Poker Cards Analysis - April 2022

The Directors
Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **April 01, 2022** to **April 30, 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	11.45	0.24622
2	9	7.80	0.55442
3	9	11.49	0.24341
4	9	12.08	0.20865
5	9	2.79	0.97191
6	9	5.16	0.82011
7	9	10.62	0.30283
8	9	6.28	0.71143
9	9	9.00	0.43773
10	9	11.45	0.24625
11	9	16.33	0.06034
12	9	4.78	0.85298
13	9	10.22	0.33328
14	9	9.93	0.35630
15	9	3.79	0.92488
16	9	10.31	0.32579
17	9	5.72	0.76802
18	9	8.26	0.50770
19	9	12.59	0.18201
20	9	9.67	0.37813
21	9	2.06	0.99054
22	9	7.08	0.62858
23	9	7.13	0.62399
24	9	7.78	0.55681

25	9	11.58	0.23821
26	9	10.28	0.32827
27	9	6.60	0.67848
28	9	14.32	0.11154
29	9	8.77	0.45911
30	9	9.18	0.42042
31	9	11.21	0.26131
32	9	10.31	0.32578
33	9	13.63	0.13607
34	9	10.47	0.31353
35	9	12.32	0.19565
36	9	6.05	0.73505
37	9	11.74	0.22844
38	9	7.44	0.59173
39	9	11.10	0.26878
40	9	15.70	0.07351
41	9	11.95	0.21621
42	9	11.23	0.26055
43	9	13.10	0.15821
44	9	10.79	0.29018
45	9	9.11	0.42733
46	9	8.56	0.47874
47	9	8.22	0.51171
48	9	5.11	0.82459
49	9	9.08	0.42968
50	9	3.00	0.96420
51	9	8.41	0.49293
52	9	6.82	0.65555
53	9	20.52	0.01498
54	9	5.98	0.74173
55	9	15.07	0.08895
56	9	6.45	0.69384
57	9	7.86	0.54783
58	9	8.28	0.50660
59	9	9.12	0.42623
60	9	8.40	0.49427
61	9	8.47	0.48779
62	9	10.72	0.29540
63	9	3.18	0.95664
64	9	6.90	0.64733
65	9	6.94	0.64306
66	9	2.44	0.98242
67	9	6.28	0.71194
68	9	4.89	0.84389
69	9	4.36	0.88642
70	9	5.06	0.82922
71	9	9.01	0.43654
72	9	5.67	0.77220
73	9	6.89	0.64841
74	9	6.06	0.73435
75	9	3.64	0.93356
76	9	4.89	0.84347
77	9	9.86	0.36195
78	9	8.65	0.47035
79	9	8.10	0.52400

80	9	9.49	0.39291
81	9	16.31	0.06060
82	9	6.44	0.69546
83	9	7.19	0.61686
84	9	13.36	0.14698
85	9	10.25	0.33093
86	9	14.44	0.10750
87	9	8.67	0.46862
88	9	5.94	0.74596
89	9	9.74	0.37204
90	9	6.41	0.69852
91	9	11.94	0.21657
92	9	14.87	0.09466
93	9	9.54	0.38885
94	9	8.09	0.52519
95	9	9.48	0.39380
96	9	19.55	0.02088
97	9	10.05	0.34608
98	9	18.84	0.02658
99	9	10.52	0.31042
100	9	1.72	0.99513
Combined P-value for all tests (Using KS method)			0.45141

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	6.25	0.61894
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.
3) Results of this test may be unreliable since not enough samples were available to ensure 5 samples in each result category

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	87.73	0.36889
2	7	84	75.57	0.73281
3	7	84	89.18	0.32878

