

Poker Cards Analysis - December 2021

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **December 01, 2021 to December 31, 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	7.67	0.56746
2	9	4.86	0.84619
3	9	6.17	0.72259
4	9	13.02	0.16164
5	9	10.36	0.32198
6	9	14.63	0.10163
7	9	8.57	0.47831
8	9	6.43	0.69633
9	9	14.46	0.10688
10	9	2.79	0.97200
11	9	5.98	0.74186
12	9	17.48	0.04171
13	9	23.96	0.00437
14	9	7.98	0.53658
15	9	12.96	0.16450
16	9	8.37	0.49715
17	9	15.48	0.07860
18	9	10.49	0.31192
19	9	5.36	0.80212
20	9	10.29	0.32788
21	9	5.43	0.79503
22	9	8.96	0.44135
23	9	10.27	0.32889
24	9	7.58	0.57706

25	9	9.82	0.36543
26	9	13.42	0.14445
27	9	8.92	0.44430
28	9	4.69	0.86026
29	9	5.68	0.77179
30	9	6.76	0.66197
31	9	6.20	0.71971
32	9	8.71	0.46476
33	9	4.66	0.86301
34	9	2.71	0.97455
35	9	7.53	0.58256
36	9	6.06	0.73426
37	9	2.32	0.98528
38	9	3.54	0.93887
39	9	4.45	0.87949
40	9	11.45	0.24603
41	9	8.65	0.46980
42	9	10.28	0.32853
43	9	4.78	0.85321
44	9	6.49	0.68961
45	9	4.42	0.88134
46	9	9.39	0.40171
47	9	14.45	0.10720
48	9	11.44	0.24660
49	9	5.14	0.82228
50	9	9.96	0.35373
51	9	5.45	0.79326
52	9	3.03	0.96296
53	9	8.97	0.44031
54	9	11.79	0.22533
55	9	7.33	0.60278
56	9	24.22	0.00396
57	9	4.88	0.84442
58	9	9.35	0.40530
59	9	5.64	0.77533
60	9	9.37	0.40427
61	9	3.13	0.95905
62	9	5.01	0.83319
63	9	8.55	0.47933
64	9	3.73	0.92824
65	9	8.06	0.52767
66	9	6.99	0.63799
67	9	11.05	0.27216
68	9	4.98	0.83569
69	9	4.06	0.90742
70	9	10.27	0.32937
71	9	13.83	0.12839
72	9	22.89	0.00645
73	9	8.74	0.46182
74	9	25.71	0.00227
75	9	10.39	0.32008
76	9	3.89	0.91829
77	9	13.86	0.12722
78	9	6.39	0.70032
79	9	10.05	0.34625

80	9	3.35	0.94874
81	9	12.34	0.19497
82	9	1.13	0.99909
83	9	7.12	0.62481
84	9	2.48	0.98147
85	9	7.27	0.60904
86	9	8.55	0.47965
87	9	8.96	0.44070
88	9	5.36	0.80173
89	9	6.87	0.65066
90	9	11.94	0.21650
91	9	6.90	0.64785
92	9	7.14	0.62246
93	9	9.90	0.35883
94	9	4.96	0.83805
95	9	6.23	0.71642
96	9	6.97	0.64002
97	9	11.82	0.22375
98	9	17.60	0.04016
99	9	13.48	0.14205
100	9	6.43	0.69602
Combined P-value for all tests (Using KS method)			0.49624

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	9.31	0.40872
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	71.23	0.83832
2	7	84	90.33	0.29870
3	7	84	73.59	0.78425
4	7	84	72.33	0.81433
5	7	84	97.53	0.14838

6	7	84	92.99	0.23529
7	7	84	79.18	0.62832
8	7	84	81.14	0.56805
9	7	84	73.89	0.77680
10	7	84	101.93	0.08907
11	7	84	100.49	0.10595
12	7	84	89.64	0.31662
13	7	84	78.02	0.66307
14	7	84	82.45	0.52748
15	7	84	77.42	0.68077
16	7	84	76.38	0.71053
17	7	84	85.78	0.42559
18	7	84	73.49	0.78691
19	7	84	76.80	0.69865
20	7	84	85.51	0.43359
21	7	84	111.22	0.02508
22	7	84	74.56	0.75968
23	7	84	114.96	0.01406
24	7	84	80.08	0.60098
25	7	84	77.66	0.67366
26	7	84	68.81	0.88475
27	7	84	103.79	0.07060
28	7	84	65.81	0.92881
29	7	84	110.73	0.02697
30	7	84	95.06	0.19232
31	7	84	64.04	0.94839
32	7	84	83.25	0.50258
33	7	84	75.01	0.74802
34	7	84	75.61	0.73185
35	7	84	98.46	0.13390
36	7	84	102.42	0.08386
37	7	84	94.36	0.20615
38	7	84	86.27	0.41115
39	7	84	67.04	0.91254
40	7	84	82.07	0.53911
41	7	84	78.75	0.64131
42	7	84	75.60	0.73196
43	7	84	89.48	0.32085
44	7	84	104.66	0.06300
45	7	84	94.32	0.20704
46	7	84	78.55	0.64727
47	7	84	88.25	0.35432
48	7	84	80.27	0.59489
49	7	84	81.54	0.55558
50	7	84	97.50	0.14894
51	7	84	89.76	0.31357
52	7	84	73.70	0.78158
53	7	84	117.68	0.00902
54	7	84	87.20	0.38383
55	7	84	92.86	0.23834
56	7	84	97.59	0.14749
57	7	84	73.25	0.79253
58	7	84	87.13	0.38601
59	7	84	86.25	0.41159
60	7	84	62.92	0.95853

