

Poker Cards Analysis - July 2021

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **July 01, 2021 to July 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	5.26	0.81076
2	9	6.29	0.71019
3	9	6.68	0.67056
4	9	6.04	0.73609
5	9	7.59	0.57559
6	9	9.50	0.39242
7	9	11.72	0.22975
8	9	3.92	0.91649
9	9	3.60	0.93549
10	9	7.30	0.60631
11	9	1.94	0.99237
12	9	10.29	0.32781
13	9	6.24	0.71536
14	9	2.06	0.99055
15	9	21.33	0.01126
16	9	7.03	0.63418
17	9	6.95	0.64278
18	9	9.58	0.38560
19	9	12.38	0.19289
20	9	4.99	0.83484
21	9	14.70	0.09957
22	9	6.01	0.73932
23	9	4.37	0.88561
24	9	12.63	0.18015

25	9	7.10	0.62667
26	9	6.88	0.64934
27	9	12.86	0.16902
28	9	9.40	0.40159
29	9	12.81	0.17122
30	9	7.14	0.62205
31	9	11.16	0.26464
32	9	9.64	0.38069
33	9	6.38	0.70085
34	9	15.07	0.08909
35	9	1.68	0.99560
36	9	7.93	0.54128
37	9	11.24	0.25976
38	9	8.13	0.52158
39	9	8.66	0.46962
40	9	15.28	0.08350
41	9	8.17	0.51746
42	9	11.96	0.21559
43	9	9.61	0.38276
44	9	7.43	0.59211
45	9	15.44	0.07950
46	9	2.56	0.97910
47	9	14.15	0.11696
48	9	11.47	0.24484
49	9	13.65	0.13534
50	9	9.42	0.39984
51	9	6.95	0.64184
52	9	5.68	0.77110
53	9	14.73	0.09852
54	9	7.77	0.55700
55	9	6.53	0.68619
56	9	17.11	0.04702
57	9	5.88	0.75228
58	9	16.97	0.04911
59	9	14.70	0.09950
60	9	6.49	0.69053
61	9	5.81	0.75920
62	9	14.92	0.09326
63	9	3.79	0.92476
64	9	14.78	0.09728
65	9	3.53	0.93950
66	9	10.10	0.34213
67	9	17.54	0.04086
68	9	17.48	0.04176
69	9	8.17	0.51756
70	9	17.63	0.03971
71	9	6.26	0.71319
72	9	10.12	0.34102
73	9	6.11	0.72934
74	9	7.15	0.62183
75	9	4.42	0.88139
76	9	7.90	0.54425
77	9	6.40	0.69964
78	9	8.63	0.47182
79	9	6.40	0.69961

80	9	10.76	0.29275
81	9	3.25	0.95344
82	9	4.19	0.89873
83	9	11.23	0.26036
84	9	8.91	0.44575
85	9	9.18	0.42043
86	9	3.80	0.92412
87	9	7.65	0.56981
88	9	4.66	0.86306
89	9	11.02	0.27423
90	9	19.15	0.02394
91	9	11.73	0.22917
92	9	16.66	0.05430
93	9	11.06	0.27175
94	9	16.07	0.06541
95	9	6.53	0.68617
96	9	5.58	0.78104
97	9	18.22	0.03272
98	9	10.42	0.31772
99	9	4.13	0.90243
100	9	10.25	0.33077
Combined P-value for all tests (Using KS method)			0.68869

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	9.15	0.42329
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	95.21	0.18935
2	7	84	90.90	0.28444
3	7	84	66.67	0.91772
4	7	84	71.86	0.82474
5	7	84	101.52	0.09373

6	7	84	89.05	0.33228
7	7	84	92.21	0.25301
8	7	84	69.60	0.87073
9	7	84	109.22	0.03363
10	7	84	73.71	0.78143
11	7	84	79.40	0.62155
12	7	84	91.15	0.27828
13	7	84	69.54	0.87183
14	7	84	79.47	0.61948
15	7	84	98.46	0.13388
16	7	84	79.98	0.60406
17	7	84	77.11	0.68979
18	7	84	69.82	0.86656
19	7	84	85.51	0.43358
20	7	84	94.05	0.21253
21	7	84	80.97	0.57336
22	7	84	83.66	0.48996
23	7	84	78.10	0.66085
24	7	84	95.51	0.18366
25	7	84	60.25	0.97657
26	7	84	96.15	0.17190
27	7	84	89.15	0.32968
28	7	84	81.67	0.55168
29	7	84	72.51	0.81007
30	7	84	87.70	0.36979
31	7	84	100.03	0.11190
32	7	84	97.68	0.14604
33	7	84	90.02	0.30680
34	7	84	79.19	0.62810
35	7	84	110.94	0.02617
36	7	84	85.15	0.44447
37	7	84	79.61	0.61540
38	7	84	89.37	0.32378
39	7	84	73.94	0.77562
40	7	84	90.50	0.29445
41	7	84	87.52	0.37492
42	7	84	76.54	0.70602
43	7	84	104.26	0.06642
44	7	84	90.68	0.29001
45	7	84	71.06	0.84188
46	7	84	112.49	0.02068
47	7	84	75.53	0.73393
48	7	84	80.80	0.57870
49	7	84	80.13	0.59946
50	7	84	80.16	0.59828
51	7	84	78.18	0.65845
52	7	84	70.31	0.85722
53	7	84	78.21	0.65741
54	7	84	104.29	0.06614
55	7	84	76.78	0.69925
56	7	84	79.28	0.62546
57	7	84	103.56	0.07268
58	7	84	99.01	0.12586
59	7	84	82.93	0.51244
60	7	84	73.05	0.79735

