



Poker Cards Analysis - May 2021

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **May 01, 2021 to May 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	14.90	0.09368
2	9	7.15	0.62133
3	9	2.24	0.98713
4	9	2.68	0.97570
5	9	8.39	0.49545
6	9	10.35	0.32280
7	9	7.56	0.57940
8	9	6.07	0.73288
9	9	18.28	0.03204
10	9	21.24	0.01161
11	9	10.58	0.30577
12	9	8.43	0.49184
13	9	5.81	0.75907
14	9	4.08	0.90618
15	9	14.06	0.12037
16	9	10.75	0.29359
17	9	14.73	0.09848
18	9	13.29	0.15003
19	9	15.33	0.08232
20	9	5.26	0.81078
21	9	4.50	0.87520
22	9	12.61	0.18103
23	9	6.61	0.67735
24	9	7.36	0.59954

25	9	3.48	0.94195
26	9	6.08	0.73158
27	9	3.69	0.93058
28	9	3.93	0.91578
29	9	8.91	0.44572
30	9	2.70	0.97508
31	9	11.58	0.23789
32	9	6.69	0.66959
33	9	6.46	0.69364
34	9	5.44	0.79449
35	9	3.85	0.92107
36	9	11.16	0.26497
37	9	8.26	0.50855
38	9	5.01	0.83363
39	9	3.64	0.93375
40	9	4.17	0.89993
41	9	8.01	0.53278
42	9	5.16	0.82057
43	9	10.27	0.32917
44	9	12.92	0.16636
45	9	5.80	0.75986
46	9	11.28	0.25698
47	9	15.03	0.09016
48	9	6.37	0.70247
49	9	9.00	0.43699
50	9	7.67	0.56777
51	9	5.42	0.79638
52	9	14.66	0.10081
53	9	10.47	0.31407
54	9	23.77	0.00468
55	9	4.08	0.90633
56	9	15.41	0.08031
57	9	16.90	0.05033
58	9	7.47	0.58811
59	9	24.32	0.00382
60	9	6.15	0.72521
61	9	8.45	0.48925
62	9	9.80	0.36659
63	9	14.82	0.09606
64	9	8.92	0.44447
65	9	17.02	0.04847
66	9	8.46	0.48813
67	9	10.33	0.32464
68	9	3.35	0.94889
69	9	6.23	0.71696
70	9	4.83	0.84848
71	9	5.06	0.82911
72	9	4.45	0.87922
73	9	15.29	0.08318
74	9	5.14	0.82154
75	9	7.77	0.55779
76	9	7.44	0.59180
77	9	14.48	0.10613
78	9	4.68	0.86119
79	9	11.30	0.25566

80	9	14.14	0.11745
81	9	10.89	0.28335
82	9	8.44	0.49071
83	9	22.03	0.00880
84	9	19.06	0.02470
85	9	11.91	0.21816
86	9	2.99	0.96470
87	9	7.49	0.58658
88	9	5.92	0.74789
89	9	6.81	0.65666
90	9	7.63	0.57140
91	9	11.13	0.26686
92	9	5.17	0.81952
93	9	3.40	0.94630
94	9	9.31	0.40927
95	9	12.23	0.20073
96	9	5.76	0.76361
97	9	4.12	0.90328
98	9	7.32	0.60348
99	9	3.41	0.94594
100	9	13.68	0.13423
Combined P-value for all tests (Using KS method)			0.57746

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	21.11	0.01218
2	9	11.20	0.26229
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	79.29	0.62514

