

Poker Cards Analysis - April 2021

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **April 01, 2021 to April 30, 2021** as recorded by the respective game servers and analyzed the Poker cards for statistical randomness. The results of the analysis are given below.

For details on the gaming sites serviced by the Entain Plc game servers and used in this audit refer to the [List](#).

1. Poker hand types statistics

These calculations were done for Royal Flush, Straight Flush, Four of a Kind, Full House, Flush, Straight, 3 of a Kind, 2 pairs, 1 Pair, High Card.

The Poker hand types analysis involved creating subsets of data and conducting Chi-square tests on each subset.

The null hypothesis for the chi-square test is that the observed frequencies of each type of hand matches the theoretical values for a deck that has been shuffled using a perfect random number generator. The p-values observed in these multiple tests are expected to follow a uniform distribution for the range 0.0 to 1.0.

The analysis performs a KS Test (Kolmogorov-Smirnov test) for uniform distribution on the observed p-values, and the combined p-value result of this test is taken as the final result of the Poker hand types statistics tests.

1.1 Poker hand types statistics for 52 cards deck:

Test No.	DOF	ChiSqr	P-Value
1	9	4.48	0.87674
2	9	3.38	0.94723
3	9	20.40	0.01558
4	9	17.50	0.04140
5	9	11.10	0.26899
6	9	9.08	0.42952
7	9	8.64	0.47131
8	9	4.58	0.86914
9	9	4.73	0.85717
10	9	13.98	0.12297
11	9	12.91	0.16665
12	9	12.19	0.20266
13	9	7.93	0.54130
14	9	4.46	0.87833
15	9	10.94	0.27990
16	9	3.23	0.95433
17	9	9.79	0.36772
18	9	5.64	0.77560
19	9	2.20	0.98787
20	9	5.60	0.77913
21	9	5.91	0.74899
22	9	12.79	0.17239
23	9	7.69	0.56551
24	9	6.44	0.69562

25	9	4.99	0.83559
26	9	10.50	0.31177
27	9	7.57	0.57847
28	9	6.40	0.69891
29	9	10.99	0.27636
30	9	7.28	0.60764
31	9	4.69	0.86060
32	9	7.93	0.54119
33	9	11.28	0.25695
34	9	17.02	0.04839
35	9	8.22	0.51188
36	9	10.61	0.30351
37	9	9.52	0.39102
38	9	5.55	0.78445
39	9	6.65	0.67371
40	9	5.39	0.79940
41	9	8.74	0.46129
42	9	10.70	0.29669
43	9	8.44	0.49062
44	9	14.19	0.11560
45	9	5.29	0.80877
46	9	5.38	0.80031
47	9	6.40	0.69927
48	9	16.20	0.06288
49	9	5.62	0.77686
50	9	3.97	0.91305
51	9	6.32	0.70762
52	9	9.95	0.35479
53	9	7.54	0.58147
54	9	7.54	0.58109
55	9	9.01	0.43606
56	9	7.42	0.59299
57	9	11.25	0.25891
58	9	24.90	0.00308
59	9	9.02	0.43569
60	9	2.67	0.97608
61	9	7.20	0.61589
62	9	20.11	0.01725
63	9	11.10	0.26902
64	9	12.55	0.18394
65	9	10.17	0.33653
66	9	8.79	0.45680
67	9	5.06	0.82924
68	9	10.92	0.28124
69	9	2.71	0.97479
70	9	6.26	0.71378
71	9	6.48	0.69121
72	9	3.94	0.91527
73	9	7.72	0.56307
74	9	5.20	0.81636
75	9	5.03	0.83135
76	9	12.99	0.16318
77	9	18.94	0.02569
78	9	4.31	0.88981
79	9	8.56	0.47839

80	9	11.97	0.21507
81	9	10.79	0.29043
82	9	10.67	0.29920
83	9	10.17	0.33692
84	9	23.54	0.00509
85	9	8.03	0.53117
86	9	6.53	0.68580
87	9	10.82	0.28809
88	9	7.48	0.58754
89	9	3.60	0.93590
90	9	10.76	0.29218
91	9	6.68	0.67026
92	9	9.48	0.39440
93	9	9.76	0.37038
94	9	8.51	0.48361
95	9	5.70	0.76981
96	9	6.51	0.68783
97	9	6.09	0.73119
98	9	4.87	0.84582
99	9	5.53	0.78628
100	9	14.02	0.12148
Combined P-value for all tests (Using KS method)			0.41962

Notes:

- 1) The P-values are observed probabilities from the Chi-Square tests. The last row shows the result of the KS Test performed on the p-values for all Chi-Square tests, where there are sufficient data.