61	7	84	87.96	0.36235
62	7	84	88.23	0.35495
63	7	84	88.84	0.33816
64	7	84	93.17	0.23130
65	7	84	83.79	0.48587
66	7	84	88.82	0.33871
67	7	84	81.94	0.54322
68	7	84	101.95	0.08890
69	7	84	97.94	0.14191
70	7	84	103.79	0.07057
71	7	84	77.14	0.68895
72	7	84	82.62	0.52214
73	7	84	88.37	0.35109
74	7	84	74.26	0.76762
75	7	84	63.49	0.95363
76	7	84	79.10	0.63070
77	7	84	77.69	0.67298
78	7	84	80.86	0.57686
79	7	84	97.57	0.14771
80	7	84	80.02	0.60282
81	7	84	90.49	0.29466
82	7	84	95.03	0.19288
83	7	84	87.30	0.38115
84	7	84	92.73	0.24127
85	7	84	112.92	0.01937
86	7	84	65.88	0.92804
87	7	84	81.41	0.55962
88	7	84	94.94	0.19468
89	7	84	62.24	0.96390
90	7	84	92.43	0.24807
91	7	84	118.53	0.00782
92	7	84	84.84	0.45379
93	7	84	80.75	0.58007
94	7	84	92.99	0.23536
95	7	84	98.75	0.12966
96	7	84	79.14	0.62972
97	7	84	95.13	0.19093
98	7	84	67.67	0.90319
99	7	84	107.99	0.04012
100	7	84	78.50	0.64872
Combined P-value for all tests (Using KS method)				0.21709

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	53.53	0.56877
2	7	56	46.69	0.80769
3	7	56	56.13	0.47013
4	7	56	55.23	0.50413
5	7	56	46.42	0.81548
6	7	56	70.13	0.09701
7	7	56	46.80	0.80453

8	7	56	65.02	0.19147
9	7	56	61.98	0.27151
10	7	56	60.73	0.30927
11	7	56	65.58	0.17877
12	7	56	49.68	0.71137
13	7	56	48.31	0.75761
14	7	56	53.37	0.57496
15	7	56	54.29	0.53985
16	7	56	51.18	0.65767
17	7	56	47.72	0.77661
18	7	56	54.94	0.51509
19	7	56	94.56	0.00098
20	7	56	60.61	0.31326
21	7	56	66.57	0.15773
22	7	56	49.63	0.71325
23	7	56	33.32	0.99312
24	7	56	59.40	0.35275
25	7	56	72.31	0.07021
26	7	56	57.19	0.43077
27	7	56	51.91	0.63023
28	7	56	55.21	0.50482
29	7	56	69.63	0.10426
30	7	56	75.37	0.04316
Combined P-value for all tests (Using KS method)				0.77318

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	21.86	0.40755
2	7	21	13.23	0.90034
3	7	21	20.29	0.50292
4	7	21	21.03	0.45694
5	7	21	25.90	0.21024
6	7	21	21.75	0.41423
7	7	21	29.07	0.11222
8	7	21	17.67	0.66993
9	7	21	20.93	0.46318
10	7	21	12.30	0.93106
11	7	21	20.52	0.48857
12	7	21	20.66	0.47988
13	7	21	13.47	0.89133
14	7	21	11.26	0.95748
15	7	21	15.82	0.77958
16	7	21	21.78	0.41220

