



Poker Cards Analysis - September 2021

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **September 01, 2021 to September 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	4.96	0.83761
2	9	15.70	0.07333
3	9	10.61	0.30327
4	9	6.74	0.66407
5	9	8.16	0.51833
6	9	7.90	0.54474
7	9	16.33	0.06030
8	9	3.88	0.91935
9	9	7.69	0.56590
10	9	4.07	0.90701
11	9	15.17	0.08644
12	9	5.41	0.79725
13	9	5.54	0.78486
14	9	5.08	0.82720
15	9	11.14	0.26625
16	9	13.01	0.16196
17	9	12.83	0.17053
18	9	7.87	0.54779
19	9	6.00	0.74000
20	9	4.85	0.84680
21	9	17.34	0.04368
22	9	11.14	0.26635
23	9	9.55	0.38805
24	9	6.98	0.63914

25	9	9.98	0.35207
26	9	5.47	0.79128
27	9	8.55	0.47963
28	9	18.71	0.02780
29	9	3.63	0.93426
30	9	11.40	0.24946
31	9	6.59	0.67971
32	9	10.55	0.30786
33	9	9.04	0.43398
34	9	2.86	0.96955
35	9	8.87	0.44930
36	9	5.81	0.75905
37	9	10.52	0.31042
38	9	5.44	0.79483
39	9	13.44	0.14353
40	9	5.46	0.79289
41	9	10.34	0.32331
42	9	5.35	0.80291
43	9	8.00	0.53374
44	9	6.69	0.66889
45	9	10.36	0.32199
46	9	5.07	0.82857
47	9	6.70	0.66880
48	9	10.92	0.28138
49	9	11.08	0.27047
50	9	12.56	0.18362
51	9	19.52	0.02115
52	9	5.63	0.77582
53	9	9.83	0.36407
54	9	15.77	0.07188
55	9	9.52	0.39054
56	9	11.76	0.22724
57	9	4.94	0.83940
58	9	5.33	0.80452
59	9	7.95	0.53966
60	9	6.15	0.72491
61	9	9.14	0.42436
62	9	2.37	0.98426
63	9	12.69	0.17734
64	9	10.85	0.28640
65	9	6.50	0.68921
66	9	9.71	0.37408
67	9	4.57	0.87043
68	9	6.40	0.69949
69	9	3.31	0.95071
70	9	14.56	0.10362
71	9	13.60	0.13743
72	9	12.17	0.20407
73	9	7.55	0.57973
74	9	6.97	0.64063
75	9	5.44	0.79485
76	9	5.93	0.74684
77	9	10.18	0.33588
78	9	9.81	0.36632
79	9	10.71	0.29607

80	9	15.49	0.07832
81	9	9.74	0.37222
82	9	10.62	0.30255
83	9	3.73	0.92806
84	9	7.89	0.54484
85	9	13.82	0.12884
86	9	23.55	0.00508
87	9	6.25	0.71516
88	9	11.49	0.24367
89	9	13.51	0.14100
90	9	7.36	0.59926
91	9	11.31	0.25514
92	9	7.05	0.63173
93	9	8.20	0.51438
94	9	7.83	0.55125
95	9	9.07	0.43046
96	9	13.15	0.15582
97	9	11.36	0.25171
98	9	2.95	0.96620
99	9	13.87	0.12715
100	9	11.16	0.26523
Combined P-value for all tests (Using KS method)			0.70505

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	13.21	0.15339
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	87.63	0.37165
2	7	84	75.80	0.72656
3	7	84	115.07	0.01380
4	7	84	79.28	0.62528
5	7	84	79.82	0.60886

