

Poker Cards Analysis - March 2021

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **March 01, 2021** to **March 31, 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	12.65	0.17922
2	9	13.69	0.13394
3	9	4.15	0.90146
4	9	9.62	0.38192
5	9	5.88	0.75175
6	9	2.80	0.97175
7	9	9.56	0.38699
8	9	11.96	0.21538
9	9	1.95	0.99221
10	9	18.60	0.02877
11	9	7.69	0.56529
12	9	19.75	0.01949
13	9	5.68	0.77169
14	9	5.14	0.82222
15	9	6.53	0.68605
16	9	13.46	0.14273
17	9	6.98	0.63950
18	9	8.62	0.47329
19	9	5.00	0.83399
20	9	5.81	0.75917
21	9	17.35	0.04357
22	9	10.14	0.33965
23	9	4.17	0.90002
24	9	6.89	0.64809

25	9	5.40	0.79826
26	9	8.96	0.44117
27	9	9.29	0.41055
28	9	10.70	0.29692
29	9	7.54	0.58136
30	9	13.79	0.13001
31	9	6.85	0.65241
32	9	9.23	0.41659
33	9	15.24	0.08461
34	9	9.54	0.38884
35	9	6.15	0.72456
36	9	8.99	0.43801
37	9	14.10	0.11890
38	9	6.29	0.71108
39	9	5.11	0.82487
40	9	8.25	0.50966
41	9	8.36	0.49785
42	9	7.87	0.54693
43	9	11.34	0.25305
44	9	3.82	0.92295
45	9	7.77	0.55794
46	9	11.73	0.22909
47	9	10.28	0.32822
48	9	3.92	0.91641
49	9	6.60	0.67892
50	9	14.45	0.10719
51	9	5.71	0.76817
52	9	6.04	0.73585
53	9	17.85	0.03701
54	9	13.58	0.13805
55	9	13.35	0.14744
56	9	8.35	0.49897
57	9	4.35	0.88658
58	9	13.86	0.12737
59	9	3.52	0.94028
60	9	10.30	0.32638
61	9	6.54	0.68527
62	9	7.69	0.56605
63	9	7.71	0.56313
64	9	7.79	0.55590
65	9	6.79	0.65902
66	9	7.54	0.58060
67	9	10.91	0.28158
68	9	8.25	0.50904
69	9	14.98	0.09135
70	9	5.58	0.78096
71	9	6.27	0.71304
72	9	12.81	0.17117
73	9	2.20	0.98798
74	9	7.05	0.63205
75	9	6.78	0.65960
76	9	13.55	0.13944
77	9	17.55	0.04075
78	9	10.65	0.30019
79	9	5.03	0.83195

80	9	11.74	0.22830
81	9	5.50	0.78845
82	9	5.74	0.76546
83	9	7.56	0.57877
84	9	12.66	0.17877
85	9	5.33	0.80459
86	9	8.81	0.45466
87	9	3.54	0.93900
88	9	4.62	0.86646
89	9	8.20	0.51430
90	9	1.09	0.99919
91	9	11.36	0.25182
92	9	11.54	0.24055
93	9	7.89	0.54562
94	9	9.09	0.42901
95	9	5.61	0.77824
96	9	6.34	0.70564
97	9	11.27	0.25738
98	9	8.68	0.46711
99	9	6.67	0.67150
100	9	15.93	0.06830
Combined P-value for all tests (Using KS method)			0.88213