1.2 Poker hand types statistics for 36 cards deck:

Test No.	DOF	ChiSqr	P-Value
1	9	15.30	0.08291
2	9	10.64	0.30129
Combined P-value for all tests (Using KS method)			N/A (Insufficient data)

Notes:

- 1) The P-values are observed probabilities from the Chi-Square tests. The last row shows the result of the KS Test performed on the p-values for all Chi-Square tests, where there are sufficient data.

2. Poker rank statistics

The Poker rank analysis aims to establish that the rank of the cards in each position was equally distributed in one of the 13 possible ranks (2, 3, 4, 5, 6, 7, 8, 9, 10, J, Q, K, A) for a 52 card deck and 9 ranks (6, 7, 8, 9, 10, J, Q, K, A) for a 36 card deck.

The Poker rank analysis involved creating subsets of data and conducting Chi-square tests on each subset. The analysis performs a KS Test (Kolmogorov-Smirnov test) for uniform distribution on the observed p-values, and the combined p-value result of this test is taken as the final result of the Ranks statistics tests.

2.1 Poker rank statistics for 52 cards deck:

Test No.	Positions	DOF	ChiSqr	P-Value
1	7	84	82.94	0.51220

2	7	84	85.68	0.42859
3	7	84	71.74	0.82746
4	7	84	62.62	0.96097
5	7	84	79.70	0.61261
6	7	84	80.03	0.60231
7	7	84	86.44	0.40597
8	7	84	62.47	0.96218
9	7	84	95.48	0.18431
10	7	84	93.76	0.21874
11	7	84	76.72	0.70075
12	7	84	78.00	0.66361
13	7	84	77.88	0.66714
14	7	84	86.01	0.41877
15	7	84	86.66	0.39949
16	7	84	105.60	0.05565
17	7	84	94.42	0.20504
18	7	84	80.67	0.58260
19	7	84	70.12	0.86089
20	7	84	74.34	0.76537
21	7	84	90.81	0.28669
22	7	84	77.25	0.68557
23	7	84	73.86	0.77775
24	7	84	93.24	0.22993
25	7	84	60.50	0.97524
26	7	84	79.78	0.60996
27	7	84	91.08	0.28015
28	7	84	95.60	0.18209
29	7	84	112.75	0.01988
30	7	84	98.30	0.13627
31	7	84	80.65	0.58338
32	7	84	96.35	0.16843
33	7	84	104.17	0.06716
34	7	84	77.85	0.66802
35	7	84	94.17	0.21021
36	7	84	85.37	0.43795
37	7	84	72.27	0.81563
38	7	84	106.21	0.05129
39	7	84	75.56	0.73316
40	7	84	67.66	0.90327
41	7	84	84.78	0.45573
42	7	84	102.50	0.08304
43	7	84	93.06	0.23391
44	7	84	83.78	0.48628
45	7	84	64.31	0.94576
46	7	84	89.41	0.32285
47	7	84	89.78	0.31294
48	7	84	71.29	0.83720
49	7	84	93.34	0.22775
50	7	84	88.41	0.34976
51	7	84	77.14	0.68890
52	7	84	71.02	0.84273
53	7	84	103.62	0.07212
54	7	84	69.43	0.87374
55	7	84	82.14	0.53715
56	7	84	97.52	0.14861

57	7	84	74.07	0.77225
58	7	84	83.80	0.48572
59	7	84	83.12	0.50648
60	7	84	81.19	0.56666
61	7	84	95.95	0.17557
62	7	84	76.19	0.71575
63	7	84	63.86	0.95015
64	7	84	78.96	0.63489
65	7	84	72.85	0.80216
66	7	84	74.34	0.76544
67	7	84	76.85	0.69720
68	7	84	56.25	0.99143
69	7	84	91.74	0.26401
70	7	84	76.74	0.70026
71	7	84	73.52	0.78608
72	7	84	92.73	0.24124
73	7	84	100.70	0.10345
74	7	84	87.07	0.38770
75	7	84	103.06	0.07743
76	7	84	107.19	0.04486
77	7	84	98.34	0.13578
78	7	84	82.30	0.53199
79	7	84	91.96	0.25877
80	7	84	68.92	0.88288
81	7	84	80.92	0.57482
82	7	84	96.50	0.16575
83	7	84	76.81	0.69837
84	7	84	90.56	0.29301
85	7	84	78.03	0.66281
86	7	84	73.63	0.78340
87	7	84	87.77	0.36775
88	7	84	107.66	0.04198
89	7	84	81.82	0.54692
90	7	84	81.85	0.54599
91	7	84	83.94	0.48136
92	7	84	83.06	0.50847
93	7	84	68.47	0.89039
94	7	84	97.41	0.15039
95	7	84	92.55	0.24526
96	7	84	84.96	0.45009
97	7	84	116.42	0.01110
98	7	84	97.49	0.14912
99	7	84	83.62	0.49106
100	7	84	99.24	0.12262
Combined P-value for all tests (Using KS method)				0.96459

