Poker Cards Analysis - June 2023

The Directors
Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **June 01, 2023** to **June 30, 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	7.67	0.56791
2	9	2.66	0.97621
3	9	5.12	0.82406
4	9	5.34	0.80334
5	9	3.31	0.95081
6	9	19.07	0.02463
7	9	7.13	0.62360
8	9	10.07	0.34462
9	9	3.78	0.92509
10	9	5.93	0.74681
11	9	7.27	0.60918
12	9	8.07	0.52692
13	9	6.30	0.70986
14	9	6.98	0.63874
15	9	2.56	0.97911
16	9	6.78	0.65954
17	9	10.99	0.27628
18	9	9.99	0.35151
19	9	11.79	0.22533
20	9	10.97	0.27765
21	9	9.85	0.36299
22	9	6.05	0.73521
23	9	12.91	0.16652
24	9	15.24	0.08443
25	9	5.84	0.75605
26	9	12.80	0.17177
27	9	16.72	0.05328

28	9	5.89	0.75099
29	9	5.62	0.77721
30	9	5.87	0.75304
31	9	4.12	0.90322
32	9	7.69	0.56537
33	9	7.37	0.59837
34	9	6.81	0.65729
35	9	17.19	0.04581
36	9	16.78	0.05230
37	9	5.88	0.75163
38	9	7.63	0.57201
39	9	7.51	0.58448
40	9	5.69	0.77010
41	9	7.78	0.55683
42	9	6.23	0.71719
43	9	6.40	0.69957
44	9	15.19	0.08576
45	9	7.08	0.62828
46	9	8.02	0.53211
47	9	19.26	0.02308
48	9	10.98	0.27675
49	9	7.56	0.57877
50	9	11.01	0.27531
51	9	5.49	0.78964
52	9	13.58	0.13820
53	9	6.91	0.64681
54	9	5.01	0.83335
55	9	9.20	0.41945
56	9	4.93	0.84030
57	9	8.08	0.52659
58	9	15.86	0.06994
59	9	12.20	0.20247
60	9	5.95	0.74477
61	9	6.06	0.73400
62	9	8.30	0.50419
63	9	11.91	0.21817
64	9	8.89	0.44739
65	9	8.35	0.49946
66	9	4.30	0.89075
67	9	7.65	0.56957
68	9	12.02	0.21243
69	9	11.23	0.26004
70	9	13.16	0.15562
71	9	9.90	0.35875
72	9	11.53	0.24097
73	9	12.22	0.20116
74	9	6.29	0.71051
75	9	10.33	0.32416
76	9	9.55	0.38791
77	9	12.01	0.21275
78	9	5.31	0.80612
79	9	9.77	0.36928
80	9	8.09	0.52503
81	9	8.57	0.47769
82	9	6.87	0.65043
83	9	7.86	0.54848

84	9	10.71	0.29609
85	9	6.05	0.73491
86	9	13.39	0.14564
87	9	11.01	0.27496
88	9	18.32	0.03167
89	9	10.35	0.32265
90	9	11.70	0.23077
91	9	7.64	0.57087
92	9	6.99	0.63867
93	9	2.91	0.96792
94	9	22.48	0.00749
95	9	10.52	0.31003
96	9	8.57	0.47799
97	9	10.94	0.27958
98	9	21.21	0.01177
99	9	4.36	0.88640
100	9	13.40	0.14539
Combined P-value for all tests (Using KS method)			0.62856

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	7.40	0.49390
2	8	11.37	0.18171
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 (2) 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 March 2023 to June 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	97.98	0.14125
2	7	84	105.40	0.05717
3	7	84	81.84	0.54629
4	7	84	109.06	0.03445
5	7	84	103.01	0.07790

