Optimizing Returns in the Gaming Industry for Players and Operators of Video Poker Machines*

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ABSTRACT
Video Poker in Australia is on the verge of extinction. These machines are being replaced in casinos as it is claimed they generate less money than the traditional slot machines. A brief outline of Video Poker is given and a method of calculating the optimal strategies for any Video Poker machine is developed. The distinction between non-progressive and progressive machines is highlighted by an extensive analysis of a Joker Wild Video Poker machine still offered at Star City casino. Video Poker is interesting to analyze due to the changing strategies produced by progressive jackpots. These allow players to have the odds in their favor, while paradoxically allowing the casinos to increase their percentage margin on extra turnover as the jackpot rises. This situation makes progressive jackpots beneficial for both the player and the casino and it seems reasonable these machines should be accessible to players in all Australian casinos. Progressive jackpots applied to other industries are also discussed.

1. INTRODUCTION
Video Poker machines along with the tradition slots provide entertainment to the player in a variety of computer operated machines. Entertainment value of traditional machines involves watching the reels spinning around in the hope of producing a win each time the reels come to a stop. These machines involve no strategy, and the expected return to the players is fixed at around 87%. Australia owns 21% of the worlds total slot machines, and proportionally have the highest number of these machines in the world. Clarke [1] details how Poker Machines can be analyzed using Excel given basic information on the prize table and the number of symbols on each reel. While prize tables are displayed, other necessary information is not readily available to the player. On the other hand, it could be argued the entertainment value of Video Poker machines is greater. They require some thought process from the player in deciding which cards to hold on any hand. Optimal strategy depends on the various payouts, and while all the necessary information is available, the calculations are extremely difficult. With perfect strategy most Video Poker machines pay back 97-99%.

Australian casinos have over reacted to these high returns and Video Poker is diminishing. This suggests that these machines are not generating the profits compared to the regular slots and are being replaced by the latter. Jensen [7] states: *the actual pay back from video poker machines is 2 to 4% less than the maximum pay back based on perfect play.* This implies that even if a machine can potentially pay back 97-99%, the actual pay back overall will be 93-97%. There appears to be a high demand from gamblers for Video Poker machines due to their possible high returns, as Jensen [7] states: *every time the payout schedules were improved, the game increased in popularity and, by 1985, it is estimated that over 25 percent of all slot machine players were playing video poker.* Further evidence for these machines being beneficial for both the player and the casino is demonstrated through progressive jackpots.

Progressive machines offer a jackpot for obtaining a Royal Flush. As people play the machines, a proportion of the total amount gambled by the players is diverted to a jackpot pool, which continues to grow until someone gets a Royal Flush. When this occurs, the jackpot is reset to its predetermined minimum value and the cycle repeats itself. An individual at times can expect to receive a return over 100% if the jackpot gets high enough. At all times the machines are making the same expected amount per play, as the money in the jackpot pool will be won by someone eventually. We have a situation here where the players are attracted by the jackpot pool, while the casinos still get their percentage of the money gambled.

The use of progressive jackpots to entice players to partake in the game has been very effective in the past. Lotto type games are prime examples of this. Jackpots in Powerball are regularly highlighted in advertising campaigns, and Croucher [3] shows the mean number of entries in Powerball is significantly greater for a higher Division 1 prize. Caribbean Stud Poker and Keno also offer progressive jackpots to entice players.

Our claim is: *Video Poker can be beneficial for both the player and the house, and these machines including progressives should be available for use in all Australian casinos*. This paper will support this claim by looking at a detailed analysis of a Joker Wild Video Poker machine (we will call it JW) still offered in Star City casino, Sydney. The current non-progressive version is included along with a progressive version for obtaining a Royal Flush. The calculations are simplified through WinPoker [4], specifically designed software for Video Poker analysis. A brief outline of the rules underlying Video Poker and how WinPoker calculates optimal strategies are discussed. The use of progressive jackpots can be applied to other situations. An example from quiz shows will illustrate this.

2. CALCULATING OPTIMAL STRATEGY

Video Poker is based on the traditional card game of Draw Poker. Each play of the Video Poker machine results in 5 cards being displayed on the screen from the number of cards in the pack used for that particular type of game (usually a standard 52 card pack or 53 if the Joker is included as a wild card). The player decides which of these cards to hold by pressing the hold button beneath the corresponding cards. The cards that are not held are randomly replaced by cards remaining in the pack. The final 5 cards are paid according to the payout table for that particular type of game. The pay tables follow the same order as traditional Draw Poker. For example a Full House pays more than a Flush. Epstein [5] has calculated probabilities and strategies for a range of Poker-like games.