6	7	84	82.90	0.51352
7	7	84	82.22	0.53449
8	7	84	100.33	0.10803
9	7	84	91.31	0.27434
10	7	84	76.65	0.70285
11	7	84	79.11	0.63043
12	7	84	115.51	0.01287
13	7	84	71.33	0.83633
14	7	84	89.17	0.32929
15	7	84	85.72	0.42739
16	7	84	116.94	0.01020
17	7	84	74.15	0.77039
18	7	84	99.65	0.11693
19	7	84	104.43	0.06499
20	7	84	77.15	0.68863
21	7	84	72.74	0.80487
22	7	84	78.87	0.63787
23	7	84	63.73	0.95143
24	7	84	102.95	0.07849
25	7	84	65.31	0.93488
26	7	84	101.48	0.09420
27	7	84	70.36	0.85618
28	7	84	91.48	0.27040
29	7	84	95.68	0.18053
30	7	84	76.10	0.71819
31	7	84	90.14	0.30373
32	7	84	75.20	0.74276
33	7	84	74.73	0.75539
34	7	84	93.82	0.21731
35	7	84	79.72	0.61193
36	7	84	93.03	0.23440
37	7	84	77.02	0.69221
38	7	84	88.40	0.35026
39	7	84	93.36	0.22724
40	7	84	101.21	0.09722
41	7	84	79.10	0.63070
42	7	84	75.87	0.72481
43	7	84	74.11	0.77132
44	7	84	101.67	0.09203
45	7	84	95.23	0.18903
46	7	84	85.10	0.44593
47	7	84	76.86	0.69687
48	7	84	80.53	0.58701
49	7	84	64.80	0.94060
50	7	84	84.46	0.46526
51	7	84	68.81	0.88463
52	7	84	83.56	0.49304
53	7	84	103.20	0.07604
54	7	84	104.96	0.06059
55	7	84	83.88	0.48309
56	7	84	93.85	0.21679
57	7	84	77.80	0.66973
58	7	84	78.29	0.65501
59	7	84	68.31	0.89305
60	7	84	79.55	0.61698

61	7	84	101.92	0.08925
62	7	84	58.58	0.98425
63	7	84	91.38	0.27278
64	7	84	90.92	0.28390
65	7	84	72.10	0.81953
66	7	84	93.18	0.23128
67	7	84	58.11	0.98600
68	7	84	77.86	0.66785
69	7	84	79.93	0.60561
70	7	84	74.66	0.75706
71	7	84	76.68	0.70202
72	7	84	94.20	0.20947
73	7	84	76.41	0.70970
74	7	84	107.96	0.04025
75	7	84	73.79	0.77949
76	7	84	80.33	0.59305
77	7	84	104.83	0.06168
78	7	84	96.27	0.16986
79	7	84	91.26	0.27565
80	7	84	76.29	0.71288
81	7	84	91.18	0.27763
82	7	84	91.34	0.27365
83	7	84	84.81	0.45473
84	7	84	108.14	0.03927
85	7	84	78.42	0.65116
86	7	84	90.86	0.28556
87	7	84	98.19	0.13801
88	7	84	75.53	0.73396
89	7	84	73.33	0.79080
90	7	84	77.62	0.67492
91	7	84	76.94	0.69469
92	7	84	78.62	0.64516
93	7	84	106.84	0.04707
94	7	84	87.86	0.36523
95	7	84	81.86	0.54586
96	7	84	72.18	0.81761
97	7	84	92.45	0.24761
98	7	84	92.57	0.24470
99	7	84	93.98	0.21414
100	7	84	93.13	0.23216
Combined P-value for all tests (Using KS method)				0.31924

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	58.93	0.36869
2	7	56	42.57	0.90707
3	7	56	51.82	0.63360
4	7	56	43.51	0.88828
5	7	56	64.37	0.20699
6	7	56	55.62	0.48912
7	7	56	51.61	0.64166

8	7	56	40.52	0.94061
9	7	56	51.05	0.66230
10	7	56	48.03	0.76691
11	7	56	54.99	0.51304
12	7	56	47.14	0.79434
13	7	56	49.70	0.71074
14	7	56	46.62	0.80979
15	7	56	41.13	0.93168
16	7	56	30.82	0.99751
17	7	56	69.23	0.11024
18	7	56	53.50	0.57015
19	7	56	65.56	0.17917
20	7	56	48.69	0.74516
21	7	56	61.94	0.27256
22	7	56	64.78	0.19698
23	7	56	48.94	0.73672
24	7	56	42.61	0.90634
Combined P-value for all tests (Using KS method)				0.06679

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	30.16	0.08883
2	7	21	39.00	0.00981
3	7	21	22.12	0.39261
4	7	21	22.02	0.39849
5	7	21	26.61	0.18403
6	7	21	18.49	0.61811
7	7	21	24.01	0.29242
8	7	21	31.88	0.06014
9	7	21	10.62	0.96962
10	7	21	15.97	0.77141
11	7	21	16.94	0.71456
12	7	21	18.64	0.60839
13	7	21	23.35	0.32536
14	7	21	27.27	0.16194
15	7	21	26.43	0.19046
16	7	21	22.54	0.36907
17	7	21	10.74	0.96768
18	7	21	34.51	0.03191
19	7	21	17.19	0.69938
20	7	21	19.01	0.58431
21	7	21	27.68	0.14946
22	7	21	14.78	0.83372

