

# DRAW 'N SHOOT 21

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## MATHEMATICAL ANALYSIS PREPARED FOR LUCKY GAMES L.L.C.

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*An analysis of the mathematics and statistics inherent to a proposed new casino table game.*

# DRAW 'N' SHOOT 21 MATHEMATICAL ANALYSIS

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*Prepared by Charles Mousseau, B.Sc. on 11 February, 2010*

## **Introduction and general procedure:**

1. Draw 'N' Shoot 21 is played with six standard 52-card decks of playing cards, and two six-sided dice.
2. At the beginning of each round, each player places one, or both, of the main wager (hereafter referred to as the "21 Wager") and the side bet (hereafter referred to as the "Craps Wager").
3. Each player is dealt one card face up.
4. After each player has been given their first card, they are given the opportunity to make a Raise Wager, up to double the amount of their 21 Wager, before they begin playing their hand.
5. After choosing whether or not to raise, players may stand, or draw additional cards until they are either satisfied with their hand, or reach a total of Hard 19 or more.
6. Once all players have finished drawing, the dealer rolls two dice. Each player's hand total will consist of the totals of the two dice and any cards in their hand, calculated in the standard blackjack fashion, and compared to the following payable:
  - a. If the player's total is 18, 19 or 20, the 21 Wager and Raise Wager will pay even money.
  - b. If the player's total is 21,
    - i. If the player stood pat on their original one-card hand, the player will be considered to have a natural, and their 21 Wager and Raise Wager will be paid at a rate of 2:1.
    - ii. If the player has multiple cards, their 21 Wager and Raise Wager will be paid at a rate of 6:5.
  - c. If the player's total is 17, the 21 Wager and Raise Wager will push.
  - d. Otherwise, the player's 21 Wager and Raise Wager will lose.

### Methodologies:

1. A spreadsheet with an infinite deck model was created, analyzing all possible outcomes to determine the player's expectation on the 21 Wager and the Craps Wager.
2. A computer program was created in the C# programming language (VS 2008 standard) to simulate 1,000,000,000 hands of play under standard casino play conditions (a six deck shoe, dealt four and a half decks deep) in order to verify the results above, as well as collate various miscellaneous statistics.
3. In all cases, the player is assumed to be playing with the optimal strategy on all bets wagered.

### Results:

1. On the 21 Wager, with optimal player strategy, the house will win, on average, ***an amount equal to 2.41% of the 21 Wager, or 1.17% of the total of the 21 and Raise Wagers.***
2. On the Craps wager, using the main payable, the house will win, on average, ***an amount equal to 4.27% of the Craps Wager.***
3. For alternate paytables and their respective House Edges, please see the Appendix.

Report completed on 11 February, 2010 by Charles Mousseau, B.Sc.



Results are deemed reliable.

# DRAW 'N SHOOT 21: APPENDIX OF TABLES

Table #1a: Simulation result of Ante and 21 Wagers

First Card:	EV	Bet Size	Value
X	-0.00001091	3	-0.00003274
A	0.017077549	3	0.051232647
2	0.001224268	3	0.003672803
3	0.001432645	3	0.004297936
4	-0.00088777	1	-0.00088777
5	-0.00599908	1	-0.00599908
6	-0.01218152	1	-0.01218152
7	-0.0186293	1	-0.0186293
8	-0.02422105	1	-0.02422105
9	-0.02132174	1	-0.02132174
<b>Total:</b>			<b>-2.41%</b>
<b>Final bet:</b>			<b>2.052418845</b>
<b>Return:</b>			<b>-1.17%</b>

Table #1b: Calculated result from infinite deck model of Ante and 21 Wagers

First Card	EV	Bet Size	Value
X:	0	3	0
A:	0.017094017	3	0.051282051
2:	0.001230734	3	0.003692202
3:	0.001431847	3	0.00429554
4:	-0.00090506	1	-0.000905062
5:	-0.00597061	1	-0.005970607
6:	-0.01207649	1	-0.012076491
7:	-0.01856572	1	-0.018565721
8:	-0.02426036	1	-0.024260355
9:	-0.02136752	1	-0.021367521
<b>Total:</b>			<b>-2.39%</b>
<b>Final Bet:</b>			<b>2.076923077</b>
<b>Return:</b>			<b>-1.15%</b>

Table #2: Craps Wager breakdown.