2	7	84	77.71	0.67221
3	7	84	86.61	0.40103
4	7	84	81.20	0.56630
5	7	84	95.79	0.17845
6	7	84	97.24	0.15313
7	7	84	89.91	0.30955
8	7	84	73.87	0.77749
9	7	84	78.26	0.65615
10	7	84	56.39	0.99107
11	7	84	79.86	0.60751
12	7	84	92.20	0.25335
13	7	84	65.64	0.93097
14	7	84	86.30	0.41020
15	7	84	94.85	0.19642
16	7	84	105.45	0.05676
17	7	84	69.95	0.86406
18	7	84	84.35	0.46888
19	7	84	60.90	0.97293
20	7	84	89.63	0.31703
21	7	84	88.54	0.34637
22	7	84	96.02	0.17433
23	7	84	95.12	0.19118
24	7	84	99.52	0.11869
25	7	84	71.26	0.83774
26	7	84	82.05	0.53979
27	7	84	69.56	0.87142
28	7	84	71.95	0.82293
29	7	84	84.76	0.45621
30	7	84	90.27	0.30048
31	7	84	69.37	0.87478
32	7	84	76.12	0.71767
33	7	84	123.29	0.00340
34	7	84	52.18	0.99749
35	7	84	83.48	0.49541
36	7	84	87.50	0.37533
37	7	84	95.73	0.17959
38	7	84	89.43	0.32220
39	7	84	104.01	0.06857
40	7	84	72.65	0.80697
41	7	84	114.82	0.01438
42	7	84	84.00	0.47950
43	7	84	79.69	0.61268
44	7	84	105.69	0.05496
45	7	84	64.51	0.94369
46	7	84	76.74	0.70040
47	7	84	75.02	0.74758
48	7	84	97.60	0.14731
49	7	84	102.88	0.07921
50	7	84	72.67	0.80646
51	7	84	90.07	0.30561
52	7	84	74.85	0.75229
53	7	84	100.62	0.10443
54	7	84	84.79	0.45547
55	7	84	99.16	0.12375
56	7	84	87.39	0.37858

57	7	84	90.03	0.30651
58	7	84	84.48	0.46484
59	7	84	67.95	0.89883
60	7	84	91.14	0.27851
61	7	84	88.83	0.33847
62	7	84	106.43	0.04974
63	7	84	93.34	0.22757
64	7	84	75.21	0.74263
65	7	84	68.41	0.89145
66	7	84	99.07	0.12506
67	7	84	105.95	0.05313
68	7	84	94.89	0.19556
69	7	84	85.37	0.43780
70	7	84	79.07	0.63161
71	7	84	87.53	0.37451
72	7	84	88.13	0.35767
73	7	84	80.92	0.57499
74	7	84	112.83	0.01965
75	7	84	89.13	0.33034
76	7	84	83.57	0.49274
77	7	84	87.79	0.36716
78	7	84	83.22	0.50341
79	7	84	85.16	0.44422
80	7	84	81.40	0.56000
81	7	84	84.56	0.46243
82	7	84	72.94	0.80018
83	7	84	102.46	0.08346
84	7	84	87.48	0.37584
85	7	84	84.85	0.45353
86	7	84	70.90	0.84524
87	7	84	69.14	0.87894
88	7	84	88.00	0.36117
89	7	84	99.29	0.12193
90	7	84	82.40	0.52886
91	7	84	73.08	0.79668
92	7	84	118.12	0.00838
93	7	84	88.93	0.33560
94	7	84	94.66	0.20014
95	7	84	73.42	0.78847
96	7	84	75.68	0.72995
97	7	84	95.30	0.18772
98	7	84	91.54	0.26885
99	7	84	77.08	0.69047
100	7	84	100.70	0.10341
Combined P-value for all tests (Using KS method)				0.19402

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	68.37	0.12424
2	7	56	56.92	0.44068
3	7	56	48.73	0.74396