61	7	84	122.62	0.00384
62	7	84	83.99	0.47977
63	7	84	57.75	0.98722
64	7	84	79.83	0.60850
65	7	84	95.90	0.17643
66	7	84	76.23	0.71456
67	7	84	95.49	0.18410
68	7	84	98.51	0.13323
69	7	84	59.96	0.97810
70	7	84	79.59	0.61591
71	7	84	100.49	0.10601
72	7	84	62.83	0.95926
73	7	84	94.28	0.20784
74	7	84	78.15	0.65914
75	7	84	79.51	0.61833
76	7	84	80.64	0.58374
77	7	84	70.73	0.84866
78	7	84	75.14	0.74441
79	7	84	101.54	0.09346
80	7	84	88.02	0.36066
81	7	84	65.85	0.92836
82	7	84	73.27	0.79224
83	7	84	110.53	0.02781
84	7	84	75.64	0.73089
85	7	84	85.53	0.43312
86	7	84	90.77	0.28765
87	7	84	102.91	0.07892
88	7	84	87.44	0.37703
89	7	84	88.20	0.35575
90	7	84	78.15	0.65923
91	7	84	89.49	0.32067
92	7	84	89.06	0.33212
93	7	84	82.45	0.52736
94	7	84	111.44	0.02428
95	7	84	62.17	0.96442
96	7	84	82.09	0.53871
97	7	84	97.20	0.15373
98	7	84	74.61	0.75860
99	7	84	95.62	0.18164
100	7	84	85.39	0.43712
Combined P-value for all tests (Using KS method)				0.73850

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	68.58	0.12062
2	7	56	50.40	0.68584
3	7	56	61.74	0.27840
4	7	56	67.72	0.13561
5	7	56	59.42	0.35214
6	7	56	53.39	0.57427
7	7	56	30.93	0.99739

8	7	56	52.81	0.59623
9	7	56	60.10	0.32947
10	7	56	49.90	0.70379
11	7	56	48.19	0.76170
12	7	56	85.75	0.00643
13	7	56	75.85	0.03983
14	7	56	85.81	0.00636
15	7	56	54.63	0.52677
16	7	56	55.91	0.47825
17	7	56	65.74	0.17519
18	7	56	70.36	0.09379
19	7	56	41.08	0.93250
20	7	56	40.03	0.94709
21	7	56	62.35	0.26058
22	7	56	77.53	0.02998
23	7	56	64.66	0.19999
24	7	56	59.02	0.36560
25	7	56	48.91	0.73793
26	7	56	53.52	0.56946
27	7	56	51.32	0.65235
28	7	56	51.55	0.64367
29	7	56	45.29	0.84631
30	7	56	69.09	0.11249
31	7	56	66.98	0.14949
32	7	56	50.05	0.69846
Combined P-value for all tests (Using KS method)				0.78870

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 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	15.47	0.79843
2	7	21	22.68	0.36108
3	7	21	27.71	0.14867
4	7	21	25.27	0.23565
5	7	21	16.03	0.76778
6	7	21	25.58	0.22276
7	7	21	17.33	0.69109
8	7	21	28.86	0.11744
9	7	21	40.57	0.00634
10	7	21	24.23	0.28197
11	7	21	35.92	0.02230
12	7	21	25.16	0.24020
13	7	21	26.31	0.19470
14	7	21	27.11	0.16734

