Poker Cards Analysis - May 2022

The Directors
Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **May 01, 2022** to **May 31, 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	10.26	0.32957
2	9	8.60	0.47496
3	9	8.91	0.44572
4	9	9.62	0.38177
5	9	3.67	0.93181
6	9	3.25	0.95363
7	9	6.50	0.68885
8	9	10.94	0.27987
9	9	11.44	0.24700
10	9	5.48	0.79030
11	9	6.48	0.69139
12	9	15.12	0.08758
13	9	10.69	0.29723
14	9	2.86	0.96967
15	9	8.29	0.50515
16	9	17.03	0.04820
17	9	10.82	0.28816
18	9	10.50	0.31170
19	9	10.43	0.31646
20	9	5.35	0.80297
21	9	13.91	0.12571
22	9	9.62	0.38231
23	9	8.37	0.49703
24	9	6.54	0.68525

25	9	4.07	0.90648
26	9	6.24	0.71582
27	9	4.55	0.87176
28	9	6.75	0.66353
29	9	6.10	0.72986
30	9	7.93	0.54144
31	9	12.20	0.20231
32	9	4.83	0.84920
33	9	7.75	0.55903
34	9	9.53	0.38987
35	9	3.79	0.92457
36	9	5.38	0.80013
37	9	10.55	0.30793
38	9	6.85	0.65248
39	9	3.72	0.92891
40	9	8.80	0.45567
41	9	7.78	0.55626
42	9	11.52	0.24200
43	9	5.54	0.78532
44	9	6.03	0.73695
45	9	7.49	0.58635
46	9	17.09	0.04727
47	9	7.99	0.53552
48	9	3.97	0.91305
49	9	11.61	0.23634
50	9	12.16	0.20463
51	9	15.34	0.08192
52	9	12.26	0.19886
53	9	9.64	0.38042
54	9	3.66	0.93250
55	9	2.35	0.98460
56	9	7.41	0.59412
57	9	6.83	0.65525
58	9	7.25	0.61149
59	9	12.00	0.21346
60	9	9.50	0.39261
61	9	9.04	0.43357
62	9	16.83	0.05142
63	9	4.31	0.88969
64	9	17.55	0.04083
65	9	10.74	0.29364
66	9	5.14	0.82200
67	9	8.74	0.46196
68	9	7.05	0.63147
69	9	5.86	0.75409
70	9	12.41	0.19113
71	9	16.16	0.06368
72	9	10.89	0.28313
73	9	7.22	0.61411
74	9	7.55	0.58004
75	9	6.26	0.71389
76	9	15.40	0.08049
77	9	6.96	0.64103
78	9	12.25	0.19967
79	9	7.95	0.53935

80	9	7.06	0.63096
81	9	13.15	0.15601
82	9	8.11	0.52330
83	9	12.31	0.19643
84	9	6.89	0.64877
85	9	10.37	0.32171
86	9	12.16	0.20440
87	9	6.17	0.72264
88	9	21.27	0.01149
89	9	14.33	0.11114
90	9	10.72	0.29505
91	9	13.94	0.12446
92	9	9.71	0.37409
93	9	14.61	0.10210
94	9	10.05	0.34618
95	9	5.03	0.83149
96	9	11.47	0.24497
97	9	9.41	0.40013
98	9	7.37	0.59910
99	9	8.08	0.52607
100	9	4.04	0.90849
Combined P-value for all tests (Using KS method)			0.93486

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	1.77	0.98716
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) No KS test was performed for combining tests since samples are adequate for a single test only.

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	103.59	0.07238
2	7	84	74.38	0.76433
3	7	84	65.33	0.93464
4	7	84	88.29	0.35315

