
3	UpperConfidenceBound	3.735	3.388	4.082	0.177	45000.0
4	qExpectedImprovement	3.465	3.118	3.812	0.177	45000.0
5	qKnowledgeGradient	3.937	3.590	4.284	0.177	45000.0
6	qProbabilityOfImprovement	4.582	4.235	4.929	0.177	45000.0
7	qSimpleRegret	3.702	3.355	4.049	0.177	45000.0
8	qUpperConfidenceBound	3.566	3.219	3.913	0.177	45000.0
9	randomSearch	4.267	3.920	4.614	0.177	45000.0

	acquisition_1	acquisition_2	Estimate	2.5_ci	
97.5_ci	SE	DF	T-stat	P-val	Sig
1	ExpectedImprovement	ProbabilityOfImprovement	0.201	-0.575	
0.977	0.25	45000.0	0.803	0.997	

2	ExpectedImprovement	UpperConfidenceBound	-0.173	-0.950
0.603	0.25 45000.0 -0.692	0.999		
3	ExpectedImprovement	qExpectedImprovement	0.097	-0.680
0.873	0.25 45000.0 0.387	1.000		
4	ExpectedImprovement	qKnowledgeGradient	-0.375	-1.152
0.401	0.25 45000.0 -1.500	0.856		
5	ExpectedImprovement	qProbabilityOfImprovement	-1.021	-1.797
-0.244	0.25 45000.0 -4.078	0.001 **		
6	ExpectedImprovement	qSimpleRegret	-0.141	-0.917
0.636	0.25 45000.0 -0.561	1.000		
7	ExpectedImprovement	qUpperConfidenceBound	-0.004	-0.781
0.772	0.25 45000.0 -0.017	1.000		
8	ExpectedImprovement	randomSearch	-0.706	-1.482
0.071	0.25 45000.0 -2.819	0.110		
9	ProbabilityOfImprovement	UpperConfidenceBound	-0.374	-1.151
0.402	0.25 45000.0 -1.495	0.858		
10	ProbabilityOfImprovement	qExpectedImprovement	-0.104	-0.881
0.672	0.25 45000.0 -0.416	1.000		
11	ProbabilityOfImprovement	qKnowledgeGradient	-0.576	-1.353
0.200	0.25 45000.0 -2.302	0.340		
12	ProbabilityOfImprovement	qProbabilityOfImprovement	-1.222	-1.998
-0.445	0.25 45000.0 -4.881	0.000 ***		
13	ProbabilityOfImprovement	qSimpleRegret	-0.341	-1.118
0.435	0.25 45000.0 -1.364	0.911		
14	ProbabilityOfImprovement	qUpperConfidenceBound	-0.205	-0.981
0.571	0.25 45000.0 -0.819	0.996		
15	ProbabilityOfImprovement	randomSearch	-0.906	-1.683
-0.130	0.25 45000.0 -3.621	0.009 **		
16	UpperConfidenceBound	qExpectedImprovement	0.270	-0.506
1.046	0.25 45000.0 1.079	0.977		
17	UpperConfidenceBound	qKnowledgeGradient	-0.202	-0.978
0.574	0.25 45000.0 -0.807	0.997		
18	UpperConfidenceBound	qProbabilityOfImprovement	-0.847	-1.624
-0.071	0.25 45000.0 -3.386	0.020 *		
19	UpperConfidenceBound	qSimpleRegret	0.033	-0.744
0.809	0.25 45000.0 0.131	1.000		
20	UpperConfidenceBound	qUpperConfidenceBound	0.169	-0.607
0.946	0.25 45000.0 0.676	0.999		
21	UpperConfidenceBound	randomSearch	-0.532	-1.309
0.244	0.25 45000.0 -2.126	0.455		
22	qExpectedImprovement	qKnowledgeGradient	-0.472	-1.248
0.304	0.25 45000.0 -1.886	0.623		
23	qExpectedImprovement	qProbabilityOfImprovement	-1.118	-1.894
-0.341	0.25 45000.0 -4.465	0.000 ***		
24	qExpectedImprovement	qSimpleRegret	-0.237	-1.014
0.539	0.25 45000.0 -0.948	0.990		
25	qExpectedImprovement	qUpperConfidenceBound	-0.101	-0.877
0.675	0.25 45000.0 -0.403	1.000		

