



Party Poker card analysis report

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Executive Summary

iTech Labs have calculated theoretical probabilities for a number of events in Texas Hold'em game and compared these against the probabilities of live cards captured from PartyPoker system. The calculations were done for 'Odds on various hands' and 'Outs'. iTech Labs have also calculated actual distribution of cards for over half a million hands.

A total of 501925 hands were captured from the live system. Of these 265629 were completed hands. For 'Odds on various hands' calculations, we have used all 501925 captured hands to avoid any bias introduced by incomplete hands. For the 'Outs' calculations, we have used only the completed hands as no bias is introduced by removing the incomplete hands.

Our calculations showed that the probabilities for 'Odds on various hands' and 'Outs' observed in production data were within 95% confidence limits of the theoretical probabilities. Chi-squared test applied to the distribution of cards indicated statistical randomness. There was no evidence of high frequency of Aces, or any other card.

iTech Labs concludes that the Party Poker Random Number Generator is operating correctly and the random numbers are being used in a fair manner.



1. Introduction

iTech labs have calculated theoretical probabilities for a number of events in Texas Hold'em game and compared these against the probabilities of live cards captured from PartyPoker system. The calculations were done for **Odds on various hands** (e.g., Royal Flush, Straight Flush, Four of a Kind etc.) and **Outs**. These are given in sections 2 and 3 below.

Section 4 **Distribution of cards** shows the actual distribution of cards for over half a million hands. Section 5 **Deviations from chance** shows the number of times a Royal Flush, Straight Flush, Four of a Kind, Full House, Flush, Straight, Three of a Kind, Two pairs, One Pair or Highest Card can occur in 500, 1000, 10,000 and 50,000 hands.

A total of 501925 hands were captured from the live system. Of these 265629 were completed hands. For some calculations, we have used 501925 captured hands, with the incomplete hands completed by a known random number generator. This was the only way of calculating the observed proportions of the various types of hands as the completed hands are likely to be better hands on average. For the **Outs** calculations, we have used only the completed hands as no bias is introduced by removing the incomplete hands.

2. Odds on various Hands

These calculations were done for Royal Flush, Straight Flush, Four of a Kind, Full House, Flush, Straight, Three of a Kind, Two pairs, One Pair, Highest Card. The theoretical values and results of calculations on cards captured from PartyPoker are given below.

2.1 Theoretical calculations

These calculations are based on receiving 7 cards and choosing the best 5.

Hands	Number of possibilities	Probability	Odds against	Odds for 5-card Poker
Royal Flush	4324	0.00003	30939	649739
Straight Flush	37260	0.00028	3590	72192
4 of a kind	224848	0.00168	594	4164
Full House	3473184	0.02596	38	693
Flush	4047644	0.03025	32	508
Straight	6180020	0.04619	21	254
3 of a kind	6461620	0.04830	20	46
2 pairs	31433400	0.23496	3.3	20
1 pair	58627800	0.43823	1.3	2.4
High card	23294460	0.17412	4.7	1
	1.34E+08	1		

Notes:

a) Number of possibilities: There are 4324 different deals of 7 cards which produce a Royal Flush.

$$4 \times \binom{47}{2} = 4324.$$

The number 4 represents the number of suits. The flush takes up 5 of the 7 cards. The other 2 cards can be selected from the remaining 47.

b) Odds against: On any deal of 7 cards, the odds against getting a Royal Flush are 30939:1



$$\frac{4324}{\binom{52}{7}} = \frac{1}{30940}$$

c) Explanations for Royal Flush calculations

Royal Flush	4324	0.00003	30939	649739
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There are 4324 different deals of 7 cards which produce a Royal Flush according to the formula:

$$4 \times \binom{47}{2} = 4324$$

This number corresponds to 1081 different deals of 7 cards per suit.

The number of ways of selecting 7 cards from 52 cards is:

$$\binom{52}{7} = \frac{52 * 51 * 50 * 49 * 48 * 47 * 46}{7 * 6 * 5 * 4 * 3 * 2 * 1} = 133,784,560 = 1.34E+08$$

Probability of a Royal Flush = $4324 / 133,784,560 = 0.0000323$

The probability of 0.00003 means that there are 3 chances in 100,000 of getting a Royal Flush as best hand from seven cards.