Notes:

- 1) The P-values are observed probabilities from the Chi-Square tests. The last row shows the result of the KS Test performed on the p-values for all Chi-Square tests, where there are sufficient data.

2.2 Poker rank statistics for 36 cards deck:

Test No.	Positions	DOF	ChiSqr	P-Value
1	7	56	38.76	0.96166
2	7	56	64.26	0.20966
3	7	56	67.90	0.13237

4	7	56	45.63	0.83734
5	7	56	63.13	0.23907
6	7	56	54.60	0.52815
7	7	56	41.01	0.93359
8	7	56	56.94	0.44002
9	7	56	50.51	0.68196
10	7	56	53.10	0.58527
11	7	56	51.54	0.64434
12	7	56	43.80	0.88204
13	7	56	54.87	0.51784
14	7	56	61.83	0.27574
15	7	56	60.32	0.32247
16	7	56	95.42	0.00080
17	7	56	29.22	0.99882
18	7	56	55.59	0.49048
19	7	56	48.76	0.74276
20	7	56	52.67	0.60170
21	7	56	59.22	0.35884
22	7	56	59.94	0.33477
23	7	56	54.40	0.53572
24	7	56	75.84	0.03995
25	7	56	66.69	0.15519
26	7	56	64.69	0.19913
27	7	56	53.07	0.58664
28	7	56	70.29	0.09477
29	7	56	72.79	0.06515
30	7	56	60.77	0.30814
31	7	56	54.51	0.53159
32	7	56	56.36	0.46138
33	7	56	51.43	0.64835
34	7	56	52.81	0.59623
35	7	56	50.26	0.69101
36	7	56	67.02	0.14879
37	7	56	61.96	0.27203
38	7	56	60.70	0.31041
39	7	56	40.32	0.94331
40	7	56	67.97	0.13109
41	7	56	55.08	0.50961
42	7	56	64.37	0.20699
43	7	56	64.48	0.20435
44	7	56	58.16	0.39574
45	7	56	62.35	0.26058
46	7	56	72.31	0.07021
47	7	56	53.66	0.56395
48	7	56	76.77	0.03413
49	7	56	98.46	0.00040
50	7	56	46.64	0.80926
51	7	56	61.89	0.27415
52	7	56	61.15	0.29637
53	7	56	65.32	0.18443
54	7	56	61.42	0.28812
55	7	56	71.19	0.08306
56	7	56	49.95	0.70188
57	7	56	68.35	0.12454
58	7	56	51.77	0.63562

59	7	56	44.80	0.85855
60	7	56	54.63	0.52677
61	7	56	59.83	0.33833
62	7	56	46.88	0.80234
Combined P-value for all tests (Using KS method)				0.23308

Notes:

- 1) The P-values are observed probabilities from the Chi-Square tests. The last row shows the result of the KS Test performed on the p-values for all Chi-Square tests, where there are sufficient data.

3. Poker suits statistics

The Poker suits analysis aims to verify that that the cards dealt exhibit an equal probability of all 4 suits (Clubs, Diamonds, Hearts and Spades) in all positions.

The Poker suits analysis involved creating subsets of data and conducting Chi-square tests on each subset. The analysis performs a KS Test (Kolmogorov-Smirnov test) for uniform distribution on the observed p-values, and the combined p-value result of this test is taken as the final result of the Suits statistics tests.

