

Poker Cards Analysis - November 2021

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **November 01, 2021 to November 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	13.48	0.14202
2	9	12.00	0.21345
3	9	12.69	0.17720
4	9	4.79	0.85206
5	9	14.86	0.09494
6	9	8.84	0.45245
7	9	15.30	0.08292
8	9	6.62	0.67703
9	9	10.89	0.28326
10	9	13.00	0.16272
11	9	14.62	0.10182
12	9	10.00	0.35012
13	9	10.19	0.33507
14	9	5.40	0.79811
15	9	8.22	0.51246
16	9	7.57	0.57788
17	9	4.86	0.84600
18	9	6.38	0.70111
19	9	8.94	0.44304
20	9	10.55	0.30761
21	9	11.54	0.24047
22	9	6.86	0.65161
23	9	12.81	0.17136
24	9	7.05	0.63140

25	9	11.63	0.23474
26	9	9.35	0.40604
27	9	8.78	0.45757
28	9	2.74	0.97372
29	9	1.78	0.99454
30	9	13.27	0.15070
31	9	8.29	0.50485
32	9	4.81	0.85055
33	9	11.07	0.27092
34	9	8.09	0.52503
35	9	3.30	0.95116
36	9	3.53	0.93954
37	9	4.54	0.87260
38	9	7.51	0.58377
39	9	17.29	0.04433
40	9	10.77	0.29153
41	9	8.05	0.52885
42	9	5.05	0.82949
43	9	7.66	0.56898
44	9	5.48	0.79020
45	9	7.32	0.60407
46	9	5.75	0.76463
47	9	10.36	0.32183
48	9	4.56	0.87081
49	9	17.62	0.03989
50	9	9.55	0.38836
51	9	4.17	0.89966
52	9	16.64	0.05460
53	9	1.86	0.99344
54	9	10.80	0.29000
55	9	7.81	0.55378
56	9	17.60	0.04010
57	9	7.84	0.55084
58	9	15.00	0.09101
59	9	8.19	0.51472
60	9	7.10	0.62682
61	9	5.27	0.80988
62	9	17.92	0.03614
63	9	6.22	0.71749
64	9	9.75	0.37072
65	9	5.73	0.76674
66	9	10.65	0.30029
67	9	4.73	0.85744
68	9	6.78	0.66023
69	9	15.33	0.08217
70	9	5.27	0.81005
71	9	7.83	0.55117
72	9	19.83	0.01901
73	9	15.82	0.07065
74	9	6.18	0.72178
75	9	3.69	0.93078
76	9	18.34	0.03140
77	9	3.42	0.94545
78	9	13.85	0.12793
79	9	13.37	0.14657

80	9	2.62	0.97762
81	9	12.66	0.17877
82	9	6.32	0.70728
83	9	19.87	0.01873
84	9	12.32	0.19588
85	9	10.56	0.30678
86	9	13.09	0.15842
87	9	5.94	0.74636
88	9	9.12	0.42663
89	9	10.95	0.27948
90	9	7.99	0.53480
91	9	7.35	0.60082
92	9	12.44	0.18953
93	9	2.91	0.96765
94	9	9.94	0.35576
95	9	10.63	0.30161
96	9	9.37	0.40368
97	9	5.88	0.75223
98	9	14.45	0.10717
99	9	4.21	0.89687
100	9	5.30	0.80781
Combined P-value for all tests (Using KS method)			0.81918

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	4.60	0.86784
2	9	14.94	0.09269
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	81.38	0.56058
2	7	84	86.23	0.41227
3	7	84	75.58	0.73251
4	7	84	83.92	0.48196

5	7	84	73.87	0.77733
6	7	84	67.41	0.90706
7	7	84	59.77	0.97904
8	7	84	87.30	0.38112
9	7	84	96.95	0.15802
10	7	84	106.72	0.04785
11	7	84	68.27	0.89365
12	7	84	101.81	0.09039
13	7	84	84.54	0.46308
14	7	84	87.04	0.38866
15	7	84	85.46	0.43515
16	7	84	91.23	0.27636
17	7	84	91.05	0.28075
18	7	84	67.32	0.90846
19	7	84	96.76	0.16114
20	7	84	85.49	0.43406
21	7	84	80.53	0.58691
22	7	84	95.83	0.17782
23	7	84	120.86	0.00524
24	7	84	65.52	0.93234
25	7	84	104.04	0.06835
26	7	84	76.74	0.70023
27	7	84	97.68	0.14595
28	7	84	84.18	0.47382
29	7	84	80.11	0.60008
30	7	84	65.91	0.92764
31	7	84	85.70	0.42798
32	7	84	77.33	0.68326
33	7	84	96.74	0.16153
34	7	84	74.97	0.74913
35	7	84	77.54	0.67720
36	7	84	65.55	0.93198
37	7	84	100.25	0.10911
38	7	84	87.85	0.36548
39	7	84	92.47	0.24710
40	7	84	116.45	0.01105
41	7	84	82.37	0.52999
42	7	84	96.34	0.16849
43	7	84	86.19	0.41350
44	7	84	81.33	0.56230
45	7	84	87.31	0.38075
46	7	84	108.34	0.03817
47	7	84	79.06	0.63192
48	7	84	74.69	0.75626
49	7	84	81.03	0.57163
50	7	84	92.30	0.25103
51	7	84	90.29	0.29992
52	7	84	78.89	0.63717
53	7	84	78.62	0.64525
54	7	84	82.09	0.53867
55	7	84	79.65	0.61413
56	7	84	75.98	0.72152
57	7	84	87.94	0.36282
58	7	84	126.19	0.00200
59	7	84	85.02	0.44834

