Poker Cards Analysis - Jul 2022

The Directors
Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **Jul 01, 2022** to **Jul 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	16.22	0.06250
2	9	13.15	0.15594
3	9	5.57	0.78205
4	9	16.80	0.05198
5	9	9.84	0.36330
6	9	9.41	0.40029
7	9	9.83	0.36434
8	9	21.04	0.01248
9	9	6.52	0.68686
10	9	5.39	0.79865
11	9	11.17	0.26419
12	9	8.20	0.51383
13	9	14.40	0.10892
14	9	14.18	0.11608
15	9	10.99	0.27640
16	9	9.79	0.36757
17	9	9.19	0.41970
18	9	6.30	0.70953
19	9	13.71	0.13295
20	9	8.68	0.46734
21	9	3.35	0.94862
22	9	5.09	0.82597
23	9	18.28	0.03208
24	9	16.02	0.06644

25	9	11.65	0.23369
26	9	6.32	0.70763
27	9	8.47	0.48792
28	9	8.81	0.45528
29	9	2.77	0.97280
30	9	7.22	0.61437
31	9	2.78	0.97250
32	9	10.92	0.28147
33	9	14.68	0.10001
34	9	6.82	0.65546
35	9	13.25	0.15166
36	9	7.53	0.58212
37	9	12.84	0.16991
38	9	14.97	0.09187
39	9	12.67	0.17815
40	9	4.18	0.89935
41	9	14.98	0.09162
42	9	6.13	0.72722
43	9	11.37	0.25095
44	9	8.52	0.48305
45	9	11.11	0.26812
46	9	2.98	0.96489
47	9	5.06	0.82921
48	9	10.64	0.30147
49	9	4.78	0.85330
50	9	10.92	0.28113
51	9	3.76	0.92627
52	9	4.42	0.88154
53	9	6.10	0.72994
54	9	19.87	0.01876
55	9	5.49	0.78924
56	9	3.64	0.93367
57	9	5.92	0.74800
58	9	12.40	0.19170
59	9	10.09	0.34323
60	9	5.73	0.76618
61	9	12.52	0.18532
62	9	13.76	0.13121
63	9	9.71	0.37471
64	9	9.82	0.36541
65	9	3.95	0.91451
66	9	6.38	0.70174
67	9	18.96	0.02556
68	9	9.61	0.38268
69	9	4.06	0.90766
70	9	3.53	0.93944
71	9	17.87	0.03667
72	9	13.79	0.12993
73	9	13.49	0.14151
74	9	13.12	0.15718
75	9	8.23	0.51117
76	9	13.55	0.13906
77	9	11.88	0.22022
78	9	8.68	0.46762
79	9	10.81	0.28905

80	9	3.87	0.91986
81	9	12.61	0.18118
82	9	8.39	0.49498
83	9	4.79	0.85251
84	9	5.73	0.76671
85	9	13.20	0.15369
86	9	8.68	0.46740
87	9	7.29	0.60662
88	9	4.98	0.83576
89	9	8.56	0.47862
90	9	7.66	0.56843
91	9	4.11	0.90421
92	9	13.30	0.14942
93	9	8.98	0.43913
94	9	5.09	0.82619
95	9	14.27	0.11301
96	9	5.41	0.79749
97	9	8.31	0.50348
98	9	4.20	0.89754
99	9	4.28	0.89210
100	9	12.88	0.16814
Combined P-value for all tests (Using KS method)			0.27450

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	16.72	0.03315
2	8	11.13	0.19438
3	8	4.09	0.84924
Combined P-value for all tests (Using KS method)			N/A (Insufficient data)

Notes:

1) Since the number of samples available was insufficient to ensure at least 5 samples in the lowest probability hand type, (Royal Flush), the chi-square test has been performed by merging the Royal Flush and Straight Flush categories.