5	7	84	81.03	0.57152
6	7	84	97.77	0.14462
7	7	84	76.75	0.70015
8	7	84	95.82	0.17792
9	7	84	82.97	0.51124
10	7	84	80.91	0.57515
11	7	84	74.50	0.76145
12	7	84	87.03	0.38875
13	7	84	92.21	0.25315
14	7	84	76.54	0.70591
15	7	84	80.03	0.60255
16	7	84	68.03	0.89753
17	7	84	79.02	0.63328
18	7	84	92.84	0.23872
19	7	84	83.78	0.48621
20	7	84	98.22	0.13758
21	7	84	116.36	0.01121
22	7	84	70.60	0.85148
23	7	84	76.66	0.70253
24	7	84	86.72	0.39781
25	7	84	103.54	0.07281
26	7	84	78.18	0.65824
27	7	84	89.19	0.32873
28	7	84	73.51	0.78633
29	7	84	76.02	0.72041
30	7	84	91.84	0.26166
31	7	84	86.27	0.41103
32	7	84	101.92	0.08925
33	7	84	63.50	0.95349
34	7	84	74.50	0.76136
35	7	84	77.47	0.67935
36	7	84	79.44	0.62052
37	7	84	80.87	0.57659
38	7	84	90.73	0.28866
39	7	84	57.44	0.98819
40	7	84	81.56	0.55502
41	7	84	96.57	0.16458
42	7	84	106.63	0.04844
43	7	84	77.54	0.67720
44	7	84	96.81	0.16035
45	7	84	89.70	0.31505
46	7	84	89.24	0.32724
47	7	84	69.17	0.87844
48	7	84	82.27	0.53291
49	7	84	90.39	0.29734
50	7	84	71.20	0.83914
51	7	84	81.72	0.55023
52	7	84	92.18	0.25383
53	7	84	79.72	0.61178
54	7	84	77.17	0.68800
55	7	84	65.08	0.93752
56	7	84	71.04	0.84243
57	7	84	86.95	0.39105
58	7	84	86.62	0.40088
59	7	84	70.45	0.85440

60	7	84	85.09	0.44613
61	7	84	87.89	0.36432
62	7	84	78.89	0.63702
63	7	84	96.90	0.15887
64	7	84	87.45	0.37668
65	7	84	78.92	0.63612
66	7	84	89.92	0.30931
67	7	84	73.84	0.77809
68	7	84	81.46	0.55809
69	7	84	70.54	0.85249
70	7	84	62.94	0.95839
71	7	84	71.46	0.83347
72	7	84	74.47	0.76219
73	7	84	89.17	0.32922
74	7	84	85.74	0.42682
75	7	84	99.88	0.11385
76	7	84	83.47	0.49572
77	7	84	74.34	0.76539
78	7	84	95.13	0.19102
79	7	84	100.16	0.11015
80	7	84	78.45	0.65042
81	7	84	85.50	0.43395
82	7	84	68.93	0.88263
83	7	84	85.02	0.44845
84	7	84	54.16	0.99531
85	7	84	76.20	0.71554
86	7	84	73.16	0.79485
87	7	84	100.19	0.10982
88	7	84	96.38	0.16776
89	7	84	76.02	0.72066
90	7	84	96.74	0.16160
91	7	84	78.16	0.65886
92	7	84	89.33	0.32486
93	7	84	88.03	0.36028
94	7	84	84.24	0.47210
95	7	84	82.64	0.52163
96	7	84	69.75	0.86779
97	7	84	70.01	0.86301
98	7	84	77.52	0.67790
99	7	84	73.56	0.78518
100	7	84	87.56	0.37378
Combined P-value for all tests (Using KS method)				0.53855

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	70.31	0.09452
2	7	56	52.89	0.59349
3	7	56	56.94	0.44002
4	7	56	71.50	0.07936
5	7	56	69.29	0.10937
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.
As the total number of tests 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.

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	15.99	0.77007
2	7	21	17.55	0.67713
3	7	21	14.42	0.85087
4	7	21	24.67	0.26185
5	7	21	23.64	0.31072
6	7	21	25.08	0.24358
7	7	21	23.01	0.34326
8	7	21	20.44	0.49371
9	7	21	23.38	0.32402
10	7	21	20.03	0.51907
11	7	21	14.57	0.84408
12	7	21	14.87	0.82938
13	7	21	19.45	0.55661
14	7	21	21.66	0.41929
15	7	21	14.46	0.84898
16	7	21	13.88	0.87454
17	7	21	26.31	0.19470
18	7	21	26.26	0.19683
19	7	21	17.13	0.70290
20	7	21	15.11	0.81743
21	7	21	11.58	0.95019
22	7	21	12.67	0.91980
23	7	21	35.18	0.02697
24	7	21	21.46	0.43106
25	7	21	26.66	0.18254
26	7	21	38.53	0.01115
27	7	21	10.42	0.97298