Odds against getting Royal Flush from 7 cards = $1 / 0.0000323 = 30,939$

2.2 Results from 501925 hands from live system

The following table compares the observed proportion of times the various types of hands occurred (**Sample** column). **Probability** shows the theoretical values. **Lower** and **Upper** are the 95% confidence limits.

The calculations are based on receiving 7 cards and choosing the best 5.

Hands	Probability	Numbers	Lower	Sample	Upper
Royal Flush	0.00003	12	0.000017	0.000024	0.000048
Straight Flush	0.00028	137	0.000232	0.000273	0.000325
4 of a kind	0.00168	811	0.001570	0.001616	0.001797
Full House	0.02596	13037	0.025514	0.025974	0.026406
Flush	0.03025	15194	0.029766	0.030271	0.030734
Straight	0.04619	23316	0.045597	0.046453	0.046783
3 of a kind	0.04830	24057	0.047707	0.047929	0.048893
2 pairs	0.23496	117755	0.233787	0.234607	0.236133
1 pair	0.43823	220128	0.436857	0.438568	0.439603
High card	0.17412	87477	0.173071	0.174283	0.175169
	1	501925			

Notes:

- For these calculations, we have used 501925 captured hands, with the incomplete hands completed by a known random number generator. This was the only way of calculating the observed proportions of the various types of hands as the completed hands are likely to be better hands on average.
- When the numbers are not small, the formula



$$p - 1.96\sqrt{\frac{p(1-p)}{n}}, p + 1.96\sqrt{\frac{p(1-p)}{n}}$$

gives approximate confidence limits. p comes from the probability column and $n=501925$.

Comments on analysis of Odds on Various hands:

All observed frequencies were in the 95% confidence intervals.

3. Outs

The theoretical values for chances of catching an **Out** and results of calculations on cards captured from PartyPoker system are given below. **Outs** are the number of cards required to make the target (**Aim** column) combination.

3.1 Theoretical calculations

The following are the usual calculations for the number of **Outs**.

Number of Outs required		
Holding	Aim	Outs
Pair	3 of a kind	2
2 pairs	Full House	4
Inside straight	Straight	4
Open straight	Straight	8
4 Flush	Flush	9
3 of a Kind	4 of a kind	1
Open flush	Straight Flush	2
Inner Flush	Straight Flush	1

Chances of catching an out			
Outs	Turn	River	Turn or River
1	2.13%	2.17%	4.26%
2	4.26%	4.35%	8.42%
3	6.38%	6.52%	12.49%
4	8.51%	8.70%	16.47%
5	10.64%	10.87%	20.35%
6	12.77%	13.04%	24.14%
7	14.89%	15.22%	27.84%
8	17.02%	17.39%	30.30%
9	19.15%	19.57%	34.97%

Notes:

$$a) \text{ Turn} = \frac{\text{Out}}{47}, \text{ River} = \frac{\text{Out}}{46}, \text{ Turn or River} = 1 - \left(1 - \frac{\text{Out}}{47}\right) \left(1 - \frac{\text{Out}}{46}\right).$$



b) River assumes that one of the right cards did not come up on Turn.

3.2 Results from 265629 hands from live system

The **Out of** column indicates how often the **Holding** occurred and the **Success** indicates how many were converted. Thus, 114540 Pairs occurred and 9627 of these were converted to 3 of a Kind, a success rate of $9627/114540 = 0.08405 = 8.405\%$. **Lower** and **Upper** are the 95% confidence limits.

Holding	Aim	Success	Out of	Prob.	Lower	Sample	Upper
Pair	3 of a kind	9627	114540	8.4%	8.2%	8.4%	8.6%
2 pairs	Full House	2164	13289	16.5%	15.8%	16.3%	17.2%
Open	Straight	2765	9431	30.3%	29.2%	29.3%	31.4%
Inside	Straight	3630	22127	16.5%	16.0%	16.4%	17.0%
4 Flush	Flush	4387	12949	35.0%	33.9%	33.9%	36.1%
3 of a Kind	4 of a kind	276	6700	4.26%	3.9%	4.1%	4.7%
Open flush	Straight Flush	15	217	8.42%	4.5%	6.9%	12.3%
Inner flush	Straight Flush	30	613	4.26%	2.6%	4.9%	6.0%

Notes:

a) For these calculations, we have used only the completed 265629 hands as no bias is introduced by removing the incomplete hands.

b) When the numbers are not small, the formula

$$p - 1.96\sqrt{\frac{p(1-p)}{n}}, p + 1.96\sqrt{\frac{p(1-p)}{n}}$$

gives approximate confidence limits. p comes from the Turn or river column and the n from the 'Out of column'.