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	106.51	0.04924

2	7	84	68.86	0.88383
3	7	84	68.20	0.89479
4	7	84	102.58	0.08228
5	7	84	90.92	0.28404
6	7	84	75.97	0.72205
7	7	84	79.87	0.60723
8	7	84	99.46	0.11951
9	7	84	97.37	0.15099
10	7	84	98.58	0.13214
11	7	84	75.45	0.73613
12	7	84	80.21	0.59672
13	7	84	85.90	0.42186
14	7	84	85.53	0.43305
15	7	84	102.74	0.08062
16	7	84	80.60	0.58484
17	7	84	57.36	0.98846
18	7	84	71.08	0.84166
19	7	84	61.16	0.97133
20	7	84	86.67	0.39917
21	7	84	100.45	0.10653
22	7	84	76.11	0.71797
23	7	84	74.49	0.76164
24	7	84	70.20	0.85923
25	7	84	99.55	0.11828
26	7	84	76.05	0.71967
27	7	84	90.02	0.30676
28	7	84	84.97	0.44981
29	7	84	93.78	0.21831
30	7	84	92.04	0.25700
31	7	84	84.59	0.46131
32	7	84	84.56	0.46223
33	7	84	71.56	0.83144
34	7	84	60.81	0.97342
35	7	84	65.17	0.93642
36	7	84	96.68	0.16264
37	7	84	90.22	0.30174
38	7	84	100.35	0.10773
39	7	84	78.59	0.64601
40	7	84	81.61	0.55355
41	7	84	82.55	0.52442
42	7	84	106.61	0.04852
43	7	84	66.12	0.92495
44	7	84	92.28	0.25136
45	7	84	59.10	0.98211
46	7	84	74.20	0.76912
47	7	84	85.98	0.41946
48	7	84	74.53	0.76053
49	7	84	71.44	0.83394
50	7	84	118.85	0.00740
51	7	84	105.22	0.05855
52	7	84	91.44	0.27122
53	7	84	78.76	0.64109
54	7	84	83.19	0.50457
55	7	84	77.80	0.66956
56	7	84	77.25	0.68553

57	7	84	64.62	0.94251
58	7	84	86.54	0.40322
59	7	84	95.21	0.18947
60	7	84	76.07	0.71913
61	7	84	80.28	0.59466
62	7	84	118.06	0.00846
63	7	84	125.10	0.00244
64	7	84	76.67	0.70230
65	7	84	68.92	0.88279
66	7	84	83.49	0.49506
67	7	84	86.33	0.40927
68	7	84	95.28	0.18798
69	7	84	75.19	0.74313
70	7	84	87.67	0.37053
71	7	84	78.63	0.64506
72	7	84	118.62	0.00770
73	7	84	68.08	0.89670
74	7	84	69.31	0.87593
75	7	84	88.61	0.34426
76	7	84	81.63	0.55282
77	7	84	98.81	0.12872
78	7	84	84.71	0.45768
79	7	84	111.99	0.02232
80	7	84	69.37	0.87477
81	7	84	106.53	0.04908
82	7	84	99.24	0.12255
83	7	84	83.54	0.49379
84	7	84	116.03	0.01182
85	7	84	89.19	0.32854
86	7	84	116.95	0.01017
87	7	84	74.75	0.75475
88	7	84	74.04	0.77323
89	7	84	107.31	0.04412
90	7	84	76.84	0.69757
91	7	84	84.27	0.47130
92	7	84	96.94	0.15810
93	7	84	74.16	0.77015
94	7	84	80.58	0.58537
95	7	84	86.69	0.39875
96	7	84	70.85	0.84639
97	7	84	90.51	0.29429
98	7	84	93.18	0.23125
99	7	84	77.02	0.69239
100	7	84	76.18	0.71606
Combined P-value for all tests (Using KS method)				0.73194

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	61.98	0.27151
2	7	56	41.24	0.93001
3	7	56	71.79	0.07600
4	7	56	52.89	0.59349
5	7	56	38.23	0.96666
6	7	56	55.55	0.49184
7	7	56	57.48	0.42028
8	7	56	56.56	0.45401
9	7	56	48.37	0.75585
10	7	56	54.16	0.54467
11	7	56	49.99	0.70061
12	7	56	61.76	0.27787
13	7	56	41.80	0.92093
14	7	56	53.80	0.55877
Combined P-value for all tests (Using KS method)				0.54164

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	25.19	0.23882
2	7	21	12.72	0.91809
3	7	21	18.62	0.60938
4	7	21	16.97	0.71296
5	7	21	13.14	0.90346
6	7	21	16.31	0.75199
7	7	21	13.84	0.87654
8	7	21	26.74	0.17976
9	7	21	17.40	0.68686
10	7	21	14.40	0.85173
11	7	21	30.13	0.08944
12	7	21	25.55	0.22410
13	7	21	25.72	0.21719
14	7	21	28.59	0.12413
15	7	21	16.05	0.76671
16	7	21	14.05	0.86732
17	7	21	14.60	0.84270
18	7	21	29.80	0.09617
19	7	21	35.60	0.02426
20	7	21	14.76	0.83466