26	qExpectedImprovement	randomSearch	-0.802	-1.579
-0.026	0.25	45000.0	-3.205	0.036 *
27	qKnowledgeGradient	qProbabilityOfImprovement	-0.645	-1.422
0.131	0.25	45000.0	-2.579	0.195
28	qKnowledgeGradient	qSimpleRegret	0.235	-0.542
1.011	0.25	45000.0	0.938	0.991
29	qKnowledgeGradient	qUpperConfidenceBound	0.371	-0.405
1.148	0.25	45000.0	1.483	0.864
30	qKnowledgeGradient	randomSearch	-0.330	-1.107
0.446	0.25	45000.0	-1.319	0.926
31	qProbabilityOfImprovement	qSimpleRegret	0.880	0.104
1.657	0.25	45000.0	3.517	0.013 *
32	qProbabilityOfImprovement	qUpperConfidenceBound	1.017	0.240
1.793	0.25	45000.0	4.062	0.002 **
33	qProbabilityOfImprovement	randomSearch	0.315	-0.461
1.092	0.25	45000.0	1.260	0.943
34	qSimpleRegret	qUpperConfidenceBound	0.136	-0.640
0.913	0.25	45000.0	0.545	1.000
35	qSimpleRegret	randomSearch	-0.565	-1.341
0.211	0.25	45000.0	-2.257	0.368
36	qUpperConfidenceBound	randomSearch	-0.701	-1.478
0.075	0.25	45000.0	-2.802	0.115

The best performing acquisition is ProbabilityOfImprovement, but
 ['ExpectedImprovement', 'UpperConfidenceBound', 'qExpectedImprovement',
 'qKnowledgeGradient', 'qSimpleRegret', 'qUpperConfidenceBound'] are only
 insignificantly worse.

Analysis for Hartmann6

boundary (singular) fit: see help('isSingular')

boundary (singular) fit: see help('isSingular')

P-value: 0.0

As the p-value 0.0 is smaller than 0.05, we can reject the Null-Hypothesis that
 the model that does not consider the acquisition describes the data as well as
 the one that does. Therefore there is significant difference within acquisition.

P-values adjusted by tukey method for family of 36 estimates

	acquisition	Estimate	2.5_ci	97.5_ci	SE	DF
1	ExpectedImprovement	-2.413	-2.440	-2.385	0.014	45000.0
2	ProbabilityOfImprovement	-1.541	-1.568	-1.513	0.014	45000.0
3	UpperConfidenceBound	-2.335	-2.363	-2.307	0.014	45000.0
4	qExpectedImprovement	-2.464	-2.491	-2.436	0.014	45000.0
5	qKnowledgeGradient	-2.483	-2.511	-2.455	0.014	45000.0
6	qProbabilityOfImprovement	-2.264	-2.292	-2.237	0.014	45000.0
7	qSimpleRegret	-1.937	-1.964	-1.909	0.014	45000.0
8	qUpperConfidenceBound	-2.337	-2.365	-2.309	0.014	45000.0