17	7	21	13.68	0.88304
18	7	21	25.15	0.24053
19	7	21	16.50	0.74121
20	7	21	25.37	0.23129
21	7	21	28.37	0.12997
22	7	21	22.76	0.35712
23	7	21	17.01	0.71078
24	7	21	30.28	0.08648
25	7	21	15.31	0.80730
26	7	21	16.75	0.72590
27	7	21	24.39	0.27446
28	7	21	17.50	0.68063
29	7	21	14.34	0.85462
30	7	21	30.14	0.08913
31	7	21	20.36	0.49878
32	7	21	16.81	0.72239
33	7	21	35.10	0.02751
34	7	21	20.86	0.46734
35	7	21	21.97	0.40115
36	7	21	24.97	0.24830
37	7	21	23.36	0.32501
38	7	21	32.38	0.05360
39	7	21	32.11	0.05701
40	7	21	13.87	0.87495
41	7	21	24.36	0.27607
42	7	21	37.39	0.01517
43	7	21	19.45	0.55644
44	7	21	28.18	0.13511
45	7	21	31.44	0.06659
46	7	21	17.44	0.68438
47	7	21	23.76	0.30466
48	7	21	25.11	0.24224
49	7	21	28.85	0.11760
50	7	21	20.55	0.48683
51	7	21	17.36	0.68902
52	7	21	12.39	0.92849
53	7	21	22.36	0.37902
54	7	21	22.01	0.39886
55	7	21	27.28	0.16186
56	7	21	24.85	0.25365
57	7	21	13.35	0.89583
58	7	21	22.94	0.34694
59	7	21	20.86	0.46759
60	7	21	16.39	0.74722
61	7	21	16.35	0.74992
62	7	21	27.23	0.16352
63	7	21	18.64	0.60813
64	7	21	19.17	0.57434
65	7	21	19.02	0.58393
66	7	21	11.40	0.95445
67	7	21	23.40	0.32278
68	7	21	22.35	0.37947
69	7	21	19.66	0.54259
70	7	21	18.42	0.62216
71	7	21	15.55	0.79425

72	7	21	25.44	0.22854
73	7	21	25.92	0.20951
74	7	21	18.20	0.63654
75	7	21	15.17	0.81418
76	7	21	36.05	0.02160
77	7	21	17.45	0.68363
78	7	21	22.11	0.39299
79	7	21	26.94	0.17284
80	7	21	11.29	0.95677
81	7	21	14.90	0.82787
82	7	21	13.31	0.89734
83	7	21	16.81	0.72256
84	7	21	12.03	0.93874
85	7	21	13.88	0.87455
86	7	21	15.95	0.77247
87	7	21	21.78	0.41214
88	7	21	25.46	0.22763
89	7	21	9.20	0.98755
90	7	21	24.69	0.26064
91	7	21	18.19	0.63696
92	7	21	27.78	0.14662
93	7	21	21.06	0.45520
94	7	21	27.81	0.14576
95	7	21	18.60	0.61066
96	7	21	27.72	0.14826
97	7	21	13.14	0.90371
98	7	21	18.33	0.62817
99	7	21	12.70	0.91864
100	7	21	9.66	0.98295
Combined P-value for all tests (Using KS method)				0.98700

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	11.38	0.95496
2	7	21	26.35	0.19334
3	7	21	16.38	0.74817
4	7	21	26.16	0.20041
5	7	21	18.83	0.59592
6	7	21	15.10	0.81770
7	7	21	30.13	0.08945
8	7	21	12.62	0.92122
9	7	21	23.55	0.31527
10	7	21	21.82	0.41018
11	7	21	13.17	0.90263
12	7	21	15.95	0.77234
13	7	21	21.70	0.41721
14	7	21	14.10	0.86544
15	7	21	20.18	0.50963
16	7	21	24.38	0.27483
17	7	21	27.82	0.14545
18	7	21	11.67	0.94805

19	7	21	14.50	0.84699
20	7	21	41.82	0.00443
21	7	21	17.34	0.69005
22	7	21	30.21	0.08789
23	7	21	19.92	0.52633
24	7	21	14.94	0.82575
25	7	21	17.09	0.70576
26	7	21	19.13	0.57693
27	7	21	20.34	0.50008
28	7	21	20.09	0.51569
29	7	21	19.73	0.53854
30	7	21	22.45	0.37420
Combined P-value for all tests (Using KS method)				0.62817

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	0.21709	0.65128
Suits Test	0.98700	1.00000
Hand Types Test	0.68869	1.00000
Combined P-Value using Holm's Method		0.65128

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	0.77318	1.00000
Suits Test	0.62817	1.00000
Hands Type Test	0.42329	1.00000

Combined P-Value using Holm's Method	1.00000
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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

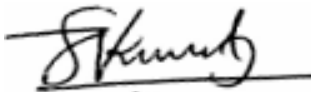
Analysis of actual data from game logs for 'Hand Types', 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

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: 19 August 2021

Signed:



Geoff Nicoll
Principal Consultant
iTech Labs Australia
Date: 19 August 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.