21	7	21	32.12	0.05693
22	7	21	27.37	0.15887
23	7	21	19.69	0.54122
24	7	21	21.68	0.41808
25	7	21	17.84	0.65921
26	7	21	17.10	0.70507
27	7	21	15.27	0.80937
28	7	21	10.70	0.96826
29	7	21	20.26	0.50502
30	7	21	11.57	0.95055
31	7	21	15.43	0.80068
32	7	21	27.74	0.14775
33	7	21	20.77	0.47286
34	7	21	25.84	0.21257
35	7	21	17.93	0.65363
36	7	21	18.88	0.59271
37	7	21	20.12	0.51374
38	7	21	30.01	0.09184
39	7	21	19.54	0.55055
40	7	21	21.24	0.44466
41	7	21	17.53	0.67853
42	7	21	18.57	0.61268
43	7	21	22.70	0.36043
44	7	21	29.86	0.09483
45	7	21	25.67	0.21925
46	7	21	20.49	0.49027
47	7	21	16.22	0.75717
48	7	21	16.50	0.74118
49	7	21	32.19	0.05597
50	7	21	24.48	0.27017
51	7	21	21.17	0.44870
52	7	21	33.87	0.03738
53	7	21	31.81	0.06122
54	7	21	22.00	0.39932
55	7	21	23.16	0.33551
56	7	21	20.89	0.46543
57	7	21	17.62	0.67273
58	7	21	14.35	0.85418
59	7	21	13.38	0.89465
60	7	21	28.82	0.11829
61	7	21	17.56	0.67635
62	7	21	17.87	0.65710
63	7	21	23.85	0.30020
64	7	21	18.32	0.62842
65	7	21	27.19	0.16472
66	7	21	18.85	0.59492
67	7	21	19.20	0.57239
68	7	21	21.18	0.44828
69	7	21	22.47	0.37274
70	7	21	22.82	0.35363
71	7	21	23.47	0.31954
72	7	21	30.81	0.07696
73	7	21	12.13	0.93602
74	7	21	16.35	0.74988
75	7	21	13.50	0.89026

76	7	21	46.09	0.00124
77	7	21	25.07	0.24404
78	7	21	23.30	0.32827
79	7	21	25.50	0.22627
80	7	21	24.14	0.28611
81	7	21	9.03	0.98901
82	7	21	15.02	0.82170
83	7	21	17.05	0.70817
84	7	21	32.66	0.05016
85	7	21	27.15	0.16603
86	7	21	9.15	0.98795
87	7	21	26.91	0.17375
88	7	21	22.77	0.35631
89	7	21	24.52	0.26874
90	7	21	18.11	0.64229
91	7	21	18.15	0.63944
92	7	21	20.31	0.50185
93	7	21	21.19	0.44723
94	7	21	18.93	0.58963
95	7	21	20.79	0.47207
96	7	21	12.97	0.90963
97	7	21	26.36	0.19292
98	7	21	9.97	0.97924
99	7	21	27.65	0.15028
100	7	21	24.83	0.25448
Combined P-value for all tests (Using KS method)				0.99681

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	26.82	0.17703
2	7	21	13.98	0.87029
3	7	21	15.81	0.78034
4	7	21	24.71	0.25985
5	7	21	24.54	0.26745
6	7	21	28.93	0.11574
7	7	21	20.42	0.49457
8	7	21	22.06	0.39629
9	7	21	22.22	0.38716
10	7	21	14.59	0.84285
11	7	21	24.24	0.28158
12	7	21	20.40	0.49607
13	7	21	29.48	0.10295
14	7	21	15.36	0.80435
Combined P-value for all tests (Using KS method)				0.90000

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	0.73194	1.00000
Suits Test	0.99681	1.00000
HandTypes Test	0.27450	0.82350
Combined P-Value using Holm's Method		0.82350

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	0.54164	1.00000
Suits Test	0.90000	1.00000
HandTypes Test	0.03315	0.16575
HandTypes Test	0.19438	0.77753
HandTypes Test	0.84924	1.00000
Combined P-Value using Holm's Method		0.16575

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.

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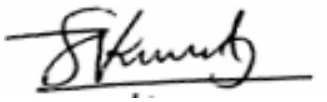

Kiren Sreekumar
Principal Consultant
iTech Labs Australia
Date: 18 Aug 2022

Signed:

Geoff Nicoll
Principal Consultant
iTech Labs Australia
Date: 18 Aug 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.