

Poker Cards Analysis - Jun 2022

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **Jun 01, 2022** to **Jun 30, 2022** 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	7.31	0.60511
2	9	6.67	0.67168
3	9	4.25	0.89413
4	9	8.51	0.48362
5	9	6.42	0.69729
6	9	8.08	0.52604
7	9	8.50	0.48487
8	9	7.21	0.61536
9	9	5.71	0.76893
10	9	7.30	0.60569
11	9	5.23	0.81418
12	9	24.40	0.00372
13	9	6.80	0.65836
14	9	10.24	0.33166
15	9	10.78	0.29141
16	9	6.68	0.67046
17	9	11.82	0.22348
18	9	1.41	0.99776
19	9	7.94	0.54037
20	9	12.81	0.17143
21	9	7.30	0.60564
22	9	6.45	0.69434
23	9	14.20	0.11550
24	9	5.57	0.78200

25	9	7.04	0.63301
26	9	6.73	0.66557
27	9	8.20	0.51410
28	9	14.06	0.12020
29	9	8.03	0.53075
30	9	3.95	0.91472
31	9	5.39	0.79918
32	9	6.79	0.65899
33	9	9.09	0.42873
34	9	6.97	0.64058
35	9	7.28	0.60778
36	9	7.26	0.61010
37	9	4.98	0.83642
38	9	8.54	0.48072
39	9	10.30	0.32701
40	9	13.80	0.12949
41	9	11.37	0.25144
42	9	13.15	0.15596
43	9	7.43	0.59249
44	9	3.16	0.95782
45	9	13.01	0.16216
46	9	7.78	0.55643
47	9	7.47	0.58825
48	9	11.13	0.26703
49	9	8.14	0.52058
50	9	8.16	0.51797
51	9	12.87	0.16857
52	9	12.77	0.17341
53	9	7.57	0.57767
54	9	9.90	0.35891
55	9	4.93	0.84016
56	9	15.22	0.08497
57	9	6.54	0.68537
58	9	8.47	0.48717
59	9	11.58	0.23778
60	9	6.80	0.65820
61	9	13.35	0.14720
62	9	8.39	0.49564
63	9	5.91	0.74895
64	9	5.18	0.81874
65	9	5.76	0.76382
66	9	13.05	0.16051
67	9	6.83	0.65523
68	9	4.82	0.84991
69	9	7.60	0.57469
70	9	8.23	0.51070
71	9	9.44	0.39747
72	9	16.45	0.05811
73	9	4.92	0.84080
74	9	7.32	0.60403
75	9	3.51	0.94082
76	9	10.42	0.31739
77	9	6.50	0.68879
78	9	10.94	0.28016
79	9	11.86	0.22133

80	9	9.89	0.35974
81	9	17.83	0.03719
82	9	7.60	0.57539
83	9	5.54	0.78502
84	9	8.23	0.51103
85	9	6.26	0.71402
86	9	6.77	0.66140
87	9	11.68	0.23217
88	9	12.72	0.17584
89	9	8.67	0.46865
90	9	5.23	0.81371
91	9	9.07	0.43114
92	9	4.39	0.88417
93	9	8.83	0.45307
94	9	4.15	0.90148
95	9	16.04	0.06600
96	9	5.50	0.78883
97	9	10.39	0.31954
98	9	3.75	0.92725
99	9	9.33	0.40775
100	9	8.23	0.51088
Combined P-value for all tests (Using KS method)			0.10041

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	8	1.79	0.98684
2	8	3.97	0.85972
3	8	7.87	0.44595
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) As the total number of tests (3) is insufficient to perform a meaningful KS Test, individual p-values from these tests are carried over to the next stage for combining using the Holm's method.