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	11.40	0.24922
2	9	3.62	0.93472
3	9	21.23	0.01168
4	9	18.95	0.02559
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	84.96	0.45015
2	7	84	74.58	0.75927
3	7	84	82.20	0.53506
4	7	84	98.68	0.13059
5	7	84	65.74	0.92974
6	7	84	84.96	0.45018
7	7	84	105.03	0.06004
8	7	84	84.72	0.45753
9	7	84	77.87	0.66754
10	7	84	92.70	0.24188
11	7	84	66.45	0.92060
12	7	84	71.11	0.84103
13	7	84	80.38	0.59168
14	7	84	76.23	0.71476
15	7	84	88.01	0.36110
16	7	84	46.01	0.99976
17	7	84	82.04	0.54003
18	7	84	69.54	0.87178
19	7	84	65.36	0.93428
20	7	84	78.01	0.66330
21	7	84	85.42	0.43628
22	7	84	81.39	0.56047
23	7	84	82.55	0.52446
24	7	84	112.99	0.01916
25	7	84	79.50	0.61873
26	7	84	67.67	0.90318
27	7	84	91.70	0.26512
28	7	84	79.76	0.61063
29	7	84	84.63	0.46018
30	7	84	75.59	0.73231
31	7	84	92.74	0.24096
32	7	84	92.16	0.25418
33	7	84	65.18	0.93632
34	7	84	63.45	0.95393
35	7	84	100.19	0.10979
36	7	84	88.24	0.35462
37	7	84	78.68	0.64340
38	7	84	66.93	0.91402
39	7	84	101.91	0.08937
40	7	84	68.27	0.89366
41	7	84	81.10	0.56924
42	7	84	75.31	0.74001
43	7	84	87.34	0.37992
44	7	84	86.74	0.39721
45	7	84	91.28	0.27521
46	7	84	76.23	0.71483
47	7	84	84.27	0.47118
48	7	84	59.93	0.97827
49	7	84	68.52	0.88960
50	7	84	111.65	0.02350
51	7	84	73.22	0.79327
52	7	84	87.22	0.38348
53	7	84	87.46	0.37653
54	7	84	77.22	0.68657

55	7	84	80.41	0.59065
56	7	84	69.69	0.86890
57	7	84	76.86	0.69700
58	7	84	92.54	0.24557
59	7	84	64.28	0.94605
60	7	84	84.90	0.45208
61	7	84	114.16	0.01597
62	7	84	80.28	0.59475
63	7	84	73.83	0.77843
64	7	84	60.40	0.97579
65	7	84	89.08	0.33167
66	7	84	83.04	0.50910
67	7	84	74.36	0.76503
68	7	84	76.53	0.70629
69	7	84	81.60	0.55394
70	7	84	62.46	0.96226
71	7	84	79.68	0.61328
72	7	84	111.91	0.02260
73	7	84	96.44	0.16672
74	7	84	76.78	0.69906
75	7	84	104.40	0.06518
76	7	84	81.34	0.56183
77	7	84	73.18	0.79433
78	7	84	93.33	0.22783
79	7	84	69.90	0.86499
80	7	84	77.68	0.67325
81	7	84	103.74	0.07098
82	7	84	95.28	0.18813
83	7	84	107.82	0.04106
84	7	84	74.23	0.76823
85	7	84	91.68	0.26546
86	7	84	65.69	0.93031
87	7	84	92.12	0.25503
88	7	84	84.50	0.46418
89	7	84	68.41	0.89140
90	7	84	84.27	0.47128
91	7	84	91.98	0.25842
92	7	84	85.64	0.42968
93	7	84	59.77	0.97902
94	7	84	91.20	0.27710
95	7	84	66.08	0.92544
96	7	84	85.94	0.42086
97	7	84	85.37	0.43768
98	7	84	83.43	0.49705
99	7	84	91.58	0.26788
100	7	84	63.68	0.95186
Combined P-value for all tests (Using KS method)				0.24635