6	7	84	96.98	0.15741
7	7	84	63.94	0.94937
8	7	84	98.86	0.12799
9	7	84	79.08	0.63127
10	7	84	95.87	0.17708
11	7	84	89.27	0.32642
12	7	84	85.10	0.44609
13	7	84	90.68	0.28992
14	7	84	71.70	0.82833
15	7	84	85.60	0.43099
16	7	84	92.12	0.25522
17	7	84	54.88	0.99418
18	7	84	86.59	0.40161
19	7	84	98.94	0.12688
20	7	84	61.79	0.96718
21	7	84	99.17	0.12365
22	7	84	107.69	0.04185
23	7	84	85.34	0.43876
24	7	84	84.38	0.46790
25	7	84	80.75	0.58030
26	7	84	93.07	0.23363
27	7	84	100.23	0.10928
28	7	84	110.99	0.02598
29	7	84	81.17	0.56720
30	7	84	69.52	0.87220
31	7	84	89.17	0.32923
32	7	84	88.17	0.35646
33	7	84	96.42	0.16721
34	7	84	123.42	0.00332
35	7	84	98.91	0.12734
36	7	84	86.68	0.39908
37	7	84	76.23	0.71459
38	7	84	79.03	0.63285
39	7	84	73.89	0.77698
40	7	84	79.75	0.61112
41	7	84	72.49	0.81059
42	7	84	84.73	0.45731
43	7	84	74.21	0.76882
44	7	84	85.46	0.43525
45	7	84	81.75	0.54921
46	7	84	93.05	0.23412
47	7	84	89.32	0.32529
48	7	84	75.33	0.73947
49	7	84	79.92	0.60576
50	7	84	91.66	0.26593
51	7	84	73.67	0.78245
52	7	84	80.08	0.60081
53	7	84	76.72	0.70101
54	7	84	68.69	0.88674
55	7	84	89.26	0.32689
56	7	84	100.38	0.10743
57	7	84	93.97	0.21424
58	7	84	87.36	0.37943
59	7	84	96.19	0.17118
60	7	84	75.09	0.74596
61	7	84	79.03	0.63287

62	7	84	83.90	0.48248
63	7	84	94.30	0.20737
64	7	84	79.12	0.63004
65	7	84	95.10	0.19152
66	7	84	98.13	0.13893
67	7	84	91.90	0.26032
68	7	84	66.00	0.92649
69	7	84	81.63	0.55286
70	7	84	87.13	0.38610
71	7	84	85.06	0.44719
72	7	84	66.04	0.92594
73	7	84	89.10	0.33105
74	7	84	80.37	0.59208
75	7	84	79.76	0.61057
76	7	84	101.03	0.09940
77	7	84	65.59	0.93158
78	7	84	80.32	0.59359
79	7	84	97.24	0.15308
80	7	84	74.76	0.75445
81	7	84	78.55	0.64731
82	7	84	82.19	0.53556
83	7	84	61.41	0.96970
84	7	84	85.42	0.43645
85	7	84	86.77	0.39640
86	7	84	89.20	0.32832
87	7	84	72.09	0.81962
88	7	84	80.31	0.59394
89	7	84	74.82	0.75289
90	7	84	109.32	0.03315
91	7	84	74.43	0.76306
92	7	84	87.85	0.36551
93	7	84	97.27	0.15271
94	7	84	83.76	0.48687
95	7	84	90.16	0.30306
96	7	84	92.64	0.24330
97	7	84	81.33	0.56232
98	7	84	93.31	0.22831
99	7	84	72.10	0.81938
100	7	84	75.70	0.72945
Combined P-value for all tests (Using KS method)				0.18949

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	52.98	0.59007
2	7	56	51.61	0.64166
3	7	56	41.85	0.92001
4	7	56	66.87	0.15161
5	7	56	46.46	0.81445
6	7	56	51.27	0.65435
7	7	56	56.85	0.44334
8	7	56	55.84	0.48096
9	7	56	71.40	0.08049
Combined P-value for all tests (Using KS method)				N/A (Insufficient data)

Notes:

1) As the total number of tests (9) 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 March 2023 to June 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	14.33	0.85517
2	7	21	14.92	0.82677
3	7	21	19.35	0.56301
4	7	21	15.67	0.78766
5	7	21	19.03	0.58337
6	7	21	24.59	0.26540
7	7	21	14.93	0.82630
8	7	21	34.38	0.03301
9	7	21	29.46	0.10342
10	7	21	16.15	0.76132
11	7	21	19.41	0.55897
12	7	21	28.21	0.13438
13	7	21	15.17	0.81456
14	7	21	22.30	0.38260
15	7	21	24.58	0.26566
16	7	21	20.72	0.47632
17	7	21	23.27	0.32984
18	7	21	28.55	0.12533
19	7	21	10.58	0.97040
20	7	21	19.51	0.55261
21	7	21	20.71	0.47653

