Poker Cards Analysis - May 2023

The Directors
Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **May 01, 2023** to **May 31, 2023** 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	7.84	0.55037
2	9	6.09	0.73092
3	9	13.41	0.14511
4	9	5.35	0.80325
5	9	6.47	0.69169
6	9	10.55	0.30777
7	9	11.25	0.25881
8	9	9.12	0.42604
9	9	5.03	0.83187
10	9	15.06	0.08926
11	9	5.15	0.82069
12	9	19.35	0.02241
13	9	3.01	0.96408
14	9	6.18	0.72168
15	9	12.36	0.19377
16	9	14.02	0.12147
17	9	5.82	0.75760
18	9	5.97	0.74246
19	9	14.15	0.11717
20	9	23.90	0.00447
21	9	4.95	0.83899
22	9	10.39	0.31963
23	9	12.83	0.17022
24	9	8.16	0.51821
25	9	5.51	0.78739
26	9	13.19	0.15440
27	9	2.98	0.96508

28	9	9.62	0.38247
29	9	8.60	0.47490
30	9	23.57	0.00503
31	9	1.79	0.99442
32	9	19.97	0.01809
33	9	5.77	0.76278
34	9	5.67	0.77197
35	9	5.78	0.76126
36	9	8.00	0.53442
37	9	4.98	0.83579
38	9	7.25	0.61084
39	9	6.17	0.72249
40	9	5.51	0.78739
41	9	7.42	0.59349
42	9	13.06	0.15978
43	9	14.40	0.10883
44	9	3.78	0.92511
45	9	7.83	0.55095
46	9	10.17	0.33714
47	9	2.76	0.97289
48	9	10.13	0.34042
49	9	8.30	0.50470
50	9	3.83	0.92250
51	9	14.56	0.10367
52	9	7.03	0.63395
53	9	8.82	0.45409
54	9	13.86	0.12749
55	9	15.13	0.08755
56	9	11.97	0.21480
57	9	10.55	0.30756
58	9	9.05	0.43300
59	9	12.67	0.17797
60	9	7.56	0.57931
61	9	12.72	0.17586
62	9	7.12	0.62433
63	9	13.27	0.15089
64	9	5.81	0.75840
65	9	6.82	0.65550
66	9	9.99	0.35145
67	9	9.39	0.40207
68	9	7.30	0.60631
69	9	10.61	0.30347
70	9	15.93	0.06838
71	9	11.28	0.25675
72	9	7.98	0.53623
73	9	2.18	0.98829
74	9	7.54	0.58098
75	9	10.51	0.31105
76	9	16.00	0.06692
77	9	10.25	0.33035
78	9	5.02	0.83256
79	9	11.36	0.25190
80	9	3.98	0.91304
81	9	5.77	0.76299
82	9	4.79	0.85184
83	9	16.85	0.05110

84	9	6.16	0.72420
85	9	9.94	0.35564
86	9	9.65	0.37926
87	9	14.44	0.10738
88	9	19.26	0.02306
89	9	10.58	0.30591
90	9	13.49	0.14173
91	9	5.09	0.82644
92	9	10.51	0.31076
93	9	8.15	0.51885
94	9	15.58	0.07619
95	9	6.57	0.68158
96	9	4.82	0.84981
97	9	14.95	0.09223
98	9	8.50	0.48507
99	9	8.95	0.44227
100	9	7.81	0.55377
Combined P-value for all tests (Using KS method)			0.66130

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	8.84	0.35620
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 (1) 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) Since the number of games played each month using 36 card decks is small, the number of samples available this month as well as a few previous months were insufficient to perform a meaningful statistical analysis. Hence the analysis performed this month was done using the cumulative data for the last 4 months - i.e Feb 2023 to May 2023.

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	80.05	0.60193
2	7	84	79.26	0.62600
3	7	84	99.97	0.11268
4	7	84	90.78	0.28758
5	7	84	61.62	0.96833
6	7	84	89.64	0.31680