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	86.08	0.41658

2	7	84	58.62	0.98410
3	7	84	108.01	0.03997
4	7	84	74.82	0.75290
5	7	84	94.03	0.21298
6	7	84	75.19	0.74327
7	7	84	98.55	0.13252
8	7	84	56.09	0.99179
9	7	84	73.40	0.78909
10	7	84	65.12	0.93705
11	7	84	72.42	0.81220
12	7	84	84.69	0.45851
13	7	84	91.03	0.28116
14	7	84	70.19	0.85953
15	7	84	90.68	0.29009
16	7	84	68.77	0.88544
17	7	84	85.09	0.44631
18	7	84	58.74	0.98360
19	7	84	72.52	0.80992
20	7	84	95.19	0.18973
21	7	84	63.24	0.95583
22	7	84	90.96	0.28291
23	7	84	73.61	0.78394
24	7	84	92.43	0.24806
25	7	84	78.82	0.63912
26	7	84	89.97	0.30804
27	7	84	75.36	0.73846
28	7	84	75.08	0.74619
29	7	84	86.28	0.41069
30	7	84	80.17	0.59811
31	7	84	94.37	0.20604
32	7	84	86.01	0.41875
33	7	84	89.13	0.33036
34	7	84	94.56	0.20218
35	7	84	88.76	0.34027
36	7	84	69.41	0.87419
37	7	84	81.93	0.54372
38	7	84	83.12	0.50667
39	7	84	96.76	0.16124
40	7	84	83.30	0.50106
41	7	84	82.50	0.52596
42	7	84	88.61	0.34434
43	7	84	95.10	0.19149
44	7	84	71.93	0.82328
45	7	84	92.58	0.24454
46	7	84	64.12	0.94767
47	7	84	85.15	0.44455
48	7	84	90.23	0.30147
49	7	84	65.01	0.93831
50	7	84	101.53	0.09360
51	7	84	71.36	0.83570
52	7	84	89.31	0.32548
53	7	84	83.50	0.49481
54	7	84	76.50	0.70717
55	7	84	58.27	0.98541
56	7	84	87.73	0.36879

57	7	84	101.58	0.09301
58	7	84	108.87	0.03538
59	7	84	84.66	0.45926
60	7	84	104.96	0.06059
61	7	84	83.34	0.49982
62	7	84	92.67	0.24260
63	7	84	74.91	0.75051
64	7	84	71.49	0.83295
65	7	84	68.88	0.88355
66	7	84	91.96	0.25896
67	7	84	93.21	0.23048
68	7	84	85.35	0.43835
69	7	84	111.14	0.02537
70	7	84	84.00	0.47959
71	7	84	98.29	0.13649
72	7	84	82.86	0.51472
73	7	84	80.22	0.59667
74	7	84	82.86	0.51477
75	7	84	79.38	0.62237
76	7	84	81.89	0.54474
77	7	84	82.14	0.53707
78	7	84	91.54	0.26885
79	7	84	75.61	0.73178
80	7	84	88.41	0.34982
81	7	84	98.00	0.14096
82	7	84	71.27	0.83757
83	7	84	65.94	0.92718
84	7	84	97.45	0.14969
85	7	84	75.15	0.74417
86	7	84	63.16	0.95653
87	7	84	82.89	0.51385
88	7	84	89.56	0.31884
89	7	84	77.89	0.66697
90	7	84	58.94	0.98278
91	7	84	95.14	0.19085
92	7	84	97.71	0.14545
93	7	84	97.83	0.14367
94	7	84	77.84	0.66856
95	7	84	72.45	0.81149
96	7	84	81.60	0.55379
97	7	84	83.66	0.49000
98	7	84	65.99	0.92657
99	7	84	81.78	0.54811
100	7	84	102.87	0.07933
Combined P-value for all tests (Using KS method)				0.81730

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	66.69	0.15519
2	7	56	69.93	0.09981
3	7	56	51.97	0.62821
4	7	56	53.39	0.57427
5	7	56	48.80	0.74156
6	7	56	71.95	0.07416
7	7	56	58.09	0.39830
8	7	56	41.17	0.93112
9	7	56	69.95	0.09955
10	7	56	61.96	0.27203
11	7	56	66.87	0.15161
12	7	56	47.32	0.78900
Combined P-value for all tests (Using KS method)				0.80102

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	15.06	0.81980
2	7	21	16.18	0.75971
3	7	21	20.12	0.51384
4	7	21	24.76	0.25790
5	7	21	23.33	0.32657
6	7	21	21.52	0.42760
7	7	21	36.98	0.01694
8	7	21	14.60	0.84227
9	7	21	21.34	0.43857
10	7	21	14.45	0.84952
11	7	21	22.13	0.39190
12	7	21	16.07	0.76589
13	7	21	22.44	0.37468
14	7	21	12.73	0.91776
15	7	21	23.78	0.30366
16	7	21	23.04	0.34208
17	7	21	13.90	0.87376
18	7	21	25.34	0.23272
19	7	21	14.47	0.84854
20	7	21	23.14	0.33630
21	7	21	25.89	0.21053