60	7	84	89.08	0.33161
61	7	84	66.44	0.92076
62	7	84	72.34	0.81410
63	7	84	123.38	0.00334
64	7	84	76.96	0.69394
65	7	84	101.24	0.09692
66	7	84	80.85	0.57709
67	7	84	100.11	0.11079
68	7	84	73.74	0.78058
69	7	84	93.36	0.22731
70	7	84	69.88	0.86535
71	7	84	63.84	0.95032
72	7	84	95.43	0.18523
73	7	84	92.62	0.24367
74	7	84	89.78	0.31311
75	7	84	67.68	0.90304
76	7	84	99.31	0.12168
77	7	84	115.32	0.01328
78	7	84	74.87	0.75162
79	7	84	104.12	0.06761
80	7	84	73.36	0.79007
81	7	84	69.26	0.87685
82	7	84	70.27	0.85793
83	7	84	75.70	0.72939
84	7	84	60.29	0.97639
85	7	84	90.09	0.30508
86	7	84	95.47	0.18446
87	7	84	88.89	0.33660
88	7	84	79.81	0.60916
89	7	84	103.84	0.07013
90	7	84	81.95	0.54284
91	7	84	81.39	0.56044
92	7	84	94.92	0.19508
93	7	84	90.71	0.28920
94	7	84	74.79	0.75376
95	7	84	80.89	0.57580
96	7	84	71.51	0.83238
97	7	84	95.34	0.18684
98	7	84	70.25	0.85834
99	7	84	96.48	0.16607
100	7	84	95.32	0.18732
Combined P-value for all tests (Using KS method)				0.78005

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	49.83	0.70632
2	7	56	38.45	0.96465
3	7	56	62.28	0.26264
4	7	56	62.57	0.25446
5	7	56	46.59	0.81083
6	7	56	45.06	0.85228

7	7	56	48.58	0.74874
8	7	56	46.71	0.80717
9	7	56	36.70	0.97849
10	7	56	39.35	0.95531
11	7	56	57.21	0.43011
12	7	56	55.39	0.49798
13	7	56	51.66	0.63965
14	7	56	59.08	0.36375
15	7	56	45.81	0.83250
16	7	56	69.37	0.10803
17	7	56	47.09	0.79597
18	7	56	40.27	0.94403
19	7	56	41.58	0.92454
20	7	56	58.14	0.39638
21	7	56	53.34	0.57634
22	7	56	61.69	0.28001
23	7	56	54.56	0.52952
24	7	56	63.29	0.23471
25	7	56	56.22	0.46676
26	7	56	55.59	0.49048
27	7	56	69.68	0.10346
28	7	56	50.49	0.68260
29	7	56	60.64	0.31211
30	7	56	43.18	0.89503
31	7	56	49.99	0.70061
32	7	56	50.83	0.67020
33	7	56	63.54	0.22804
34	7	56	49.27	0.72570
35	7	56	52.44	0.61057
36	7	56	37.08	0.97593
37	7	56	62.32	0.26161
38	7	56	70.44	0.09281
39	7	56	56.94	0.44002
40	7	56	72.99	0.06318
41	7	56	52.09	0.62347
42	7	56	60.81	0.30701
43	7	56	64.39	0.20655
44	7	56	56.92	0.44068
45	7	56	39.96	0.94800
46	7	56	72.11	0.07236
47	7	56	73.07	0.06242
Combined P-value for all tests (Using KS method)				0.91973

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	28.45	0.12780
2	7	21	28.24	0.13361
3	7	21	25.50	0.22636
4	7	21	17.80	0.66179
5	7	21	22.61	0.36521
6	7	21	23.13	0.33703
7	7	21	19.32	0.56478
8	7	21	28.49	0.12676
9	7	21	14.68	0.83848
10	7	21	29.00	0.11398
11	7	21	19.14	0.57590
12	7	21	14.91	0.82739
13	7	21	14.44	0.84976
14	7	21	14.88	0.82879
15	7	21	12.08	0.93736
16	7	21	18.27	0.63161
17	7	21	16.25	0.75537
18	7	21	23.50	0.31770
19	7	21	16.37	0.74859
20	7	21	17.67	0.66948
21	7	21	20.24	0.50597
22	7	21	12.09	0.93705
23	7	21	15.74	0.78407
24	7	21	18.18	0.63786
25	7	21	13.43	0.89288
26	7	21	13.07	0.90606
27	7	21	24.03	0.29164
28	7	21	27.02	0.17009
29	7	21	17.25	0.69559
30	7	21	27.58	0.15251
31	7	21	23.16	0.33544
32	7	21	12.73	0.91780
33	7	21	21.54	0.42618
34	7	21	15.25	0.81035
35	7	21	28.77	0.11956
36	7	21	21.49	0.42912
37	7	21	29.74	0.09737
38	7	21	16.87	0.71897
39	7	21	17.73	0.66611
40	7	21	16.34	0.75000
41	7	21	20.79	0.47214
42	7	21	20.69	0.47775
43	7	21	22.23	0.38651
44	7	21	12.61	0.92164
45	7	21	16.79	0.72383
46	7	21	26.13	0.20150
47	7	21	20.83	0.46966
48	7	21	27.15	0.16584
49	7	21	19.45	0.55660
50	7	21	17.62	0.67319
51	7	21	19.37	0.56161
52	7	21	17.48	0.68184
53	7	21	24.05	0.29078