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	47.95	0.76921

2	7	56	60.03	0.33182
3	7	56	58.05	0.39958
4	7	56	69.28	0.10941
5	7	56	70.92	0.08644
6	7	56	44.34	0.86978
7	7	56	44.10	0.87518
8	7	56	44.73	0.86032
9	7	56	80.26	0.01843
10	7	56	62.34	0.26109
11	7	56	53.35	0.57565
12	7	56	72.25	0.07079
13	7	56	72.13	0.07217
14	7	56	66.58	0.15736
15	7	56	56.18	0.46811
16	7	56	42.99	0.89903
17	7	56	64.59	0.20173
18	7	56	46.50	0.81342
19	7	56	58.18	0.39510
20	7	56	27.90	0.99940
21	7	56	46.78	0.80506
22	7	56	51.52	0.64501
23	7	56	73.23	0.06092
24	7	56	42.27	0.91273
25	7	56	60.52	0.31612
26	7	56	52.51	0.60784
27	7	56	71.55	0.07872
28	7	56	48.30	0.75819
29	7	56	46.95	0.80027
30	7	56	48.24	0.75995
31	7	56	44.39	0.86851
32	7	56	63.34	0.23327
33	7	56	64.64	0.20042
34	7	56	69.55	0.10532
35	7	56	73.01	0.06301
36	7	56	59.19	0.36007
37	7	56	46.55	0.81187
38	7	56	61.78	0.27734
39	7	56	89.03	0.00328
40	7	56	79.49	0.02121
41	7	56	48.60	0.74815
42	7	56	43.63	0.88557
43	7	56	46.77	0.80559
44	7	56	61.67	0.28055
45	7	56	51.27	0.65435
46	7	56	42.99	0.89903
47	7	56	54.49	0.53227
48	7	56	62.08	0.26836
49	7	56	46.91	0.80134
50	7	56	51.27	0.65435
51	7	56	42.75	0.90363
52	7	56	57.48	0.42028
53	7	56	48.19	0.76170
54	7	56	36.02	0.98257
55	7	56	63.83	0.22056
56	7	56	45.79	0.83299

57	7	56	48.58	0.74874
58	7	56	43.04	0.89795
59	7	56	52.98	0.59007
60	7	56	50.01	0.69997
61	7	56	61.90	0.27362
62	7	56	56.99	0.43803
63	7	56	66.67	0.15555
64	7	56	55.37	0.49866
65	7	56	53.91	0.55431
66	7	56	78.86	0.02374
67	7	56	52.08	0.62415
68	7	56	49.92	0.70315
69	7	56	37.01	0.97643
70	7	56	42.95	0.89975
71	7	56	65.22	0.18689
72	7	56	54.94	0.51509
73	7	56	34.42	0.98976
74	7	56	54.24	0.54191
75	7	56	36.63	0.97895
76	7	56	45.94	0.82907
77	7	56	35.89	0.98325
78	7	56	40.72	0.93782
79	7	56	64.82	0.19612
80	7	56	66.37	0.16179
81	7	56	68.69	0.11884
82	7	56	57.10	0.43407
83	7	56	56.68	0.44933
84	7	56	66.80	0.15303
85	7	56	58.74	0.37553
86	7	56	53.41	0.57359
87	7	56	58.39	0.38748
88	7	56	60.95	0.30250
89	7	56	49.05	0.73306
90	7	56	52.15	0.62144
91	7	56	47.09	0.79597
92	7	56	51.88	0.63158
93	7	56	58.56	0.38180
94	7	56	55.71	0.48572
95	7	56	47.20	0.79271
96	7	56	65.90	0.17167
97	7	56	52.67	0.60170
98	7	56	48.66	0.74636
99	7	56	62.12	0.26734
Combined P-value for all tests (Using KS method)				0.26256