22	7	21	19.94	0.52509
23	7	21	15.48	0.79831
24	7	21	27.17	0.16516
25	7	21	23.72	0.30692
26	7	21	21.54	0.42650
27	7	21	27.60	0.15195
28	7	21	10.25	0.97552
29	7	21	12.52	0.92447
30	7	21	15.97	0.77129
31	7	21	24.52	0.26849
32	7	21	23.18	0.33432
33	7	21	26.29	0.19570
34	7	21	31.43	0.06683
35	7	21	19.76	0.53672
36	7	21	21.25	0.44402
37	7	21	19.81	0.53321
38	7	21	9.60	0.98368
39	7	21	25.93	0.20915
40	7	21	14.12	0.86455
41	7	21	19.68	0.54185
42	7	21	12.20	0.93397
43	7	21	9.85	0.98085
44	7	21	19.87	0.52979
45	7	21	23.55	0.31516
46	7	21	33.14	0.04469
47	7	21	25.14	0.24122
48	7	21	24.95	0.24920
49	7	21	7.56	0.99675
50	7	21	24.31	0.27820
51	7	21	25.24	0.23684
52	7	21	18.30	0.62996
53	7	21	34.04	0.03587
54	7	21	24.25	0.28096
55	7	21	18.69	0.60470
56	7	21	16.64	0.73239
57	7	21	27.95	0.14161
58	7	21	16.12	0.76275
59	7	21	32.47	0.05242
60	7	21	22.79	0.35511
61	7	21	17.01	0.71046
62	7	21	20.41	0.49514
63	7	21	16.60	0.73509
64	7	21	14.66	0.83938
65	7	21	16.29	0.75295
66	7	21	15.50	0.79722
67	7	21	26.23	0.19773
68	7	21	20.17	0.51081
69	7	21	21.07	0.45470
70	7	21	17.18	0.69992
71	7	21	12.34	0.92995
72	7	21	11.74	0.94646
73	7	21	30.19	0.08830
74	7	21	21.64	0.42068
75	7	21	17.36	0.68910
76	7	21	24.36	0.27600

77	7	21	13.80	0.87821
78	7	21	18.17	0.63801
79	7	21	9.12	0.98823
80	7	21	19.07	0.58086
81	7	21	29.00	0.11407
82	7	21	13.32	0.89716
83	7	21	21.40	0.43482
84	7	21	20.25	0.50568
85	7	21	16.79	0.72395
86	7	21	32.36	0.05378
87	7	21	17.60	0.67421
88	7	21	22.65	0.36267
89	7	21	21.45	0.43159
90	7	21	16.68	0.73012
91	7	21	14.11	0.86493
92	7	21	30.60	0.08049
93	7	21	26.96	0.17209
94	7	21	16.86	0.71965
95	7	21	28.05	0.13880
96	7	21	25.75	0.21606
97	7	21	22.49	0.37190
98	7	21	28.49	0.12687
99	7	21	11.34	0.95578
100	7	21	41.84	0.00441
Combined P-value for all tests (Using KS method)				0.95630

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	14.31	0.85583
2	7	21	18.21	0.63581
3	7	21	21.55	0.42571
4	7	21	25.08	0.24372
5	7	21	22.86	0.35127
6	7	21	37.34	0.01537
7	7	21	35.62	0.02409
8	7	21	14.26	0.85799
9	7	21	26.14	0.20131
10	7	21	29.34	0.10617
11	7	21	19.10	0.57898
12	7	21	22.17	0.38998
Combined P-value for all tests (Using KS method)				0.90140

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	0.81730	1.00000
Suits Test	0.95630	1.00000
HandTypes Test	0.10041	0.30122
Combined P-Value using Holm's Method		0.30122

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	0.80102	1.00000
Suits Test	0.90140	1.00000
HandTypes Test	0.98684	1.00000
HandTypes Test	0.85972	1.00000
HandTypes Test	0.44595	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

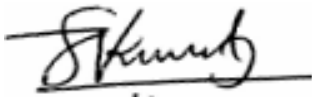
Analysis of actual data from game logs for 'Hand Types', 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

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: 29 Jul 2022

Signed:



Geoff Nicoll
Principal Consultant
iTech Labs Australia
Date: 29 Jul 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.