9		randomSearch	-1.390	-1.418	-1.362	0.014	45000.0		
		acquisition_1						acquisition_2	Estimate 2.5_ci
97.5_ci	SE	DF	T-stat	P-val	Sig				
1		ExpectedImprovement		ProbabilityOfImprovement		-0.872	-0.934		
-0.810	0.02	45000.0	-43.656	0.000	***				
2		ExpectedImprovement		UpperConfidenceBound		-0.078	-0.140		
-0.016	0.02	45000.0	-3.889	0.003	**				
3		ExpectedImprovement		qExpectedImprovement		0.051	-0.011		
0.113	0.02	45000.0	2.556	0.206					
4		ExpectedImprovement		qKnowledgeGradient		0.070	0.008		
0.132	0.02	45000.0	3.523	0.013	*				
5		ExpectedImprovement		qProbabilityOfImprovement		-0.149	-0.210		
-0.087	0.02	45000.0	-7.434	0.000	***				
6		ExpectedImprovement		qSimpleRegret		-0.476	-0.538		
-0.414	0.02	45000.0	-23.826	0.000	***				
7		ExpectedImprovement		qUpperConfidenceBound		-0.076	-0.138		
-0.014	0.02	45000.0	-3.787	0.005	**				
8		ExpectedImprovement		randomSearch		-1.023	-1.085		
-0.961	0.02	45000.0	-51.203	0.000	***				
9		ProbabilityOfImprovement		UpperConfidenceBound		0.794	0.732		
0.856	0.02	45000.0	39.767	0.000	***				
10		ProbabilityOfImprovement		qExpectedImprovement		0.923	0.861		
0.985	0.02	45000.0	46.212	0.000	***				
11		ProbabilityOfImprovement		qKnowledgeGradient		0.942	0.881		
1.004	0.02	45000.0	47.179	0.000	***				
12		ProbabilityOfImprovement		qProbabilityOfImprovement		0.724	0.662		
0.786	0.02	45000.0	36.222	0.000	***				
13		ProbabilityOfImprovement		qSimpleRegret		0.396	0.334		
0.458	0.02	45000.0	19.830	0.000	***				
14		ProbabilityOfImprovement		qUpperConfidenceBound		0.796	0.734		
0.858	0.02	45000.0	39.869	0.000	***				
15		ProbabilityOfImprovement		randomSearch		-0.151	-0.213		
-0.089	0.02	45000.0	-7.547	0.000	***				
16		UpperConfidenceBound		qExpectedImprovement		0.129	0.067		
0.191	0.02	45000.0	6.444	0.000	***				
17		UpperConfidenceBound		qKnowledgeGradient		0.148	0.086		
0.210	0.02	45000.0	7.412	0.000	***				
18		UpperConfidenceBound		qProbabilityOfImprovement		-0.071	-0.133		
-0.009	0.02	45000.0	-3.545	0.012	*				
19		UpperConfidenceBound		qSimpleRegret		-0.398	-0.460		
-0.336	0.02	45000.0	-19.938	0.000	***				
20		UpperConfidenceBound		qUpperConfidenceBound		0.002	-0.060		
0.064	0.02	45000.0	0.102	1.000					
21		UpperConfidenceBound		randomSearch		-0.945	-1.007		
-0.883	0.02	45000.0	-47.315	0.000	***				
22		qExpectedImprovement		qKnowledgeGradient		0.019	-0.043		
0.081	0.02	45000.0	0.967	0.989					
23		qExpectedImprovement		qProbabilityOfImprovement		-0.200	-0.262		

-0.138	0.02	45000.0	-9.989	0.000	***		
24	qExpectedImprovement					qSimpleRegret	-0.527 -0.589
-0.465	0.02	45000.0	-26.382	0.000	***		
25	qExpectedImprovement					qUpperConfidenceBound	-0.127 -0.189
-0.065	0.02	45000.0	-6.343	0.000	***		
26	qExpectedImprovement					randomSearch	-1.074 -1.136
-1.012	0.02	45000.0	-53.759	0.000	***		
27	qKnowledgeGradient					qProbabilityOfImprovement	-0.219 -0.281
-0.157	0.02	45000.0	-10.957	0.000	***		
28	qKnowledgeGradient					qSimpleRegret	-0.546 -0.608
-0.484	0.02	45000.0	-27.349	0.000	***		
29	qKnowledgeGradient					qUpperConfidenceBound	-0.146 -0.208
-0.084	0.02	45000.0	-7.310	0.000	***		
30	qKnowledgeGradient					randomSearch	-1.093 -1.155
-1.031	0.02	45000.0	-54.726	0.000	***		
31	qProbabilityOfImprovement					qSimpleRegret	-0.327 -0.389
-0.266	0.02	45000.0	-16.393	0.000	***		
32	qProbabilityOfImprovement					qUpperConfidenceBound	0.073 0.011
0.135	0.02	45000.0	3.647	0.008	**		
33	qProbabilityOfImprovement					randomSearch	-0.874 -0.936
-0.812	0.02	45000.0	-43.770	0.000	***		
34	qSimpleRegret					qUpperConfidenceBound	0.400 0.338
0.462	0.02	45000.0	20.039	0.000	***		
35	qSimpleRegret					randomSearch	-0.547 -0.609
-0.485	0.02	45000.0	-27.377	0.000	***		
36	qUpperConfidenceBound					randomSearch	-0.947 -1.009
-0.885	0.02	45000.0	-47.416	0.000	***		

The best performing acquisition is qKnowledgeGradient, but ['qExpectedImprovement'] are only insignificantly worse.

Analysis for Jahs_Bench

boundary (singular) fit: see help('isSingular')

boundary (singular) fit: see help('isSingular')

P-value: 0.0

As the p-value 0.0 is smaller than 0.05, we can reject the Null-Hypothesis that the model that does not consider the acquisition describes the data as well as the one that does. Therefore there is significant difference within acquisition.