3.1 Poker suits statistics for 52 cards deck:

Test No.	Positions	DOF	ChiSqr	P-Value
1	7	21	18.87	0.59337
2	7	21	13.86	0.87540
3	7	21	18.89	0.59203
4	7	21	27.52	0.15436
5	7	21	17.82	0.66036
6	7	21	20.94	0.46270
7	7	21	11.90	0.94226
8	7	21	23.65	0.31032
9	7	21	24.53	0.26825
10	7	21	27.77	0.14673
11	7	21	12.33	0.93030
12	7	21	26.25	0.19718
13	7	21	21.43	0.43308
14	7	21	20.95	0.46222
15	7	21	20.26	0.50458
16	7	21	18.60	0.61095
17	7	21	14.17	0.86232
18	7	21	18.12	0.64169
19	7	21	27.07	0.16852
20	7	21	18.27	0.63192
21	7	21	25.21	0.23825
22	7	21	18.79	0.59852
23	7	21	36.26	0.02042
24	7	21	11.06	0.96161
25	7	21	11.99	0.93993
26	7	21	20.36	0.49864
27	7	21	14.54	0.84539
28	7	21	38.72	0.01059
29	7	21	20.06	0.51773
30	7	21	23.76	0.30470
31	7	21	25.35	0.23233
32	7	21	14.83	0.83141
33	7	21	21.54	0.42644
34	7	21	21.85	0.40849
35	7	21	13.59	0.88674

36	7	21	30.71	0.07871
37	7	21	18.82	0.59671
38	7	21	25.41	0.22988
39	7	21	12.13	0.93600
40	7	21	28.57	0.12465
41	7	21	16.25	0.75571
42	7	21	19.80	0.53406
43	7	21	19.27	0.56769
44	7	21	24.16	0.28559
45	7	21	14.57	0.84380
46	7	21	20.86	0.46722
47	7	21	20.83	0.46915
48	7	21	23.88	0.29894
49	7	21	11.62	0.94924
50	7	21	23.23	0.33207
51	7	21	13.41	0.89364
52	7	21	15.74	0.78428
53	7	21	30.94	0.07469
54	7	21	17.35	0.68956
55	7	21	17.41	0.68613
56	7	21	18.88	0.59308
57	7	21	18.68	0.60587
58	7	21	21.55	0.42595
59	7	21	12.78	0.91612
60	7	21	20.36	0.49827
61	7	21	32.58	0.05112
62	7	21	23.43	0.32151
63	7	21	19.06	0.58148
64	7	21	8.42	0.99306
65	7	21	17.94	0.65271
66	7	21	20.08	0.51593
67	7	21	23.74	0.30592
68	7	21	17.87	0.65752
69	7	21	11.51	0.95180
70	7	21	24.07	0.28983
71	7	21	17.75	0.66482
72	7	21	22.37	0.37826
73	7	21	16.62	0.73411
74	7	21	43.62	0.00261
75	7	21	14.00	0.86959
76	7	21	16.31	0.75185
77	7	21	22.46	0.37348
78	7	21	14.06	0.86685
79	7	21	18.51	0.61633
80	7	21	25.54	0.22452
81	7	21	25.85	0.21219
82	7	21	13.16	0.90305
83	7	21	23.90	0.29799
84	7	21	32.85	0.04791
85	7	21	32.45	0.05263
86	7	21	23.58	0.31395
87	7	21	26.14	0.20098
88	7	21	28.56	0.12506
89	7	21	23.23	0.33171
90	7	21	31.42	0.06694

91	7	21	23.50	0.31802
92	7	21	25.78	0.21479
93	7	21	32.88	0.04752
94	7	21	17.79	0.66205
95	7	21	32.02	0.05822
96	7	21	19.69	0.54066
97	7	21	29.08	0.11218
98	7	21	23.39	0.32348
99	7	21	18.44	0.62101
100	7	21	37.26	0.01572
Combined P-value for all tests (Using KS method)				0.60753

Notes:

- 1) The P-values are observed probabilities from the Chi-Square tests. The last row shows the result of the KS Test performed on the p-values for all Chi-Square tests, where there are sufficient data.

3.2 Poker suits statistics for 36 cards deck:

Test No.	Positions	DOF	ChiSqr	P-Value
1	7	21	10.59	0.97016
2	7	21	19.54	0.55080
3	7	21	21.02	0.45797
4	7	21	32.86	0.04775
5	7	21	16.25	0.75556
6	7	21	23.14	0.33635
7	7	21	22.77	0.35647
8	7	21	12.74	0.91733
9	7	21	16.32	0.75141
10	7	21	18.76	0.60053
11	7	21	13.89	0.87436
12	7	21	27.14	0.16614
13	7	21	15.13	0.81647
14	7	21	17.02	0.71014
15	7	21	32.72	0.04942
16	7	21	13.93	0.87267
17	7	21	12.82	0.91493
18	7	21	19.47	0.55489
19	7	21	22.46	0.37365
20	7	21	23.34	0.32633
21	7	21	36.72	0.01812
22	7	21	28.87	0.11711
23	7	21	17.90	0.65558
24	7	21	15.75	0.78342
25	7	21	6.50	0.99893
26	7	21	40.38	0.00668
27	7	21	21.49	0.42951
28	7	21	16.62	0.73363
29	7	21	10.26	0.97528
30	7	21	22.84	0.35257
31	7	21	17.20	0.69891
32	7	21	22.70	0.36040
33	7	21	22.67	0.36171
34	7	21	28.06	0.13857
35	7	21	16.57	0.73694
36	7	21	11.56	0.95074
37	7	21	26.34	0.19393