<b>QuickCraps, Paytable #1</b>						
<b>Draw</b>	<b>Roll</b>	<b>p</b>	<b>EV</b>	<b>p*EV</b>	<b>Volatility</b>	
Any Card	7	0.15385	0	0.00000	0.00000	
Any Card	Any Craps	0.11111	1	0.11111	0.11111	
Ten or Face	10	0.02564	2	0.05128	0.10256	
6, 8	Match Draw	0.02137	4	0.08547	0.34188	
7	7	0.01282	4	0.05128	0.20513	
5, 9	Match Draw	0.01709	4	0.06838	0.27350	
Ace	11	0.00427	20	0.08547	1.70940	
4	4	0.00641	10	0.06410	0.64103	
4	Hardway 8	0.00214	40	0.08547	3.41880	
4-5-6-8-9-T-A	No Match	0.64530	-1	-0.64530	0.64530	
		1.00000		-0.04274	<b>7.45</b>	<b>Variance</b>
<b>House Edge:</b>				<b>4.27%</b>	<b>2.73</b>	<b>Std Deviation</b>
<b>Hit Rate:</b>				<b>One out of every 2.8 rolls.</b>		
<b>Make Point:</b>				<b>One out of every 11.1 rolls.</b>		

<b>QuickCraps, Paytable #2</b>						
<b>Draw</b>	<b>Roll</b>	<b>p</b>	<b>EV</b>	<b>p*EV</b>	<b>Volatility</b>	
Any Card	7	0.15385	0	0.00000	0.00000	
Any Card	Any Craps	0.11111	1	0.11111	0.11111	
Ten or Face	10	0.02564	2	0.05128	0.10256	
6, 8	Match Draw	0.02137	6	0.12821	0.76923	
7	7	0.01282	0	0.00000	0.00000	
5, 9	Match Draw	0.01709	6	0.10256	0.61538	
Ace	11	0.00427	20	0.08547	1.70940	
4	4	0.00641	8	0.05128	0.41026	
4	Hardway 8	0.00214	40	0.08547	3.41880	
4-5-6-8-9-T-A	No Match	0.64530	-1	-0.64530	0.64530	
		1.00000		-0.02991	<b>7.78</b>	<b>Variance</b>
<b>House Edge:</b>				<b>2.99%</b>	<b>2.79</b>	<b>Std Deviation</b>
<b>Hit Rate:</b>				<b>One out of every 2.8 rolls.</b>		
<b>Make Point:</b>				<b>One out of every 11.1 rolls.</b>		

Table #3a: 21 Wager, simulation result, win/loss/tie breakdown.

<b>Result (EV)</b>	<b>P(Result)</b>	<b>p * EV</b>	<b>Volatility</b>
<b>-3</b>	0.2341907	-0.702572	2.1077160
<b>-1</b>	0.2590548	-0.2590548	0.2590548
<b>0</b>	0.1137272	0	0.0000000
<b>1</b>	0.1239537	0.1239537	0.1239537
<b>1.2</b>	0.0396571	0.0475885	0.0571062
<b>2</b>	0.0021361	0.0042721	0.0085443
<b>3</b>	0.1880044	0.5640133	1.6920399
<b>3.6</b>	0.0158029	0.0568904	0.2048053
<b>6</b>	0.0234732	0.140839	0.8450338
<b>Totals:</b>	<b>1</b>	<b>-2.41%</b>	<b>5.30</b>
<b>Standard Deviation:</b>			<b>2.30</b>

Table #3b: 21 Wager, miscellaneous statistics.

<b>1 total cards:</b>	0.460908638
<b>2 total cards:</b>	0.426741218
<b>3 total cards:</b>	0.100684357
<b>4 total cards:</b>	0.011034794
<b>5 total cards:</b>	0.00061453
<b>6 total cards:</b>	0.000016298
<b>7 total cards:</b>	0.000000165
<b>Average:</b>	2.17 cards
<b>Loss:</b>	49.32%
<b>Push:</b>	11.37%
<b>Win</b>	39.30%