P-values adjusted by tukey method for family of 36 estimates

	acquisition	Estimate	2.5_ci	97.5_ci	SE	DF
1	ExpectedImprovement	21.886	21.679	22.094	0.106	45000.0
2	ProbabilityOfImprovement	22.563	22.356	22.770	0.106	45000.0
3	UpperConfidenceBound	22.110	21.903	22.317	0.106	45000.0
4	qExpectedImprovement	22.282	22.075	22.489	0.106	45000.0
5	qKnowledgeGradient	23.563	23.356	23.770	0.106	45000.0

6	qProbabilityOfImprovement	22.809	22.602	23.016	0.106	45000.0		
7	qSimpleRegret	21.656	21.449	21.863	0.106	45000.0		
8	qUpperConfidenceBound	22.418	22.211	22.626	0.106	45000.0		
9	randomSearch	23.727	23.519	23.934	0.106	45000.0		
	acquisition_1			acquisition_2	Estimate	2.5_ci		
97.5_ci	SE	DF	T-stat	P-val	Sig			
1	ExpectedImprovement	ProbabilityOfImprovement	-0.677	-1.140				
-0.213	0.149	45000.0	-4.530	0.000	***			
2	ExpectedImprovement	UpperConfidenceBound	-0.224	-0.687				
0.240	0.149	45000.0	-1.499	0.857				
3	ExpectedImprovement	qExpectedImprovement	-0.395	-0.859				
0.068	0.149	45000.0	-2.647	0.167				
4	ExpectedImprovement	qKnowledgeGradient	-1.676	-2.140				
-1.213	0.149	45000.0	-11.219	0.000	***			
5	ExpectedImprovement	qProbabilityOfImprovement	-0.922	-1.386				
-0.459	0.149	45000.0	-6.173	0.000	***			
6	ExpectedImprovement	qSimpleRegret	0.231	-0.233				
0.694	0.149	45000.0	1.544	0.835				
7	ExpectedImprovement	qUpperConfidenceBound	-0.532	-0.995				
-0.069	0.149	45000.0	-3.561	0.011	*			
8	ExpectedImprovement	randomSearch	-1.840	-2.303				
-1.377	0.149	45000.0	-12.316	0.000	***			
9	ProbabilityOfImprovement	UpperConfidenceBound	0.453	-0.011				
0.916	0.149	45000.0	3.031	0.062	.			
10	ProbabilityOfImprovement	qExpectedImprovement	0.281	-0.182				
0.745	0.149	45000.0	1.883	0.626				
11	ProbabilityOfImprovement	qKnowledgeGradient	-0.999	-1.463				
-0.536	0.149	45000.0	-6.689	0.000	***			
12	ProbabilityOfImprovement	qProbabilityOfImprovement	-0.245	-0.709				
0.218	0.149	45000.0	-1.643	0.781				
13	ProbabilityOfImprovement	qSimpleRegret	0.907	0.444				
1.371	0.149	45000.0	6.074	0.000	***			
14	ProbabilityOfImprovement	qUpperConfidenceBound	0.145	-0.319				
0.608	0.149	45000.0	0.969	0.989				
15	ProbabilityOfImprovement	randomSearch	-1.163	-1.627				
-0.700	0.149	45000.0	-7.786	0.000	***			
16	UpperConfidenceBound	qExpectedImprovement	-0.172	-0.635				
0.292	0.149	45000.0	-1.148	0.967				
17	UpperConfidenceBound	qKnowledgeGradient	-1.452	-1.916				
-0.989	0.149	45000.0	-9.720	0.000	***			
18	UpperConfidenceBound	qProbabilityOfImprovement	-0.698	-1.162				
-0.235	0.149	45000.0	-4.674	0.000	***			
19	UpperConfidenceBound	qSimpleRegret	0.455	-0.009				
0.918	0.149	45000.0	3.043	0.059	.			
20	UpperConfidenceBound	qUpperConfidenceBound	-0.308	-0.771				
0.155	0.149	45000.0	-2.062	0.500				
21	UpperConfidenceBound	randomSearch	-1.616	-2.080				
-1.153	0.149	45000.0	-10.817	0.000	***			