Comments on analysis of Outs:

All observed values lie within the 95% confidence limits.

4. Distribution of cards

The distribution all cards for 501925 hands is given below:

Type of Card	Position in which cards were dealt						
	1	2	3	4	5	6	7
A	38445	38812	38590	38356	38525	38573	38306
2	38453	38685	38726	38439	38653	38709	39020
3	38633	38723	38834	38696	38958	38724	38855
4	38765	38213	38478	38839	38588	38552	38725
5	38556	38662	38852	38749	38510	38874	38964
6	38612	38435	38711	38645	38776	38548	38958
7	38773	38619	38595	38749	38701	38167	38651

8	38215	38696	38717	38769	38345	38478	38791
9	38899	38622	38545	38717	38547	38721	38553
10	38305	38473	38551	38750	38385	38607	38482
J	38910	38546	38379	38437	38659	38814	38263
Q	38637	38444	38592	38405	38511	38620	38203
K	38722	38995	38355	38374	38767	38538	38154

Notes:

- a) For these calculations, we have used 501925 captured hands, with the incomplete hands completed by a known random number generator. This was the only way of calculating the distribution of the cards, as the completed hands are likely to be better hands on average.

Comments on distribution of cards

The average number of times each card could be expected to have appeared in a particular position is 38610. Chi-squared test applied to the actual number of cards indicated statistical randomness. There is no evidence of high frequency of Aces, or any other card.

5. Deviations from Chance

The following table shows the lower and upper limits for the number of times various types of hands should appear in 500, 1000, 10,000 and 50,000 hands.

Hands	Probability	500 hands		1000 hands		10,000 hands		50,000 hands	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Royal Flush	0.00003	0	0	0	0	0	1	0	4
Straight Flush	0.00028	0	1	0	1	0	6	7	21
4 of a kind	0.00168	0	3	0	4	9	25	66	102
Full House	0.02596	6	20	16	36	228	291	1228	1368
Flush	0.03025	8	23	20	41	269	336	1438	1588
Straight	0.04619	14	32	33	59	421	503	2218	2402
3 of a kind	0.04830	15	34	35	62	441	525	2321	2509
2 pairs	0.23496	99	136	209	261	2266	2433	11562	11934
1 pair	0.43823	197	241	407	469	4285	4480	21694	22129
High card	0.17412	70	104	151	198	1667	1816	8540	8872

Notes:

- a) Example calculation for 2 pairs that has a probability of 0.235

Standard deviation for 10,000 hands with probability 0.235 is

$$\sqrt{\frac{p(1-p)}{n}} = \sqrt{\frac{0.235 \times 0.765}{10000}} = 0.00424$$

Thus 95% of the time, the observed proportion in 10,000 hands should lie within 1.96 standard deviations of the true proportion, that is, for the case of two pairs

$$0.23496 \pm 1.96 \times 0.00424 = (0.22665, 0.24327).$$

In other words, in 95% of sets of 10,000 hands an event which should occur 23.5% of the time should occur between 2266 and 2433 times (a more accurate formula should be used when the probabilities of an event are small).

Note: 1.96 standard deviations correspond to the 95% confidence interval.



6. Conclusion

Probabilities for various hands: These calculations indicated statistical randomness. All observed probabilities were within 95% confidence limits of the theoretical probabilities.

Probabilities for outs: These calculations indicated statistical randomness. All observed probabilities were within 95% confidence limits of the theoretical probabilities.

Distribution of cards: These calculations indicated statistical randomness. Chi-squared test applied to the distribution of cards indicated statistical randomness. There was no evidence of high frequency of Aces, or any other card.

iTech Labs concludes that the Party Poker Random Number Generator is operating correctly and the random numbers are being used in a fair manner.

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