15	7	21	16.06	0.76636
16	7	21	17.17	0.70101
17	7	21	21.98	0.40089
18	7	21	13.58	0.88687
19	7	21	12.48	0.92564
20	7	21	15.89	0.77577
21	7	21	16.17	0.76029
22	7	21	20.12	0.51352
23	7	21	15.34	0.80569
24	7	21	11.65	0.94864
25	7	21	21.61	0.42243
26	7	21	14.98	0.82419
27	7	21	7.80	0.99593
28	7	21	17.23	0.69738
29	7	21	34.05	0.03577
30	7	21	12.61	0.92156
31	7	21	27.84	0.14465
32	7	21	25.26	0.23607
33	7	21	11.49	0.95227
34	7	21	21.49	0.42944
35	7	21	26.99	0.17121
36	7	21	33.26	0.04346
37	7	21	15.77	0.78234
38	7	21	14.96	0.82519
39	7	21	14.44	0.85011
40	7	21	19.63	0.54469
41	7	21	25.71	0.21776
42	7	21	19.54	0.55031
43	7	21	28.52	0.12590
44	7	21	27.66	0.15000
45	7	21	30.01	0.09178
46	7	21	13.03	0.90746
47	7	21	18.58	0.61182
48	7	21	18.49	0.61762
49	7	21	24.17	0.28506
50	7	21	18.06	0.64526
51	7	21	19.84	0.53133
52	7	21	7.33	0.99739
53	7	21	27.39	0.15823
54	7	21	23.58	0.31368
55	7	21	16.98	0.71231
56	7	21	19.95	0.52474
57	7	21	28.37	0.13009
58	7	21	18.06	0.64524
59	7	21	18.92	0.59013
60	7	21	27.53	0.15402
61	7	21	17.43	0.68449
62	7	21	30.94	0.07469
63	7	21	22.87	0.35092
64	7	21	19.63	0.54467
65	7	21	23.60	0.31277
66	7	21	18.30	0.62969
67	7	21	19.64	0.54430
68	7	21	18.80	0.59776
69	7	21	26.03	0.20519

70	7	21	25.89	0.21077
71	7	21	21.97	0.40142
72	7	21	12.15	0.93554
73	7	21	20.11	0.51422
74	7	21	24.99	0.24747
75	7	21	21.37	0.43646
76	7	21	26.54	0.18657
77	7	21	17.98	0.65019
78	7	21	18.71	0.60374
79	7	21	21.98	0.40071
80	7	21	24.58	0.26560
81	7	21	21.31	0.44025
82	7	21	21.90	0.40516
83	7	21	21.05	0.45570
84	7	21	23.56	0.31505
85	7	21	24.19	0.28379
86	7	21	19.58	0.54778
87	7	21	18.42	0.62235
88	7	21	7.34	0.99737
89	7	21	15.16	0.81480
90	7	21	21.14	0.45035
91	7	21	14.43	0.85035
92	7	21	16.45	0.74375
93	7	21	29.59	0.10049
94	7	21	12.30	0.93108
95	7	21	19.74	0.53752
96	7	21	14.70	0.83771
97	7	21	14.46	0.84895
98	7	21	35.44	0.02523
99	7	21	22.01	0.39887
100	7	21	9.84	0.98091
Combined P-value for all tests (Using KS method)				0.99875

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	17.97	0.65103
2	7	21	35.42	0.02535
3	7	21	13.73	0.88100
4	7	21	15.65	0.78909
5	7	21	21.34	0.43812
6	7	21	19.78	0.53498
7	7	21	29.04	0.11304
8	7	21	24.33	0.27744
9	7	21	16.24	0.75602
10	7	21	25.01	0.24682
11	7	21	24.42	0.27334
12	7	21	14.78	0.83402
13	7	21	27.79	0.14615
14	7	21	14.15	0.86298
15	7	21	17.87	0.65709
16	7	21	21.90	0.40552

17	7	21	26.46	0.18931
18	7	21	22.59	0.36611
19	7	21	34.58	0.03141
20	7	21	13.43	0.89274
21	7	21	14.70	0.83751
22	7	21	15.42	0.80151
23	7	21	20.94	0.46237
24	7	21	26.14	0.20101
25	7	21	17.54	0.67815
26	7	21	20.75	0.47418
27	7	21	24.51	0.26892
28	7	21	15.40	0.80236
29	7	21	36.20	0.02076
30	7	21	32.22	0.05567
31	7	21	16.70	0.72936
32	7	21	31.00	0.07360
Combined P-value for all tests (Using KS method)				0.90642

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	0.73850	1.00000
Suits Test	0.99875	1.00000
Hand Types Test	0.49624	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	0.78870	1.00000
Suits Test	0.90642	1.00000
Hands Type Test	0.40872	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 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

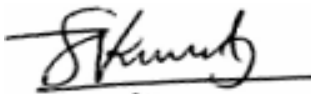
Analysis of actual data from game logs for 'Hand Types', 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

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: 1 February 2022

Signed:



Geoff Nicoll
Principal Consultant
iTech Labs Australia
Date: 1 February 2022

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.