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 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	9.49	0.98481
2	7	21	16.09	0.76448
3	7	21	8.13	0.99458
4	7	21	24.77	0.25742
5	7	21	24.64	0.26317
6	7	21	9.18	0.98770
7	7	21	39.49	0.00857
8	7	21	37.87	0.01336
9	7	21	26.29	0.19550
10	7	21	20.83	0.46948
11	7	21	25.82	0.21358
12	7	21	14.34	0.85476
13	7	21	24.45	0.27164
14	7	21	10.32	0.97439
15	7	21	13.74	0.88059
16	7	21	23.60	0.31282
17	7	21	23.94	0.29617
18	7	21	18.65	0.60734
19	7	21	29.36	0.10552
20	7	21	20.83	0.46965
21	7	21	27.00	0.17082
22	7	21	34.59	0.03126
23	7	21	26.94	0.17292
24	7	21	30.42	0.08393
25	7	21	14.57	0.84369
26	7	21	23.40	0.32279
27	7	21	29.52	0.10202
28	7	21	22.96	0.34628
29	7	21	13.13	0.90406
30	7	21	26.83	0.17660
31	7	21	24.04	0.29090
32	7	21	11.98	0.94004
33	7	21	21.79	0.41181
34	7	21	18.25	0.63332
35	7	21	15.23	0.81115
36	7	21	30.56	0.08127
37	7	21	25.58	0.22309
38	7	21	34.02	0.03603
39	7	21	19.18	0.57350
40	7	21	15.63	0.79011
41	7	21	28.45	0.12795
42	7	21	18.86	0.59393
43	7	21	25.50	0.22614
44	7	21	15.78	0.78193
45	7	21	23.81	0.30244
46	7	21	19.02	0.58367
47	7	21	16.39	0.74731
48	7	21	23.09	0.33920
49	7	21	14.88	0.82915
50	7	21	20.83	0.46955
51	7	21	25.68	0.21901

52	7	21	24.31	0.27816
53	7	21	17.39	0.68738
54	7	21	27.63	0.15105
55	7	21	17.03	0.70912
56	7	21	16.52	0.73977
57	7	21	25.08	0.24368
58	7	21	32.57	0.05126
59	7	21	11.61	0.94944
60	7	21	9.80	0.98134
61	7	21	14.12	0.86430
62	7	21	19.61	0.54631
63	7	21	23.27	0.32985
64	7	21	22.81	0.35436
65	7	21	16.45	0.74365
66	7	21	21.25	0.44405
67	7	21	22.46	0.37329
68	7	21	35.46	0.02515
69	7	21	13.93	0.87267
70	7	21	27.03	0.16981
71	7	21	24.08	0.28925
72	7	21	16.44	0.74442
73	7	21	22.06	0.39623
74	7	21	33.83	0.03777
75	7	21	11.61	0.94964
76	7	21	25.06	0.24459
77	7	21	26.72	0.18046
78	7	21	32.91	0.04718
79	7	21	15.08	0.81908
80	7	21	19.97	0.52334
81	7	21	22.36	0.37910
82	7	21	25.59	0.22237
83	7	21	9.35	0.98614
84	7	21	24.75	0.25836
85	7	21	15.52	0.79582
86	7	21	19.85	0.53109
87	7	21	26.81	0.17736
88	7	21	16.76	0.72536
89	7	21	30.84	0.07637
90	7	21	16.65	0.73228
91	7	21	7.90	0.99556
92	7	21	13.93	0.87270
93	7	21	21.73	0.41518
94	7	21	20.22	0.50748
95	7	21	14.39	0.85210
96	7	21	23.28	0.32924
97	7	21	17.83	0.65943
98	7	21	21.54	0.42633
99	7	21	28.34	0.13070
100	7	21	19.94	0.52484
Combined P-value for all tests (Using KS method)				0.30480