28	7	21	20.68	0.47856
29	7	21	24.72	0.25970
30	7	21	18.56	0.61314
31	7	21	27.31	0.16083
32	7	21	15.68	0.78720
33	7	21	29.57	0.10094
34	7	21	19.12	0.57755
35	7	21	16.25	0.75559
36	7	21	23.18	0.33420
37	7	21	18.84	0.59524
38	7	21	21.41	0.43427
39	7	21	20.15	0.51200
40	7	21	25.07	0.24394
41	7	21	10.85	0.96564
42	7	21	13.35	0.89600
43	7	21	21.71	0.41612
44	7	21	21.09	0.45320
45	7	21	22.96	0.34604
46	7	21	25.28	0.23542
47	7	21	15.84	0.77884
48	7	21	27.18	0.16499
49	7	21	27.04	0.16943
50	7	21	29.48	0.10302
51	7	21	15.32	0.80671
52	7	21	14.18	0.86188
53	7	21	15.71	0.78572
54	7	21	20.57	0.48567
55	7	21	16.74	0.72660
56	7	21	28.38	0.12973
57	7	21	11.91	0.94206
58	7	21	13.81	0.87744
59	7	21	16.13	0.76208
60	7	21	19.49	0.55364
61	7	21	26.53	0.18708
62	7	21	31.34	0.06816
63	7	21	27.19	0.16451
64	7	21	14.43	0.85022
65	7	21	22.19	0.38844
66	7	21	13.70	0.88233
67	7	21	21.08	0.45386
68	7	21	19.06	0.58128
69	7	21	16.83	0.72138
70	7	21	17.65	0.67125
71	7	21	23.31	0.32759
72	7	21	20.76	0.47354
73	7	21	13.83	0.87661
74	7	21	20.58	0.48475
75	7	21	13.57	0.88737
76	7	21	22.54	0.36894
77	7	21	21.86	0.40755
78	7	21	23.38	0.32403
79	7	21	22.24	0.38594
80	7	21	30.63	0.08006
81	7	21	12.73	0.91787
82	7	21	12.83	0.91455

83	7	21	18.70	0.60455
84	7	21	24.04	0.29129
85	7	21	11.05	0.96183
86	7	21	18.28	0.63145
87	7	21	16.42	0.74539
88	7	21	23.28	0.32938
89	7	21	28.71	0.12122
90	7	21	24.22	0.28233
91	7	21	14.45	0.84965
92	7	21	25.11	0.24260
93	7	21	30.62	0.08024
94	7	21	21.08	0.45398
95	7	21	29.85	0.09508
96	7	21	21.51	0.42792
97	7	21	7.90	0.99555
98	7	21	16.93	0.71544
99	7	21	21.57	0.42437
100	7	21	23.19	0.33414
Combined P-value for all tests (Using KS method)				0.84203

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	30.17	0.08866
2	7	21	33.14	0.04464
3	7	21	20.79	0.47171
4	7	21	16.77	0.72507
5	7	21	21.40	0.43487
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 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.

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	0.53855	1.00000
Suits Test	0.84203	1.00000
Hand Types Test	0.93486	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 1	0.09452	0.79797
Ranks Test 2	0.59349	1.00000
Ranks Test 3	0.44002	1.00000
Ranks Test 4	0.07936	0.79362
Ranks Test 5	0.10937	0.79797
Suits Test 1	0.08866	0.79797
Suits Test 2	0.04464	0.49109
Suits Test 3	0.47171	1.00000
Suits Test 4	0.72507	1.00000
Suits Test 5	0.43487	1.00000
HandTypes Test 1	0.98716	1.00000
Combined P-Value using Holm's Method		0.49109

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

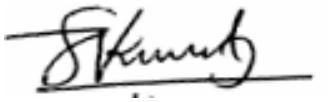
Analysis of actual data from game logs for 'Hand Types, 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

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: 13 Jul 2022

Signed:

Geoff Nicoll
Principal Consultant
iTech Labs Australia
Date: 13 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.