23	7	21	38.37	0.01165
24	7	21	17.23	0.69707
25	7	21	16.29	0.75334
26	7	21	23.48	0.31893
27	7	21	14.30	0.85625
28	7	21	22.93	0.34772
29	7	21	18.35	0.62650
30	7	21	20.81	0.47033
31	7	21	25.52	0.22553
32	7	21	39.70	0.00809
33	7	21	16.15	0.76136
34	7	21	13.10	0.90521
35	7	21	23.12	0.33735
36	7	21	16.06	0.76631
37	7	21	24.62	0.26407
38	7	21	29.13	0.11091
39	7	21	12.70	0.91864
40	7	21	15.75	0.78359
41	7	21	19.93	0.52589
42	7	21	19.80	0.53414
43	7	21	21.08	0.45430
44	7	21	20.99	0.45943
45	7	21	24.63	0.26343
46	7	21	25.11	0.24261
47	7	21	19.82	0.53293
48	7	21	29.29	0.10712
49	7	21	19.22	0.57099
50	7	21	28.88	0.11701
51	7	21	7.21	0.99770
52	7	21	17.01	0.71049
53	7	21	14.98	0.82398
54	7	21	18.86	0.59443
55	7	21	16.07	0.76545
56	7	21	18.39	0.62404
57	7	21	20.40	0.49623
58	7	21	23.18	0.33446
59	7	21	22.92	0.34851
60	7	21	27.71	0.14870
61	7	21	17.36	0.68931
62	7	21	19.39	0.55994
63	7	21	26.12	0.20207
64	7	21	15.22	0.81193
65	7	21	20.46	0.49248
66	7	21	17.48	0.68191
67	7	21	21.01	0.45851
68	7	21	15.62	0.79052
69	7	21	24.48	0.27038
70	7	21	29.72	0.09780
71	7	21	18.42	0.62225
72	7	21	22.08	0.39499
73	7	21	22.33	0.38086
74	7	21	20.59	0.48413
75	7	21	13.24	0.90003
76	7	21	14.67	0.83919
77	7	21	12.19	0.93421

78	7	21	15.44	0.80017
79	7	21	19.30	0.56592
80	7	21	45.04	0.00171
81	7	21	18.80	0.59804
82	7	21	25.16	0.24033
83	7	21	18.55	0.61409
84	7	21	19.46	0.55552
85	7	21	15.55	0.79451
86	7	21	20.66	0.47987
87	7	21	13.88	0.87465
88	7	21	22.35	0.37962
89	7	21	15.41	0.80177
90	7	21	17.65	0.67111
91	7	21	24.25	0.28119
92	7	21	18.75	0.60106
93	7	21	14.46	0.84888
94	7	21	10.42	0.97299
95	7	21	22.47	0.37312
96	7	21	11.10	0.96079
97	7	21	14.22	0.86014
98	7	21	23.57	0.31431
99	7	21	12.86	0.91343
100	7	21	14.53	0.84592
Combined P-value for all tests (Using KS method)				0.78971

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	20.10	0.51468
2	7	21	14.93	0.82655
3	7	21	15.54	0.79470
4	7	21	33.98	0.03638
5	7	21	27.30	0.16102
6	7	21	38.38	0.01164
7	7	21	26.66	0.18253
8	7	21	27.44	0.15676
9	7	21	20.14	0.51216
10	7	21	20.53	0.48807
11	7	21	11.46	0.95315
12	7	21	20.87	0.46678
13	7	21	12.18	0.93452
14	7	21	15.96	0.77189
15	7	21	17.39	0.68709
16	7	21	20.07	0.51670
17	7	21	17.79	0.66213
18	7	21	29.11	0.11134
19	7	21	16.35	0.74956
20	7	21	19.13	0.57693
21	7	21	27.36	0.15925
22	7	21	22.77	0.35647
23	7	21	21.35	0.43764
24	7	21	22.37	0.37825

Combined P-value for all tests (Using KS method)	0.99983
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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	0.31924	0.95773
Suits Test	0.78971	1.00000
Hand Types Test	0.70505	1.00000
Combined P-Value using Holm's Method		0.95773

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	0.06679	0.20036
Suits Test	0.99983	0.99983
Hands Type Test	0.15339	0.30677
Combined P-Value using Holm's Method		0.20036

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

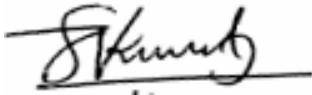
Analysis of actual data from game logs for 'Hand Types', 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

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 November 2021

Signed:



Geoff Nicoll
Principal Consultant
iTech Labs Australia

Date: 19 November 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.