7	7	84	77.50	0.67834
8	7	84	68.42	0.89119
9	7	84	68.46	0.89059
10	7	84	62.72	0.96018
11	7	84	104.26	0.06636
12	7	84	79.93	0.60542
13	7	84	81.73	0.54990
14	7	84	84.62	0.46050
15	7	84	86.60	0.40136
16	7	84	101.51	0.09380
17	7	84	87.11	0.38667
18	7	84	70.03	0.86258
19	7	84	96.56	0.16473
20	7	84	83.86	0.48366
21	7	84	65.97	0.92690
22	7	84	82.98	0.51093
23	7	84	71.92	0.82340
24	7	84	63.57	0.95289
25	7	84	83.90	0.48242
26	7	84	75.52	0.73418
27	7	84	75.07	0.74624
28	7	84	115.94	0.01201
29	7	84	82.31	0.53181
30	7	84	89.88	0.31031
31	7	84	98.64	0.13123
32	7	84	72.57	0.80874
33	7	84	90.74	0.28839
34	7	84	84.64	0.46000
35	7	84	73.76	0.78004
36	7	84	91.68	0.26540
37	7	84	102.89	0.07912
38	7	84	99.65	0.11697
39	7	84	83.28	0.50176
40	7	84	76.10	0.71837
41	7	84	88.21	0.35535
42	7	84	79.41	0.62137
43	7	84	90.37	0.29788
44	7	84	88.58	0.34523
45	7	84	70.77	0.84785
46	7	84	60.11	0.97732
47	7	84	73.07	0.79690
48	7	84	80.80	0.57859
49	7	84	91.68	0.26544
50	7	84	88.14	0.35748
51	7	84	106.56	0.04887
52	7	84	89.69	0.31542
53	7	84	74.87	0.75153
54	7	84	72.12	0.81892
55	7	84	108.37	0.03799
56	7	84	64.59	0.94280
57	7	84	82.35	0.53064
58	7	84	73.56	0.78501
59	7	84	87.00	0.38979
60	7	84	124.69	0.00264
61	7	84	97.04	0.15650
62	7	84	75.53	0.73392

63	7	84	82.21	0.53488
64	7	84	86.50	0.40429
65	7	84	71.36	0.83564
66	7	84	79.26	0.62606
67	7	84	60.22	0.97673
68	7	84	84.04	0.47811
69	7	84	95.61	0.18186
70	7	84	64.50	0.94377
71	7	84	99.84	0.11440
72	7	84	88.45	0.34877
73	7	84	91.88	0.26065
74	7	84	80.84	0.57757
75	7	84	55.49	0.99306
76	7	84	82.37	0.52995
77	7	84	75.03	0.74745
78	7	84	98.76	0.12949
79	7	84	83.08	0.50774
80	7	84	93.62	0.22172
81	7	84	75.01	0.74803
82	7	84	81.33	0.56236
83	7	84	86.86	0.39362
84	7	84	91.24	0.27614
85	7	84	80.06	0.60147
86	7	84	57.29	0.98864
87	7	84	64.94	0.93902
88	7	84	86.99	0.39003
89	7	84	72.01	0.82137
90	7	84	112.97	0.01922
91	7	84	73.97	0.77476
92	7	84	97.91	0.14230
93	7	84	52.97	0.99676
94	7	84	91.47	0.27054
95	7	84	85.31	0.43964
96	7	84	78.36	0.65307
97	7	84	89.27	0.32662
98	7	84	57.02	0.98942
99	7	84	83.13	0.50646
100	7	84	63.07	0.95724
Combined P-value for all tests (Using KS method)				0.51668

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	53.50	0.57015
2	7	56	73.21	0.06109
3	7	56	44.05	0.87641
4	7	56	57.89	0.40536
5	7	56	43.31	0.89244
6	7	56	55.65	0.48796
Combined P-value for all tests (Using KS method)				N/A (Insufficient data)

Notes:

1) As the total number of tests (6) 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) Since the number of games played each month using 36 card decks is small, the number of samples available this month as well as a few previous months were insufficient to perform a meaningful statistical analysis. Hence the analysis performed this month was done using the cumulative data for the last 4 months - i.e Feb 2023 to May 2023.

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	11.55	0.95087
2	7	21	20.99	0.45934
3	7	21	20.71	0.47685
4	7	21	15.13	0.81617
5	7	21	17.77	0.66341
6	7	21	14.10	0.86522
7	7	21	21.86	0.40768
8	7	21	26.78	0.17835
9	7	21	13.06	0.90653
10	7	21	23.77	0.30436
11	7	21	33.44	0.04155
12	7	21	37.85	0.01342
13	7	21	25.23	0.23739
14	7	21	25.05	0.24515
15	7	21	13.81	0.87742
16	7	21	21.46	0.43089
17	7	21	15.22	0.81155
18	7	21	36.57	0.01886
19	7	21	11.71	0.94721
20	7	21	18.66	0.60692
21	7	21	26.09	0.20290
22	7	21	37.14	0.01624
23	7	21	10.43	0.97273
24	7	21	13.41	0.89339