38	7	21	25.14	0.24098
39	7	21	11.84	0.94384
40	7	21	29.50	0.10242
41	7	21	17.83	0.65961
42	7	21	19.74	0.53752
43	7	21	16.42	0.74584
44	7	21	19.05	0.58206
45	7	21	13.94	0.87199
46	7	21	18.70	0.60463
47	7	21	21.26	0.44293
48	7	21	14.75	0.83519
49	7	21	15.44	0.80024
50	7	21	18.62	0.60925
51	7	21	25.62	0.22147
52	7	21	13.31	0.89730
53	7	21	16.55	0.73788
54	7	21	20.35	0.49907
55	7	21	22.41	0.37633
56	7	21	24.80	0.25593
57	7	21	17.51	0.67964
58	7	21	32.18	0.05619
59	7	21	14.22	0.85979
60	7	21	11.98	0.94026
61	7	21	26.10	0.20281
62	7	21	17.76	0.66444
Combined P-value for all tests (Using KS method)				0.28361

Notes:

- 1) The P-values are observed probabilities from the Chi-Square tests. The last row shows the result of the KS Test performed on the p-values for all Chi-Square tests, where there are sufficient data.

4. Summary of the analysis

4.1 Summary of the analysis of 52 cards deck:

The analysis of 52 cards completes by combining the result of the KS Test performed in the 3 types of analysis (Hand Types, Ranks and Suits) for 52 card decks using the Holm's method and producing a single Combined P -value.

The combined p-value produced using the Holm's method is used as indication for statistical randomness.

Combination of p-values using Holm's Method		
Test	P-Value	P-Adjusted
Ranks Test	0.96459	1.00000
Suits Test	0.60753	1.00000
Hand Types Test	0.41962	1.00000
Combined P-Value using Holm's Method		1.00000

Notes:

- 1) The combined p-value of all statistical tests using Holm's Method conducted for 52 card decks is greater than the minimum value of 0.05 which indicates that the randomness of the observed data falls within 95% confidence limits.

The final outcome of the analysis of 52 cards deck indicates that the RNG is working correctly.

4.2 Summary of the analysis of 36 cards deck:

The analysis of 36 cards completes by combining the result of the KS Test performed in the 3 types of analysis (Hand Types, Ranks and Suits) for 36 card decks using the Holm's method and producing a single Combined P -value. Where there are insufficient data the individual Chi-Square tests results are used in the Holm's method for producing a combined p-value.

The combined p-value produced from the using the Holm's method is used as indication for statistical randomness.

Combination of p-values using Holm's Method		
Test	P-Value	P-Adjusted
Ranks Test	0.23308	0.69924
Suits Test	0.28361	0.69924
Hands Type Test	0.08291	0.33164
Hands Type Test	0.30129	0.69924
Combined P-Value using Holm's Method		0.33164

Notes:

- 1) The combined p-value of all statistical tests using Holm's Method conducted for 36 card decks is greater than the minimum value of 0.05 which indicates that the randomness of the observed data falls within 95% confidence limits.

The final outcome of the analysis of 36 cards deck indicates that the RNG is working correctly.

5. Conclusion

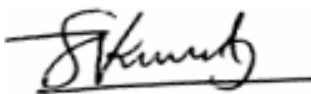
Analysis of actual data from game logs for 'Hand Types', 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

iTech Labs has done limited sanity checks to verify the integrity of the game logs. iTech Labs also maintains a copy of the game logs for verification purposes. There were a large enough number of game records to give the calculations sufficient statistical power.

We conclude that the Random Number Generator (RNG) is working correctly.

Please click here to see the [Original](#) report.

Signed:



Kiren Sreekumar
Principal Consultant
iTech Labs Australia
Date: 15 July 2021

Signed:



Geoff Nicoll
Principal Consultant
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Date: 15 July 2021

Disclaimer.

While it is not possible to test all possible scenarios in a laboratory environment, iTech Labs has conducted a level of testing appropriate for a component test of this type.