Poker Cards Analysis - February 2021

The Directors
Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **February 01, 2021** to **February 28, 2021** 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	6.59	0.67984
2	9	12.13	0.20581
3	9	6.35	0.70397
4	9	8.29	0.50497
5	9	11.46	0.24552
6	9	6.58	0.68109
7	9	8.34	0.49985
8	9	8.23	0.51128
9	9	15.97	0.06748
10	9	12.53	0.18519
11	9	8.13	0.52063
12	9	8.30	0.50408
13	9	10.98	0.27694
14	9	4.71	0.85895
15	9	7.36	0.59919
16	9	11.11	0.26802
17	9	6.61	0.67731
18	9	5.12	0.82371
19	9	4.79	0.85249
20	9	11.76	0.22747
21	9	16.80	0.05202
22	9	21.83	0.00945
23	9	12.19	0.20282
24	9	6.55	0.68378

25	9	4.11	0.90421
26	9	9.78	0.36857
27	9	3.11	0.95997
28	9	12.76	0.17387
29	9	5.35	0.80285
30	9	7.00	0.63702
31	9	13.71	0.13295
32	9	7.58	0.57650
33	9	9.07	0.43046
34	9	14.33	0.11105
35	9	6.39	0.69998
36	9	9.77	0.36974
37	9	10.45	0.31522
38	9	14.37	0.10962
39	9	19.62	0.02039
40	9	6.50	0.68909
41	9	11.26	0.25840
42	9	4.64	0.86437
43	9	3.66	0.93239
44	9	12.50	0.18663
45	9	7.59	0.57595
46	9	3.76	0.92649
47	9	15.43	0.07976
48	9	6.00	0.73951
49	9	10.08	0.34365
50	9	5.11	0.82456
51	9	4.39	0.88382
52	9	6.05	0.73537
53	9	10.54	0.30850
54	9	9.20	0.41911
55	9	7.85	0.54920
56	9	9.89	0.35930
57	9	4.81	0.85089
58	9	6.66	0.67290
59	9	7.85	0.54956
60	9	19.80	0.01920
61	9	10.38	0.32056
62	9	7.17	0.61990
63	9	8.98	0.43870
64	9	6.00	0.74039
65	9	9.07	0.43091
66	9	14.66	0.10078
67	9	5.77	0.76243
68	9	8.92	0.44509
69	9	4.85	0.84746
70	9	7.84	0.55085
71	9	4.09	0.90542
72	9	10.38	0.32081
73	9	4.56	0.87122
74	9	14.44	0.10750
75	9	9.56	0.38719
76	9	11.40	0.24937
77	9	9.27	0.41285
78	9	25.31	0.00265
79	9	2.90	0.96798

80	9	4.29	0.89116
81	9	11.94	0.21652
82	9	10.55	0.30769
83	9	3.24	0.95411
84	9	10.73	0.29441
85	9	10.45	0.31545
86	9	20.68	0.01415
87	9	2.55	0.97947
88	9	11.32	0.25439
89	9	5.60	0.77933
90	9	11.74	0.22839
91	9	5.64	0.77566
92	9	5.66	0.77302
93	9	7.37	0.59903
94	9	8.19	0.51482
95	9	14.88	0.09437
96	9	9.29	0.41117
97	9	10.50	0.31151
98	9	5.81	0.75923
99	9	6.76	0.66242
100	9	8.52	0.48280
Combined P-value for all tests (Using KS method)			0.99957