4	7	84	75.98	0.72172
5	7	84	85.89	0.42226
6	7	84	79.79	0.60971
7	7	84	54.36	0.99501
8	7	84	79.26	0.62593
9	7	84	77.56	0.67664
10	7	84	78.45	0.65049
11	7	84	74.55	0.75995
12	7	84	82.56	0.52403
13	7	84	94.27	0.20815
14	7	84	90.08	0.30535
15	7	84	105.19	0.05882
16	7	84	74.04	0.77300
17	7	84	50.58	0.99855
18	7	84	143.94	0.00005
19	7	84	90.43	0.29628
20	7	84	86.50	0.40420
21	7	84	75.76	0.72761
22	7	84	77.70	0.67264
23	7	84	75.48	0.73524
24	7	84	68.80	0.88483
25	7	84	88.70	0.34193
26	7	84	68.02	0.89766
27	7	84	77.90	0.66656
28	7	84	105.02	0.06010
29	7	84	97.19	0.15398
30	7	84	81.31	0.56272
31	7	84	80.73	0.58088
32	7	84	99.32	0.12145
33	7	84	98.01	0.14076
34	7	84	85.97	0.41983
35	7	84	80.29	0.59444
36	7	84	91.49	0.26998
37	7	84	73.60	0.78416
38	7	84	79.60	0.61551
39	7	84	67.68	0.90310
40	7	84	91.52	0.26935
41	7	84	84.58	0.46177
42	7	84	93.50	0.22424
43	7	84	68.21	0.89463
44	7	84	73.33	0.79066
45	7	84	84.73	0.45729
46	7	84	94.08	0.21208
47	7	84	79.48	0.61937
48	7	84	58.24	0.98551
49	7	84	77.20	0.68721
50	7	84	75.70	0.72932
51	7	84	109.94	0.03031
52	7	84	91.96	0.25889
53	7	84	72.77	0.80410
54	7	84	98.29	0.13651
55	7	84	79.94	0.60506
56	7	84	47.69	0.99952
57	7	84	65.99	0.92658
58	7	84	101.97	0.08868

59	7	84	95.15	0.19053
60	7	84	81.30	0.56331
61	7	84	75.98	0.72161
62	7	84	88.13	0.35754
63	7	84	64.42	0.94455
64	7	84	82.13	0.53751
65	7	84	110.45	0.02813
66	7	84	85.15	0.44453
67	7	84	96.50	0.16570
68	7	84	92.59	0.24440
69	7	84	75.49	0.73509
70	7	84	83.13	0.50644
71	7	84	51.18	0.99821
72	7	84	96.97	0.15761
73	7	84	101.99	0.08845
74	7	84	54.44	0.99489
75	7	84	97.27	0.15256
76	7	84	85.02	0.44830
77	7	84	83.29	0.50131
78	7	84	91.19	0.27729
79	7	84	98.02	0.14068
80	7	84	73.44	0.78810
81	7	84	72.44	0.81179
82	7	84	81.56	0.55502
83	7	84	67.00	0.91309
84	7	84	103.59	0.07241
85	7	84	80.92	0.57485
86	7	84	113.11	0.01881
87	7	84	63.80	0.95074
88	7	84	103.49	0.07333
89	7	84	95.54	0.18308
90	7	84	72.69	0.80603
91	7	84	92.73	0.24119
92	7	84	93.78	0.21817
93	7	84	85.52	0.43346
94	7	84	88.85	0.33775
95	7	84	74.85	0.75222
96	7	84	87.55	0.37399
97	7	84	89.63	0.31690
98	7	84	75.58	0.73252
99	7	84	81.49	0.55725
100	7	84	88.88	0.33704
Combined P-value for all tests (Using KS method)				0.98359

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	68.51	0.12182
2	7	56	72.22	0.07118
3	7	56	65.85	0.17266
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.

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	17.90	0.65562
2	7	21	21.10	0.45302
3	7	21	12.36	0.92932
4	7	21	21.70	0.41676
5	7	21	11.84	0.94391
6	7	21	28.72	0.12099
7	7	21	12.52	0.92457
8	7	21	29.26	0.10790
9	7	21	29.69	0.09837
10	7	21	22.84	0.35238
11	7	21	32.14	0.05666
12	7	21	21.86	0.40744
13	7	21	22.89	0.34997
14	7	21	22.01	0.39889
15	7	21	23.61	0.31249
16	7	21	16.55	0.73790
17	7	21	19.72	0.53893
18	7	21	29.31	0.10674
19	7	21	24.13	0.28679
20	7	21	27.55	0.15335
21	7	21	22.17	0.39003
22	7	21	30.84	0.07635
23	7	21	17.06	0.70757
24	7	21	15.31	0.80716
25	7	21	16.74	0.72664
26	7	21	25.53	0.22501
27	7	21	19.74	0.53786
28	7	21	18.90	0.59128
29	7	21	30.52	0.08201
30	7	21	14.56	0.84439