25	7	21	22.85	0.35228
26	7	21	15.17	0.81423
27	7	21	10.77	0.96708
28	7	21	14.86	0.83011
29	7	21	24.35	0.27633
30	7	21	18.88	0.59252
31	7	21	26.90	0.17413
32	7	21	19.36	0.56219
33	7	21	15.85	0.77823
34	7	21	29.54	0.10174
35	7	21	20.54	0.48744
36	7	21	15.34	0.80576
37	7	21	11.70	0.94744
38	7	21	14.81	0.83237
39	7	21	12.90	0.91196
40	7	21	30.02	0.09158
41	7	21	19.37	0.56169
42	7	21	19.93	0.52598
43	7	21	11.38	0.95484
44	7	21	22.06	0.39602
45	7	21	34.72	0.03029
46	7	21	22.15	0.39065
47	7	21	23.24	0.33121
48	7	21	27.09	0.16797
49	7	21	13.21	0.90116
50	7	21	17.56	0.67680
51	7	21	30.54	0.08164
52	7	21	18.48	0.61867
53	7	21	23.00	0.34383
54	7	21	12.71	0.91839
55	7	21	27.78	0.14654
56	7	21	25.94	0.20857
57	7	21	16.79	0.72369
58	7	21	14.31	0.85578
59	7	21	24.29	0.27915
60	7	21	19.03	0.58342
61	7	21	18.05	0.64586
62	7	21	24.34	0.27668
63	7	21	26.09	0.20306
64	7	21	24.94	0.24980
65	7	21	25.24	0.23688
66	7	21	44.20	0.00220
67	7	21	10.93	0.96420
68	7	21	23.07	0.34035
69	7	21	21.64	0.42044
70	7	21	22.25	0.38517
71	7	21	24.51	0.26914
72	7	21	26.91	0.17396
73	7	21	25.39	0.23060
74	7	21	14.67	0.83903
75	7	21	23.63	0.31129
76	7	21	23.16	0.33567
77	7	21	18.42	0.62211
78	7	21	27.09	0.16793
79	7	21	14.41	0.85154
80	7	21	19.08	0.57984

81	7	21	20.71	0.47676
82	7	21	25.25	0.23650
83	7	21	9.23	0.98733
84	7	21	18.66	0.60678
85	7	21	27.61	0.15163
86	7	21	24.97	0.24866
87	7	21	24.63	0.26350
88	7	21	16.60	0.73495
89	7	21	26.50	0.18785
90	7	21	16.80	0.72319
91	7	21	17.32	0.69166
92	7	21	14.75	0.83534
93	7	21	22.08	0.39513
94	7	21	15.25	0.81000
95	7	21	23.64	0.31076
96	7	21	23.96	0.29512
97	7	21	10.54	0.97096
98	7	21	32.04	0.05797
99	7	21	25.71	0.21785
100	7	21	19.79	0.53484
Combined P-value for all tests (Using KS method)				0.59781

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	27.79	0.14615
2	7	21	25.30	0.23457
3	7	21	22.34	0.37992
4	7	21	19.05	0.58206
5	7	21	15.86	0.77769
6	7	21	18.41	0.62311
Combined P-value for all tests (Using KS method)				N/A (Insufficient data)

Notes:

1) As the total number of tests (6) 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) Since the number of games played each month using 36 card decks is small, the number of samples available this month as well as a few previous months were insufficient to perform a meaningful statistical analysis. Hence the analysis performed this month was done using the cumulative data for the last 4 months - i.e Feb 2023 to May 2023.

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	0.51668	1.00000

Suits Test	0.59781	1.00000
Hand Types Test	0.66130	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	0.57015	1.00000
Ranks Test 2	0.06109	0.79415
Ranks Test 3	0.87641	1.00000
Ranks Test 4	0.40536	1.00000
Ranks Test 5	0.89244	1.00000
Ranks Test 6	0.48796	1.00000
Suits Test 1	0.14615	1.00000
Suits Test 2	0.23457	1.00000
Suits Test 3	0.37992	1.00000
Suits Test 4	0.58206	1.00000
Suits Test 5	0.77769	1.00000
Suits Test 6	0.62311	1.00000
Hand Types Test	0.35620	1.00000
Combined P-Value using Holm's Method		0.79415

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.
2) Since the number of games played each month using 36 card decks is small, the number of samples available this month as well as a few previous months were insufficient to perform a meaningful statistical analysis. Hence the analysis performed this month was done using the cumulative data for the last 4 months - i.e Feb 2023 to May 2023.

The final outcome of the analysis of 36 cards deck indicates that the RNG is working correctly.

5. Conclusion

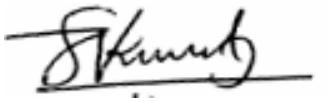
Analysis of actual data from game logs for 'Hand Types, 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

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
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Date: 04 July 2023

Signed:

Gyulserian Hyussein
Senior Consultant
iTech Labs Australia
Date: 04 July 2023

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.