4	7	56	45.11	0.85091
5	7	56	46.89	0.80188
6	7	56	45.81	0.83250
7	7	56	50.65	0.67675
8	7	56	58.09	0.39830
9	7	56	55.12	0.50824
10	7	56	45.58	0.83877
11	7	56	54.81	0.51990
12	7	56	36.54	0.97952
13	7	56	50.62	0.67805
14	7	56	59.92	0.33536
15	7	56	33.59	0.99239
16	7	56	48.10	0.76460
17	7	56	63.49	0.22946
18	7	56	58.29	0.39128
19	7	56	89.28	0.00311
20	7	56	37.80	0.97041
21	7	56	50.98	0.66494
22	7	56	44.23	0.87229
23	7	56	53.55	0.56808
24	7	56	61.26	0.29306
25	7	56	62.71	0.25043
26	7	56	62.07	0.26888
27	7	56	49.00	0.73489
28	7	56	66.87	0.15161
29	7	56	78.61	0.02482
30	7	56	66.42	0.16067
31	7	56	46.68	0.80822
32	7	56	56.45	0.45802
33	7	56	55.69	0.48640
34	7	56	43.83	0.88125
35	7	56	47.45	0.78501
36	7	56	65.00	0.19189
37	7	56	51.05	0.66230
38	7	56	50.89	0.66823
39	7	56	62.68	0.25143
40	7	56	41.65	0.92335
41	7	56	45.76	0.83396
42	7	56	43.81	0.88164
43	7	56	60.82	0.30644
44	7	56	70.60	0.09065
45	7	56	50.37	0.68714
46	7	56	50.58	0.67935
47	7	56	48.03	0.76691
48	7	56	64.05	0.21507
49	7	56	73.33	0.05989
50	7	56	61.58	0.28324
51	7	56	59.44	0.35136
Combined P-value for all tests (Using KS method)				0.17029

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	17.54	0.67784
2	7	21	16.58	0.73599
3	7	21	27.89	0.14318
4	7	21	22.38	0.37786
5	7	21	21.88	0.40629
6	7	21	21.47	0.43050
7	7	21	24.43	0.27248
8	7	21	16.20	0.75814
9	7	21	15.13	0.81614
10	7	21	29.60	0.10024
11	7	21	19.25	0.56929
12	7	21	11.76	0.94583
13	7	21	32.42	0.05306
14	7	21	28.32	0.13135
15	7	21	12.06	0.93790
16	7	21	23.82	0.30175
17	7	21	13.34	0.89620
18	7	21	25.42	0.22923
19	7	21	27.13	0.16660
20	7	21	21.99	0.39983
21	7	21	19.37	0.56128
22	7	21	18.98	0.58661
23	7	21	16.02	0.76825
24	7	21	28.75	0.12004
25	7	21	14.33	0.85500
26	7	21	18.07	0.64473
27	7	21	24.79	0.25642
28	7	21	31.21	0.07027
29	7	21	11.46	0.95298
30	7	21	11.78	0.94542
31	7	21	27.63	0.15094
32	7	21	28.25	0.13329
33	7	21	16.59	0.73581
34	7	21	19.82	0.53248
35	7	21	16.70	0.72898
36	7	21	24.21	0.28304
37	7	21	14.61	0.84183
38	7	21	23.17	0.33478
39	7	21	24.18	0.28464
40	7	21	18.17	0.63807
41	7	21	17.30	0.69263
42	7	21	28.72	0.12086
43	7	21	21.51	0.42811
44	7	21	12.67	0.91987
45	7	21	31.88	0.06025
46	7	21	21.98	0.40083