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	9	18.64	0.02843
2	9	4.34	0.88784
3	9	15.51	0.07773
4	9	10.20	0.33476
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. 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	93.69	0.22009
2	7	84	81.07	0.57041
3	7	84	102.11	0.08715
4	7	84	104.66	0.06300
5	7	84	87.91	0.36385
6	7	84	75.62	0.73164
7	7	84	97.92	0.14211
8	7	84	108.56	0.03697
9	7	84	73.40	0.78898
10	7	84	67.11	0.91150
11	7	84	73.66	0.78264
12	7	84	76.53	0.70630
13	7	84	86.62	0.40088
14	7	84	73.27	0.79220
15	7	84	84.47	0.46516
16	7	84	68.56	0.88889
17	7	84	81.46	0.55826
18	7	84	60.06	0.97757
19	7	84	99.49	0.11919
20	7	84	77.65	0.67399
21	7	84	90.44	0.29609
22	7	84	75.99	0.72141
23	7	84	63.97	0.94906
24	7	84	77.07	0.69096
25	7	84	82.66	0.52082
26	7	84	89.78	0.31306
27	7	84	90.70	0.28956
28	7	84	88.64	0.34349
29	7	84	63.40	0.95439
30	7	84	98.05	0.14012
31	7	84	66.36	0.92179
32	7	84	92.43	0.24803
33	7	84	92.86	0.23832
34	7	84	96.61	0.16383
35	7	84	92.26	0.25188
36	7	84	66.26	0.92314
37	7	84	79.24	0.62663
38	7	84	85.97	0.41977
39	7	84	75.08	0.74622
40	7	84	65.67	0.93063
41	7	84	62.50	0.96194
42	7	84	63.66	0.95205
43	7	84	102.34	0.08476
44	7	84	77.40	0.68141
45	7	84	118.76	0.00752
46	7	84	107.86	0.04086
47	7	84	87.20	0.38394
48	7	84	99.51	0.11884
49	7	84	93.03	0.23448
50	7	84	69.03	0.88086
51	7	84	104.56	0.06389
52	7	84	74.68	0.75662
53	7	84	95.43	0.18524
54	7	84	132.80	0.00055

55	7	84	76.76	0.69961
56.	7	84	91.94	0.25924
57	7	84	69.50	0.87242
58	7	84	112.77	0.01983
59	7	84	93.57	0.22270
60	7	84	85.45	0.43534
61	7	84	78.79	0.64022
62	7	84	106.83	0.04713
63	7	84	102.31	0.08504
64	7	84	78.61	0.64558
65	7	84	68.52	0.88966
66	7	84	69.31	0.87601
67	7	84	91.80	0.26269
68	7	84	83.10	0.50722
69	7	84	90.67	0.29025
70	7	84	76.92	0.69516
71	7	84	81.02	0.57173
72	7	84	95.99	0.17486
73	7	84	72.60	0.80799
74	7	84	69.28	0.87650
75	7	84	68.04	0.89739
76	7	84	97.22	0.15351
77	7	84	73.50	0.78657
78	7	84	90.50	0.29461
79	7	84	69.96	0.86389
80	7	84	99.90	0.11357
81	7	84	94.65	0.20047
82	7	84	66.10	0.92519
83	7	84	83.25	0.50262
84	7	84	76.02	0.72063
85	7	84	87.51	0.37518
86	7	84	81.72	0.55011
87	7	84	77.44	0.68005
88	7	84	100.52	0.10568
89	7	84	83.11	0.50703
90	7	84	63.57	0.95284
91	7	84	84.97	0.44995
92	7	84	99.40	0.12037
93	7	84	80.09	0.60042
94	7	84	89.28	0.32612
95	7	84	84.86	0.45317
96	7	84	75.43	0.73679
97	7	84	85.53	0.43293
98	7	84	78.40	0.65190
99	7	84	97.51	0.14868
100	7	84	70.11	0.86100
Combined P-value for all tests (Using KS method)				0.83964