22	qExpectedImprovement	qKnowledgeGradient	-1.281	-1.744
-0.817	0.149	45000.0 -8.572	0.000	***
23	qExpectedImprovement	qProbabilityOfImprovement	-0.527	-0.990
-0.063	0.149	45000.0 -3.526	0.013	*
24	qExpectedImprovement	qSimpleRegret	0.626	0.163
1.089	0.149	45000.0 4.191	0.001	***
25	qExpectedImprovement	qUpperConfidenceBound	-0.137	-0.600
0.327	0.149	45000.0 -0.914	0.992	
26	qExpectedImprovement	randomSearch	-1.445	-1.908
-0.981	0.149	45000.0 -9.669	0.000	***
27	qKnowledgeGradient	qProbabilityOfImprovement	0.754	0.290
1.217	0.149	45000.0 5.046	0.000	***
28	qKnowledgeGradient	qSimpleRegret	1.907	1.443
2.370	0.149	45000.0 12.763	0.000	***
29	qKnowledgeGradient	qUpperConfidenceBound	1.144	0.681
1.608	0.149	45000.0 7.658	0.000	***
30	qKnowledgeGradient	randomSearch	-0.164	-0.627
0.299	0.149	45000.0 -1.097	0.975	
31	qProbabilityOfImprovement	qSimpleRegret	1.153	0.689
1.616	0.149	45000.0 7.717	0.000	***
32	qProbabilityOfImprovement	qUpperConfidenceBound	0.390	-0.073
0.854	0.149	45000.0 2.612	0.181	
33	qProbabilityOfImprovement	randomSearch	-0.918	-1.381
-0.454	0.149	45000.0 -6.143	0.000	***
34	qSimpleRegret	qUpperConfidenceBound	-0.763	-1.226
-0.299	0.149	45000.0 -5.105	0.000	***
35	qSimpleRegret	randomSearch	-2.071	-2.534
-1.607	0.149	45000.0 -13.860	0.000	***
36	qUpperConfidenceBound	randomSearch	-1.308	-1.771
-0.845	0.149	45000.0 -8.755	0.000	***

The best performing acquisition is qSimpleRegret, but ['ExpectedImprovement', 'UpperConfidenceBound'] are only insignificantly worse.

Analysis for NN_HPO_Bench

boundary (singular) fit: see help('isSingular')

boundary (singular) fit: see help('isSingular')

P-value: 0.0005685529942927037

As the p-value 0.0005685529942927037 is smaller than 0.05, we can reject the Null-Hypothesis that the model that does not consider the acquisition describes the data as well as the one that does. Therefore there is significant difference within acquisition.

P-values adjusted by tukey method for family of 36 estimates

	acquisition	Estimate	2.5_ci	97.5_ci	SE	DF
1	ExpectedImprovement	0.003	0.003	0.004	0.0	45000.0

2	ProbabilityOfImprovement	0.003	0.003	0.004	0.0	45000.0		
3	UpperConfidenceBound	0.003	0.003	0.004	0.0	45000.0		
4	qExpectedImprovement	0.003	0.003	0.004	0.0	45000.0		
5	qKnowledgeGradient	0.003	0.003	0.004	0.0	45000.0		
6	qProbabilityOfImprovement	0.004	0.004	0.005	0.0	45000.0		
7	qSimpleRegret	0.003	0.003	0.004	0.0	45000.0		
8	qUpperConfidenceBound	0.003	0.002	0.003	0.0	45000.0		
9	randomSearch	0.004	0.003	0.004	0.0	45000.0		
	acquisition_1						acquisition_2	Estimate 2.5_ci
97.5_ci	SE	DF	T-stat	P-val	Sig			
1	ExpectedImprovement	ProbabilityOfImprovement	-0.000	-0.001				
0.001	0.0	45000.0	-0.243	1.000				
2	ExpectedImprovement	UpperConfidenceBound	-0.000	-0.001				
0.001	0.0	45000.0	-0.120	1.000				
3	ExpectedImprovement	qExpectedImprovement	0.000	-0.001				
0.001	0.0	45000.0	0.071	1.000				
4	ExpectedImprovement	qKnowledgeGradient	0.000	-0.001				
0.001	0.0	45000.0	0.022	1.000				
5	ExpectedImprovement	qProbabilityOfImprovement	-0.001	-0.002				
-0.000	0.0	45000.0	-3.337	0.024	*			
6	ExpectedImprovement	qSimpleRegret	0.000	-0.001				
0.001	0.0	45000.0	0.205	1.000				
7	ExpectedImprovement	qUpperConfidenceBound	0.000	-0.001				
0.002	0.0	45000.0	1.408	0.895				
8	ExpectedImprovement	randomSearch	-0.000	-0.001				
0.001	0.0	45000.0	-1.327	0.923				
9	ProbabilityOfImprovement	UpperConfidenceBound	0.000	-0.001				
0.001	0.0	45000.0	0.123	1.000				
10	ProbabilityOfImprovement	qExpectedImprovement	0.000	-0.001				
0.001	0.0	45000.0	0.315	1.000				
11	ProbabilityOfImprovement	qKnowledgeGradient	0.000	-0.001				
0.001	0.0	45000.0	0.265	1.000				
12	ProbabilityOfImprovement	qProbabilityOfImprovement	-0.001	-0.002				
0.000	0.0	45000.0	-3.094	0.051	.			
13	ProbabilityOfImprovement	qSimpleRegret	0.000	-0.001				
0.001	0.0	45000.0	0.448	1.000				
14	ProbabilityOfImprovement	qUpperConfidenceBound	0.001	-0.000				
0.002	0.0	45000.0	1.651	0.776				
15	ProbabilityOfImprovement	randomSearch	-0.000	-0.001				
0.001	0.0	45000.0	-1.084	0.977				
16	UpperConfidenceBound	qExpectedImprovement	0.000	-0.001				
0.001	0.0	45000.0	0.192	1.000				
17	UpperConfidenceBound	qKnowledgeGradient	0.000	-0.001				
0.001	0.0	45000.0	0.143	1.000				
18	UpperConfidenceBound	qProbabilityOfImprovement	-0.001	-0.002				
-0.000	0.0	45000.0	-3.217	0.035	*			
19	UpperConfidenceBound	qSimpleRegret	0.000	-0.001				
0.001	0.0	45000.0	0.326	1.000				