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	28.26	0.13282
2	7	21	15.46	0.79897
3	7	21	20.69	0.47813
4	7	21	20.86	0.46777
5	7	21	25.58	0.22308
6	7	21	28.64	0.12292
7	7	21	28.37	0.13002
8	7	21	25.03	0.24578
9	7	21	22.03	0.39767
10	7	21	23.83	0.30127
11	7	21	36.50	0.01918
12	7	21	28.31	0.13152
13	7	21	13.90	0.87402
14	7	21	18.10	0.64292
15	7	21	15.64	0.78952
16	7	21	21.51	0.42808
17	7	21	16.20	0.75831
18	7	21	23.94	0.29617
19	7	21	17.47	0.68213
20	7	21	19.44	0.55694
21	7	21	21.93	0.40367
22	7	21	17.23	0.69695
23	7	21	26.15	0.20071
24	7	21	17.76	0.66414
25	7	21	27.07	0.16848
26	7	21	18.54	0.61437
27	7	21	18.62	0.60976
28	7	21	31.33	0.06837
29	7	21	18.79	0.59848
30	7	21	14.10	0.86509
31	7	21	15.80	0.78078
32	7	21	25.06	0.24475
33	7	21	15.65	0.78909
34	7	21	15.98	0.77055
35	7	21	15.83	0.77901
36	7	21	21.14	0.45018
37	7	21	29.51	0.10224
38	7	21	15.42	0.80151
39	7	21	17.03	0.70916
40	7	21	23.62	0.31163
41	7	21	20.01	0.52075
42	7	21	19.90	0.52786
43	7	21	10.06	0.97818
44	7	21	9.14	0.98804
45	7	21	31.50	0.06579
46	7	21	17.29	0.69351
47	7	21	28.14	0.13611
48	7	21	33.33	0.04270
49	7	21	19.04	0.58257
50	7	21	20.46	0.49256
51	7	21	20.36	0.49857
52	7	21	12.40	0.92818
53	7	21	22.19	0.38852
54	7	21	13.71	0.88165

55	7	21	26.06	0.20432
56	7	21	24.14	0.28652
57	7	21	18.95	0.58822
58	7	21	20.19	0.50913
59	7	21	34.38	0.03295
60	7	21	19.24	0.56975
61	7	21	15.90	0.77502
62	7	21	15.50	0.79727
63	7	21	13.69	0.88262
64	7	21	30.28	0.08650
65	7	21	24.80	0.25593
66	7	21	12.60	0.92199
67	7	21	9.42	0.98547
68	7	21	18.82	0.59643
69	7	21	18.01	0.64850
70	7	21	11.46	0.95315
71	7	21	22.91	0.34869
72	7	21	15.26	0.80989
73	7	21	27.20	0.16433
74	7	21	19.55	0.54977
75	7	21	20.34	0.50008
76	7	21	30.66	0.07943
77	7	21	36.58	0.01878
78	7	21	20.97	0.46090
79	7	21	32.04	0.05801
80	7	21	26.22	0.19804
81	7	21	11.99	0.93983
82	7	21	15.68	0.78735
83	7	21	34.68	0.03060
84	7	21	24.32	0.27781
85	7	21	15.41	0.80194
86	7	21	32.74	0.04923
87	7	21	18.50	0.61744
88	7	21	25.71	0.21764
89	7	21	18.08	0.64394
90	7	21	18.05	0.64596
91	7	21	25.65	0.22019
92	7	21	18.60	0.61078
93	7	21	17.59	0.67466
94	7	21	20.49	0.49057
95	7	21	13.18	0.90204
96	7	21	29.65	0.09929
97	7	21	17.97	0.65103
98	7	21	25.90	0.21044
99	7	21	27.24	0.16317
Combined P-value for all tests (Using KS method)				0.87377

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	0.24635	0.73905
Suits Test	0.30480	0.73905
Hand Types Test	0.88213	0.88213
Combined P-Value using Holm's Method		0.73905

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	0.26256	0.99688
Suits Test	0.87377	1.00000
Hands Type Test	0.24922	0.99688
Hands Type Test	0.93472	1.00000
Hands Type Test	0.01168	0.07010
Hands Type Test	0.02559	0.12797
Combined P-Value using Holm's Method		0.07010

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
Principal Consultant
iTech Labs Australia
Date: 09 June 2021

Signed:



Geoff Nicoll
Principal Consultant
iTech Labs Australia
Date: 09 June 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.