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	56.04	0.47351

2	7	56	61.33	0.29086
3	7	56	58.66	0.37804
4	7	56	66.10	0.16744
5	7	56	41.71	0.92245
6	7	56	73.24	0.06075
7	7	56	80.55	0.01748
8	7	56	50.71	0.67479
9	7	56	54.72	0.52333
10	7	56	71.64	0.07767
11	7	56	44.75	0.85988
12	7	56	61.45	0.28704
13	7	56	41.92	0.91878
14	7	56	45.04	0.85273
15	7	56	50.67	0.67609
16	7	56	46.69	0.80769
17	7	56	45.02	0.85318
18	7	56	57.46	0.42093
19	7	56	67.86	0.13301
20	7	56	52.80	0.59692
21	7	56	75.51	0.04216
22	7	56	47.68	0.77774
23	7	56	43.04	0.89795
24	7	56	58.57	0.38117
25	7	56	39.80	0.95002
26	7	56	52.06	0.62482
27	7	56	45.76	0.83396
28	7	56	62.84	0.24694
29	7	56	67.75	0.13495
30	7	56	66.26	0.16403
31	7	56	60.52	0.31612
32	7	56	44.84	0.85766
33	7	56	45.02	0.85318
34	7	56	46.51	0.81290
35	7	56	80.88	0.01647
36	7	56	47.50	0.78334
37	7	56	45.63	0.83734
38	7	56	71.37	0.08087
39	7	56	38.94	0.95981
40	7	56	62.86	0.24644
41	7	56	61.81	0.27627
42	7	56	58.81	0.37304
43	7	56	42.48	0.90876
44	7	56	91.95	0.00175
45	7	56	73.26	0.06057
46	7	56	71.71	0.07683
47	7	56	56.25	0.46542
48	7	56	42.28	0.91240
49	7	56	74.74	0.04786
50	7	56	57.69	0.41247
51	7	56	47.16	0.79380
52	7	56	52.81	0.59623
53	7	56	45.00	0.85363
54	7	56	54.67	0.52540
55	7	56	66.93	0.15055
56	7	56	42.39	0.91043

57	7	56	32.04	0.99582
58	7	56	51.72	0.63764
59	7	56	56.25	0.46542
60	7	56	43.00	0.89867
61	7	56	49.16	0.72939
62	7	56	64.26	0.20966
63	7	56	38.04	0.96842
64	7	56	55.14	0.50755
65	7	56	38.41	0.96499
66	7	56	63.51	0.22898
67	7	56	57.91	0.40472
68	7	56	50.42	0.68520
69	7	56	64.30	0.20877
70	7	56	77.10	0.03229
71	7	56	53.91	0.55431
72	7	56	60.16	0.32771
73	7	56	45.58	0.83877
74	7	56	59.62	0.34550
75	7	56	56.70	0.44866
76	7	56	43.24	0.89393
77	7	56	62.88	0.24594
78	7	56	63.56	0.22756
79	7	56	58.12	0.39702
80	7	56	46.82	0.80400
81	7	56	52.08	0.62415
82	7	56	52.81	0.59623
83	7	56	82.91	0.01123
84	7	56	49.92	0.70315
85	7	56	46.01	0.82709
86	7	56	62.44	0.25802
87	7	56	46.95	0.80027
88	7	56	60.64	0.31211
89	7	56	51.00	0.66428
90	7	56	48.84	0.74035
91	7	56	43.60	0.88635
92	7	56	55.75	0.48436
93	7	56	65.90	0.17167
94	7	56	49.59	0.71475
95	7	56	68.76	0.11763
96	7	56	57.96	0.40272
97	7	56	57.78	0.40916
98	7	56	50.02	0.69958
99	7	56	72.34	0.06990
100	7	56	41.19	0.93080
Combined P-value for all tests (Using KS method)				0.28064