20	UpperConfidenceBound	qUpperConfidenceBound	0.001	-0.001
0.002	0.0 45000.0 1.528 0.843			
21	UpperConfidenceBound	randomSearch	-0.000	-0.001
0.001	0.0 45000.0 -1.207 0.955			
22	qExpectedImprovement	qKnowledgeGradient	-0.000	-0.001
0.001	0.0 45000.0 -0.049 1.000			
23	qExpectedImprovement	qProbabilityOfImprovement	-0.001	-0.002
-0.000	0.0 45000.0 -3.409 0.019 *			
24	qExpectedImprovement	qSimpleRegret	0.000	-0.001
0.001	0.0 45000.0 0.134 1.000			
25	qExpectedImprovement	qUpperConfidenceBound	0.000	-0.001
0.001	0.0 45000.0 1.336 0.921			
26	qExpectedImprovement	randomSearch	-0.000	-0.002
0.001	0.0 45000.0 -1.399 0.899			
27	qKnowledgeGradient	qProbabilityOfImprovement	-0.001	-0.002
-0.000	0.0 45000.0 -3.360 0.022 *			
28	qKnowledgeGradient	qSimpleRegret	0.000	-0.001
0.001	0.0 45000.0 0.183 1.000			
29	qKnowledgeGradient	qUpperConfidenceBound	0.000	-0.001
0.002	0.0 45000.0 1.385 0.904			
30	qKnowledgeGradient	randomSearch	-0.000	-0.001
0.001	0.0 45000.0 -1.350 0.916			
31	qProbabilityOfImprovement	qSimpleRegret	0.001	0.000
0.002	0.0 45000.0 3.543 0.012 *			
32	qProbabilityOfImprovement	qUpperConfidenceBound	0.002	0.001
0.003	0.0 45000.0 4.745 0.000 ***			
33	qProbabilityOfImprovement	randomSearch	0.001	-0.000
0.002	0.0 45000.0 2.010 0.536			
34	qSimpleRegret	qUpperConfidenceBound	0.000	-0.001
0.001	0.0 45000.0 1.202 0.956			
35	qSimpleRegret	randomSearch	-0.001	-0.002
0.001	0.0 45000.0 -1.533 0.840			
36	qUpperConfidenceBound	randomSearch	-0.001	-0.002
0.000	0.0 45000.0 -2.735 0.136			

The best performing acquisition is ExpectedImprovement, but
 ['ProbabilityOfImprovement', 'UpperConfidenceBound', 'qExpectedImprovement',
 'qKnowledgeGradient', 'qSimpleRegret', 'qUpperConfidenceBound', 'randomSearch']
 are only insignificantly worse.