31	7	21	19.26	0.56819
32	7	21	20.66	0.47973
33	7	21	25.84	0.21269
34	7	21	19.29	0.56624
35	7	21	16.59	0.73589
36	7	21	19.98	0.52279
37	7	21	22.21	0.38755
38	7	21	11.92	0.94181
39	7	21	27.14	0.16641
40	7	21	19.93	0.52538
41	7	21	18.94	0.58928
42	7	21	14.28	0.85724
43	7	21	17.98	0.65037
44	7	21	21.59	0.42348
45	7	21	19.01	0.58466
46	7	21	39.02	0.00977
47	7	21	21.27	0.44263
48	7	21	27.67	0.14970
49	7	21	22.54	0.36884
50	7	21	12.49	0.92555
51	7	21	10.24	0.97558
52	7	21	31.02	0.07326
53	7	21	18.09	0.64343
54	7	21	18.36	0.62630
55	7	21	17.07	0.70690
56	7	21	20.80	0.47129
57	7	21	20.53	0.48764
58	7	21	36.39	0.01978
59	7	21	16.78	0.72419
60	7	21	21.25	0.44348
61	7	21	20.82	0.46977
62	7	21	25.49	0.22638
63	7	21	14.28	0.85732
64	7	21	18.64	0.60801
65	7	21	21.20	0.44683
66	7	21	19.53	0.55130
67	7	21	25.20	0.23852
68	7	21	29.44	0.10374
69	7	21	11.46	0.95298
70	7	21	27.93	0.14224
71	7	21	18.46	0.62000
72	7	21	21.75	0.41379
73	7	21	21.26	0.44304
74	7	21	26.64	0.18302
75	7	21	22.56	0.36763
76	7	21	16.73	0.72720
77	7	21	25.63	0.22099
78	7	21	15.13	0.81645
79	7	21	17.10	0.70527
80	7	21	30.45	0.08323
81	7	21	15.95	0.77273
82	7	21	16.64	0.73246
83	7	21	27.15	0.16591
84	7	21	14.34	0.85434
85	7	21	17.65	0.67090

86	7	21	23.85	0.30063
87	7	21	14.68	0.83845
88	7	21	12.52	0.92451
89	7	21	26.73	0.17983
90	7	21	26.12	0.20183
91	7	21	26.75	0.17912
92	7	21	16.63	0.73355
93	7	21	37.67	0.01408
94	7	21	22.95	0.34662
95	7	21	20.51	0.48950
96	7	21	21.22	0.44584
97	7	21	21.75	0.41411
98	7	21	25.97	0.20753
99	7	21	42.11	0.00407
100	7	21	18.16	0.63917
Combined P-value for all tests (Using KS method)				0.34877

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	16.42	0.74584
2	7	21	31.80	0.06134
3	7	21	24.01	0.29237
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.

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	0.98359	1.00000
Suits Test	0.34877	1.00000
Hand Types Test	0.45141	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	0.12182	0.60908
Ranks Test 2	0.07118	0.42935
Ranks Test 3	0.17266	0.69062
Suits Test 1	0.74584	1.00000
Suits Test 2	0.06134	0.42935
Suits Test 3	0.29237	0.87712
Hands Type Test	0.61894	1.00000
Combined P-Value using Holm's Method		0.42935

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.
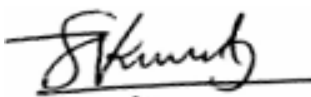
5. Conclusion

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:

Signed:

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Kiren Sreekumar
Principal Consultant
iTech Labs Australia
Date: 06 Jun 2022

Geoff Nicoll
Principal Consultant
iTech Labs Australia
Date: 06 Jun 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.