54	7	21	16.82	0.72188
55	7	21	34.21	0.03442
56	7	21	16.16	0.76085
57	7	21	23.71	0.30741
58	7	21	21.97	0.40111
59	7	21	18.24	0.63366
60	7	21	21.31	0.44013
61	7	21	25.90	0.21020
62	7	21	27.50	0.15491
63	7	21	40.56	0.00635
64	7	21	7.21	0.99769
65	7	21	14.16	0.86275
66	7	21	25.10	0.24304
67	7	21	17.26	0.69503
68	7	21	13.36	0.89539
69	7	21	13.99	0.86994
70	7	21	18.88	0.59294
71	7	21	12.93	0.91091
72	7	21	18.97	0.58677
73	7	21	26.96	0.17222
74	7	21	18.46	0.61952
75	7	21	19.76	0.53650
76	7	21	19.47	0.55483
77	7	21	11.75	0.94610
78	7	21	34.08	0.03554
79	7	21	22.54	0.36885
80	7	21	25.39	0.23075
81	7	21	15.90	0.77506
82	7	21	15.70	0.78603
83	7	21	16.56	0.73740
84	7	21	24.92	0.25066
85	7	21	13.57	0.88749
86	7	21	12.14	0.93590
87	7	21	22.18	0.38903
88	7	21	20.27	0.50412
89	7	21	21.75	0.41375
90	7	21	30.63	0.07995
91	7	21	35.51	0.02479
92	7	21	20.96	0.46122
93	7	21	14.17	0.86240
94	7	21	21.27	0.44273
95	7	21	14.89	0.82852
96	7	21	29.62	0.09999
97	7	21	20.84	0.46888
98	7	21	14.53	0.84595
99	7	21	24.74	0.25866
100	7	21	16.45	0.74414
Combined P-value for all tests (Using KS method)				0.61346

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
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1	7	21	28.10	0.13723
2	7	21	29.39	0.10490
3	7	21	15.71	0.78561
4	7	21	20.63	0.48161
5	7	21	31.31	0.06862
6	7	21	18.01	0.64850
7	7	21	10.85	0.96567
8	7	21	21.17	0.44873
9	7	21	21.88	0.40645
10	7	21	19.10	0.57898
11	7	21	19.68	0.54160
12	7	21	27.97	0.14106
13	7	21	13.96	0.87131
14	7	21	35.49	0.02494
15	7	21	9.37	0.98601
16	7	21	14.34	0.85437
17	7	21	20.18	0.51014
18	7	21	11.76	0.94587
19	7	21	22.88	0.35041
20	7	21	17.68	0.66915
21	7	21	14.90	0.82774
22	7	21	24.97	0.24855
23	7	21	21.59	0.42334
24	7	21	26.07	0.20372
25	7	21	14.30	0.85655
26	7	21	25.97	0.20767
27	7	21	23.33	0.32674
28	7	21	12.50	0.92525
29	7	21	33.73	0.03874
30	7	21	14.08	0.86614
31	7	21	33.59	0.04005
32	7	21	20.43	0.49406
33	7	21	13.89	0.87436
34	7	21	14.96	0.82495
35	7	21	41.48	0.00489
36	7	21	22.80	0.35473
37	7	21	25.60	0.22211
38	7	21	20.22	0.50762
39	7	21	9.74	0.98214
40	7	21	22.42	0.37589
41	7	21	17.42	0.68511
42	7	21	13.81	0.87770
43	7	21	20.62	0.48260
44	7	21	14.01	0.86926
45	7	21	11.62	0.94922
46	7	21	20.52	0.48857
47	7	21	23.05	0.34114
Combined P-value for all tests (Using KS method)				0.26202

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	0.78005	1.00000
Suits Test	0.61346	1.00000
Hand Types Test	0.81918	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	0.91973	1.00000
Suits Test	0.26202	0.78607
Hands Type Test	0.86784	1.00000
Hands Type Test	0.09269	0.37076
Combined P-Value using Holm's Method		0.37076

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

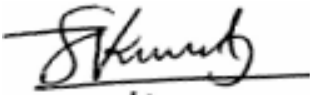
Analysis of actual data from game logs for 'Hand Types', 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

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.