22	7	21	18.58	0.61204
23	7	21	28.61	0.12379
24	7	21	11.77	0.94557
25	7	21	19.76	0.53675
26	7	21	18.66	0.60681
27	7	21	29.70	0.09828
28	7	21	20.98	0.46040
29	7	21	31.49	0.06594
30	7	21	22.11	0.39348
31	7	21	32.88	0.04752
32	7	21	33.96	0.03663
33	7	21	16.59	0.73567
34	7	21	15.73	0.78475
35	7	21	25.83	0.21310
36	7	21	34.11	0.03524
37	7	21	16.38	0.74797
38	7	21	16.27	0.75452
39	7	21	15.47	0.79886
40	7	21	30.11	0.08975
41	7	21	19.65	0.54336
42	7	21	28.39	0.12954
43	7	21	14.85	0.83023
44	7	21	11.78	0.94535
45	7	21	35.78	0.02313
46	7	21	13.37	0.89515
47	7	21	23.72	0.30663
48	7	21	12.60	0.92193
49	7	21	30.16	0.08881
50	7	21	13.78	0.87867
51	7	21	21.70	0.41696
52	7	21	13.23	0.90018
53	7	21	19.04	0.58228
54	7	21	17.35	0.68971
55	7	21	22.58	0.36688
56	7	21	15.71	0.78559
57	7	21	22.21	0.38768
58	7	21	17.70	0.66809
59	7	21	12.52	0.92438
60	7	21	12.24	0.93280
61	7	21	13.09	0.90537
62	7	21	21.05	0.45610
63	7	21	20.35	0.49905
64	7	21	28.04	0.13912
65	7	21	20.03	0.51935
66	7	21	14.36	0.85357
67	7	21	23.16	0.33567
68	7	21	30.33	0.08554
69	7	21	13.27	0.89874
70	7	21	17.32	0.69184
71	7	21	12.88	0.91261
72	7	21	31.90	0.05989
73	7	21	13.29	0.89819
74	7	21	11.37	0.95498
75	7	21	14.71	0.83723
76	7	21	29.21	0.10901
77	7	21	21.06	0.45554

78	7	21	21.64	0.42029
79	7	21	16.10	0.76389
80	7	21	21.15	0.44952
81	7	21	18.18	0.63762
82	7	21	39.30	0.00903
83	7	21	20.34	0.49998
84	7	21	20.79	0.47191
85	7	21	19.14	0.57603
86	7	21	21.40	0.43469
87	7	21	12.58	0.92265
88	7	21	23.79	0.30355
89	7	21	21.18	0.44802
90	7	21	9.20	0.98751
91	7	21	22.25	0.38517
92	7	21	24.64	0.26299
93	7	21	14.46	0.84885
94	7	21	22.39	0.37707
95	7	21	29.20	0.10935
96	7	21	20.59	0.48452
97	7	21	18.19	0.63694
98	7	21	34.88	0.02909
99	7	21	12.56	0.92322
100	7	21	26.60	0.18452
Combined P-value for all tests (Using KS method)				0.56060

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	26.00	0.20645
2	7	21	24.92	0.25065
3	7	21	37.82	0.01354
4	7	21	19.30	0.56565
5	7	21	35.67	0.02379
6	7	21	27.42	0.15750
7	7	21	21.67	0.41862
8	7	21	21.06	0.45553
9	7	21	28.09	0.13768
Combined P-value for all tests (Using KS method)				N/A (Insufficient data)

Notes:

1) As the total number of tests (9) 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 March 2023 to June 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	0.18949	0.56848
Suits Test	0.56060	1.00000
Hand Types Test	0.62856	1.00000
Combined P-Value using Holm's Method		0.56848

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	0.59007	1.00000
Ranks Test 2	0.64166	1.00000
Ranks Test 3	0.92001	1.00000
Ranks Test 4	0.15161	1.00000
Ranks Test 5	0.81445	1.00000
Ranks Test 6	0.65435	1.00000
Ranks Test 7	0.44334	1.00000
Ranks Test 8	0.48096	1.00000
Ranks Test 9	0.08049	1.00000
Suits Test 1	0.20645	1.00000
Suits Test 2	0.25065	1.00000
Suits Test 3	0.01354	0.27087
Suits Test 4	0.56565	1.00000
Suits Test 5	0.02379	0.45208
Suits Test 6	0.15750	1.00000
Suits Test 7	0.41862	1.00000
Suits Test 8	0.45553	1.00000
Suits Test 9	0.13768	1.00000
Hand Types Test 1	0.49390	1.00000
Hand Types Test 2	0.18171	1.00000
Combined P-Value using Holm's Method		0.27087

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 March 2023 to June 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.

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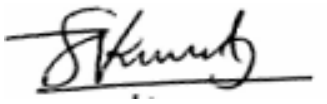

Kiren Sreekumar
Principal Consultant
iTech Labs Australia
Date: 10 July 2023

Signed:

Gyulserian Hyussein
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iTech Labs Australia
Date: 10 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.