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	15.16	0.81463
2	7	21	18.42	0.62246
3	7	21	26.64	0.18318
4	7	21	19.38	0.56088
5	7	21	21.74	0.41477
6	7	21	17.35	0.68989
7	7	21	17.47	0.68200
8	7	21	14.04	0.86775
9	7	21	16.84	0.72090
10	7	21	25.40	0.23007
11	7	21	21.48	0.42972
12	7	21	30.45	0.08327
13	7	21	17.89	0.65594
14	7	21	12.80	0.91552
15	7	21	14.62	0.84176
16	7	21	19.25	0.56934
17	7	21	18.33	0.62778
18	7	21	20.94	0.46238
19	7	21	10.37	0.97377
20	7	21	14.67	0.83921
21	7	21	26.86	0.17543
22	7	21	10.97	0.96340
23	7	21	17.88	0.65652
24	7	21	12.51	0.92473
25	7	21	19.75	0.53745
26	7	21	13.96	0.87126
27	7	21	29.55	0.10142
28	7	21	13.27	0.89904
29	7	21	30.22	0.08757
30	7	21	15.17	0.81452
31	7	21	34.01	0.03616
32	7	21	21.18	0.44813
33	7	21	12.21	0.93376
34	7	21	19.75	0.53731
35	7	21	21.90	0.40537
36	7	21	27.70	0.14893
37	7	21	22.46	0.37367
38	7	21	16.52	0.73995
39	7	21	22.13	0.39231
40	7	21	21.94	0.40288
41	7	21	17.24	0.69660
42	7	21	20.37	0.49775
43	7	21	20.73	0.47535
44	7	21	19.43	0.55780
45	7	21	20.47	0.49173
46	7	21	26.26	0.19679
47	7	21	16.58	0.73603
48	7	21	13.11	0.90477

49	7	21	21.12	0.45168
50	7	21	17.73	0.66625
51	7	21	19.10	0.57845
52	7	21	32.41	0.05323
53	7	21	20.47	0.49156
54	7	21	16.79	0.72358
55	7	21	16.66	0.73178
56	7	21	23.49	0.31858
57	7	21	21.94	0.40279
58	7	21	21.90	0.40510
59	7	21	18.14	0.63983
60	7	21	12.90	0.91193
61	7	21	14.46	0.84913
62	7	21	20.41	0.49555
63	7	21	15.71	0.78590
64	7	21	23.39	0.32376
65	7	21	24.85	0.25391
66	7	21	19.71	0.53947
67	7	21	16.06	0.76613
68	7	21	11.51	0.95189
69	7	21	18.31	0.62929
70	7	21	18.08	0.64383
71	7	21	24.20	0.28352
72	7	21	29.73	0.09759
73	7	21	19.98	0.52261
74	7	21	10.16	0.97672
75	7	21	26.64	0.18321
76	7	21	23.65	0.31045
77	7	21	16.49	0.74140
78	7	21	22.12	0.39236
79	7	21	15.03	0.82128
80	7	21	22.78	0.35560
81	7	21	11.97	0.94041
82	7	21	15.40	0.80219
83	7	21	35.78	0.02315
84	7	21	10.46	0.97228
85	7	21	25.81	0.21379
86	7	21	13.13	0.90417
87	7	21	21.84	0.40874
88	7	21	12.50	0.92522
89	7	21	18.02	0.64798
90	7	21	18.56	0.61325
91	7	21	24.18	0.28432
92	7	21	18.33	0.62826
93	7	21	17.63	0.67206
94	7	21	13.79	0.87864
95	7	21	30.59	0.08083
96	7	21	18.53	0.61521
97	7	21	13.64	0.88462
98	7	21	23.11	0.33805
99	7	21	28.09	0.13768
100	7	21	32.31	0.05446
Combined P-value for all tests (Using KS method)				0.05500

Notes:

3.2 Poker suits statistics for 36 cards deck:

Test No.	Positions	DOF	ChiSqr	P-Value
1	7	21	14.90	0.82813
2	7	21	18.75	0.60105
3	7	21	12.04	0.93853
4	7	21	22.78	0.35604
5	7	21	19.18	0.57385
6	7	21	13.14	0.90350
7	7	21	25.90	0.21013
8	7	21	15.78	0.78166
9	7	21	25.33	0.23324
10	7	21	19.32	0.56462
11	7	21	19.46	0.55591
12	7	21	18.62	0.60976
13	7	21	27.44	0.15676
14	7	21	15.72	0.78517
15	7	21	21.80	0.41111
16	7	21	18.98	0.58617
17	7	21	21.62	0.42145
18	7	21	29.62	0.09981
19	7	21	26.82	0.17703
20	7	21	24.10	0.28843
21	7	21	27.41	0.15775
22	7	21	30.70	0.07873
23	7	21	21.46	0.43094
24	7	21	22.34	0.38037
25	7	21	17.56	0.67665
26	7	21	17.86	0.65759
27	7	21	18.74	0.60156
28	7	21	18.06	0.64546
29	7	21	20.46	0.49207
30	7	21	16.14	0.76196
31	7	21	41.79	0.00447
32	7	21	20.18	0.50963
33	7	21	23.77	0.30443
34	7	21	16.78	0.72459
35	7	21	8.98	0.98940
36	7	21	19.14	0.57590
37	7	21	12.26	0.93245
38	7	21	19.59	0.54722
39	7	21	33.40	0.04197
40	7	21	19.48	0.55438
41	7	21	16.03	0.76785
42	7	21	17.50	0.68014
43	7	21	27.92	0.14243
44	7	21	21.64	0.42050
45	7	21	20.58	0.48459
46	7	21	22.99	0.34441
47	7	21	20.29	0.50309
48	7	21	24.14	0.28613
49	7	21	28.76	0.11988
50	7	21	18.05	0.64596

51	7	21	34.51	0.03192
52	7	21	16.22	0.75694
53	7	21	22.43	0.37499
54	7	21	10.90	0.96462
55	7	21	17.19	0.69940
56	7	21	19.92	0.52633
57	7	21	22.47	0.37276
58	7	21	30.90	0.07527
59	7	21	20.31	0.50158
60	7	21	34.24	0.03415
61	7	21	25.70	0.21796
62	7	21	17.30	0.69301
63	7	21	23.21	0.33299
64	7	21	17.60	0.67416
65	7	21	22.36	0.37903
66	7	21	16.89	0.71787
67	7	21	22.13	0.39217
68	7	21	18.82	0.59643
69	7	21	17.34	0.69055
70	7	21	24.93	0.25030
71	7	21	15.39	0.80278
72	7	21	19.06	0.58155
73	7	21	13.66	0.88359
74	7	21	18.56	0.61334
75	7	21	38.32	0.01182
76	7	21	17.60	0.67416
77	7	21	12.62	0.92122
78	7	21	17.18	0.69989
79	7	21	13.30	0.89760
80	7	21	28.03	0.13925
81	7	21	23.28	0.32923
82	7	21	24.18	0.28461
83	7	21	23.94	0.29578
84	7	21	30.19	0.08820
85	7	21	32.57	0.05123
86	7	21	18.41	0.62306
87	7	21	16.57	0.73694
88	7	21	19.74	0.53752
89	7	21	32.25	0.05525
90	7	21	19.14	0.57590
91	7	21	24.95	0.24925
92	7	21	24.57	0.26636
93	7	21	10.81	0.96640
94	7	21	21.98	0.40043
95	7	21	28.98	0.11458
96	7	21	16.31	0.75187
97	7	21	30.98	0.07406
98	7	21	17.62	0.67316
99	7	21	20.38	0.49732
100	7	21	20.92	0.46400
Combined P-value for all tests (Using KS method)				0.31451

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	0.83964	1.00000
Suits Test	0.05500	0.16501
Hand Types Test	0.99957	1.00000
Combined P-Value using Holm's Method		0.16501

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	0.28064	1.00000
Suits Test	0.31451	1.00000
Hands Type Test	0.02843	0.17058
Hands Type Test	0.88784	1.00000
Hands Type Test	0.07773	0.38865
Hands Type Test	0.33476	1.00000
Combined P-Value using Holm's Method		0.17058

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

Kiren Sreekumar
Principal Consultant
iTech Labs Australia
Date: 12 April 2021

Signed:

G. J. Nicoll

Geoff Nicoll
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Date: 12 April 2021

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.