47	7	21	20.67	0.47937
48	7	21	29.72	0.09775
49	7	21	11.53	0.95152
50	7	21	19.89	0.52846
51	7	21	28.57	0.12475
52	7	21	16.65	0.73203
53	7	21	18.39	0.62440
54	7	21	34.48	0.03214
55	7	21	25.62	0.22123
56	7	21	18.56	0.61345
57	7	21	25.27	0.23562
58	7	21	26.01	0.20616
59	7	21	27.35	0.15971
60	7	21	10.55	0.97080
61	7	21	25.48	0.22688
62	7	21	37.89	0.01328
63	7	21	12.80	0.91548
64	7	21	20.55	0.48683
65	7	21	19.35	0.56266
66	7	21	19.80	0.53408
67	7	21	17.55	0.67746
68	7	21	9.33	0.98635
69	7	21	10.91	0.96446
70	7	21	23.83	0.30160
71	7	21	24.80	0.25583
72	7	21	10.35	0.97401
73	7	21	27.68	0.14934
74	7	21	10.66	0.96906
75	7	21	35.03	0.02804
76	7	21	14.86	0.82982
77	7	21	19.52	0.55170
78	7	21	12.76	0.91693
79	7	21	28.38	0.12979
80	7	21	26.94	0.17301
81	7	21	13.91	0.87364
82	7	21	21.86	0.40746
83	7	21	27.43	0.15719
84	7	21	35.92	0.02233
85	7	21	25.82	0.21348
86	7	21	20.92	0.46386
87	7	21	22.88	0.35058
88	7	21	34.55	0.03161
89	7	21	17.77	0.66381
90	7	21	14.87	0.82955
91	7	21	32.26	0.05507
92	7	21	27.03	0.16987
93	7	21	22.17	0.38976
94	7	21	25.66	0.21985
95	7	21	35.60	0.02423
96	7	21	20.91	0.46448
97	7	21	34.55	0.03160
98	7	21	11.32	0.95628
99	7	21	17.01	0.71041
100	7	21	42.98	0.00316

Combined P-value for all tests (Using KS method)	0.18035
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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.

3.2 Poker suits statistics for 36 cards deck:

Test No.	Positions	DOF	ChiSqr	P-Value
1	7	21	22.96	0.34611
2	7	21	28.05	0.13880
3	7	21	15.90	0.77547
4	7	21	14.41	0.85144
5	7	21	15.03	0.82134
6	7	21	18.64	0.60822
7	7	21	22.02	0.39859
8	7	21	18.21	0.63581
9	7	21	17.25	0.69597
10	7	21	22.96	0.34611
11	7	21	19.20	0.57231
12	7	21	17.63	0.67216
13	7	21	23.13	0.33719
14	7	21	21.08	0.45407
15	7	21	33.94	0.03674
16	7	21	11.21	0.95858
17	7	21	17.13	0.70332
18	7	21	29.62	0.09998
19	7	21	11.74	0.94627
20	7	21	17.96	0.65153
21	7	21	16.38	0.74770
22	7	21	17.11	0.70429
23	7	21	21.34	0.43860
24	7	21	31.26	0.06938
25	7	21	16.78	0.72411
26	7	21	15.43	0.80067
27	7	21	25.03	0.24578
28	7	21	27.21	0.16407
29	7	21	16.86	0.71980
30	7	21	14.56	0.84437
31	7	21	16.25	0.75556
32	7	21	25.67	0.21923
33	7	21	11.39	0.95460
34	7	21	29.54	0.10154
35	7	21	36.92	0.01719
36	7	21	25.94	0.20859
37	7	21	32.73	0.04932
38	7	21	16.09	0.76469
39	7	21	15.76	0.78298
40	7	21	14.06	0.86718
41	7	21	10.54	0.97108
42	7	21	27.27	0.16203
43	7	21	10.64	0.96935
44	7	21	26.83	0.17648
45	7	21	17.10	0.70527
46	7	21	24.06	0.29035
47	7	21	13.01	0.90834
48	7	21	25.21	0.23827

49	7	21	32.15	0.05651
50	7	21	24.99	0.24751
51	7	21	17.20	0.69870
Combined P-value for all tests (Using KS method)				0.20295

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	0.19402	0.54106
Suits Test	0.18035	0.54106
Hand Types Test	0.57746	0.57746
Combined P-Value using Holm's Method		0.54106

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	0.17029	0.51086
Suits Test	0.20295	0.51086
Hands Type Test	0.01218	0.04872
Hands Type Test	0.26229	0.51086
Combined P-Value using Holm's Method		0.04872

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

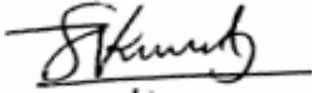
Analysis of actual data from game logs for 'Hand Types', 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

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: 15 July 2021

Signed:



Geoff Nicoll
Principal Consultant
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Date: 15 July 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.