Unlike traditional Poker machines, a player is faced with many decisions on how to play each hand. For example being dealt the Ace of Hearts(AH), Ace of Diamonds(AD), 6 of Hearts(6H), 5 of Hearts(5H), 4 of Hearts(4H), a player might play the hand in three reasonable ways (a) Hold the Pair AH, AD and draw 3 cards, hoping for 3,4,5 of a Kind or a Full House, with the additional possibility of 2 Pair (b) Hold the AH, 6H, 5H, 4H and draw a single card, hoping for a Flush (c) Hold the 6H, 5H, 4H and draw 2 cards, hoping for a Straight Flush but with the possibility of 2 Pair, 3 of a Kind, Straight and a Flush.

The optimal strategies depend on the probabilities of getting the various possible hands and their payouts. This is an extremely difficult problem to solve and most Video Poker players would copy their Draw Poker strategies or go with a subjective decision. Clearly many players would choose non optimal strategies.

More formally, to optimize the return requires knowing which cards to hold from ${}^{n}C_5$ card combinations, where n = number of cards in the pack for the particular type of Video Poker game. A card is either held or not held resulting in 2^5 = 32 ways to hold the cards in any particular hand. In the above example, most sensible players would quickly discard the 29 other strategies and choose one of the three discussed above. However differentiating between these three choices would be more difficult. WinPoker is a commercial product available from the web www.zamzone.com which calculates by complete enumeration, the number of all possible resultant hands and hence the expected return value (EV), for each of the 32 hold combinations. The highest EV is the best way to play that hand. For example, Table 1 gives 3 of the 32 rows from WinPoker analysis of the above hand from a 53 card pack (joker included). The notation used: N = Nothing, 2P = 2 Pair, 3K = 3 of a Kind, ST = Straight, FL = Flush, FH = Full House, 4K = 4 of a Kind, SF = Straight Flush, 5K = 5 of a Kind, JR = Joker Royal, RF = Royal Flush. It shows for example that for case (a), there are 10 from 48 draw possibilities that will result in obtaining a Flush and 38 from 48 draw possibilities that will result in nothing. Given the payouts also shown in Table 1 above each hand type, this gives an expected return of $\frac{10}{48} \times 4 = 0.83$ for strategy (a). Similar calculations show (b) has a return of 0.75 and (c) a return of 0.65. (a), (b) and (c) do give the highest EV for the 32 hold combinations indicating our intuitive sense to the problem is indeed correct, and clearly (a) is the best way to play that hand.

Using these optimal strategies WinPoker can also calculate the probabilities for different hand types, the total return for the machine with perfect play and the variance associated with this return. We look first at machines without jackpots.

3. NON-PROGRESSIVE MACHINES

A pay table for the winning hands, their contribution to the total return, and their probabilities for JW are shown in Table 2. You can play 1,2,3,4 or 10 coins where 1 coin = \$1. The payouts are proportional to the amount bet, with the exception of 10 coins paying extra for obtaining a Royal Flush. From this game 70% of the time the player will not receive any return. The most likely winning hand is 3 of a kind occurring 13% of the time even though its payout it twice as much as Two Pair. Similar anomalies occur with Joker Royal and 5 of a Kind. 3 of a Kind generates the highest contribution to the total return by contributing 26% and a Royal Flush although not the lowest contributes only 1.31% for 1-4 coins and 2.66% for 10 coins. For this situation WinPoker calculated a return with perfect strategy of 92.3% for 1 coin and 93.6% for 10 coins and corresponding variances of \$44.04 and \$6428.29.

Although there are ${}^{53}C_5$ = 2,869,685 card combinations for JW, duplication of hands can reduce that number for the playing strategies. For example if we are dealt 4 of a Kind with no joker on the first 5 cards we would hold the 4 of a Kind regardless of the suit and the extra 5th card. Therefore one playing strategy would simply be 4 of a Kind - Draw 1, as opposed to $13 \times 4 \times 48 = 2496$ different strategies if we were to list every combination containing 4 of a Kind with no joker.

Something not so obvious is being dealt the hand Jack of Hearts(JH), 8 of Hearts(8H), 6 of Diamonds(6D), 3 of Clubs (3C), 2 of Spades(2S). For a 1-4 coin play the optimal strategy calculated by WinPoker is to hold JH and 8H giving a return of 23.33%. However, for the same hand for a 10 coin play, the optimal strategy is to only hold JH for an increased return of 23.49%. The difference in strategies is a result of the increased payout for obtaining a Royal Flush when playing 10 coins. This and other changes in strategies

Table 1: The Number of all Possible Resultant Hands for 3 Hold Combinations from the Hand AH,AD,4H,5H,6H

EV	Hold	Total	N	1 2P	2 3K	3 ST	4 FL	5 FH	27 4K	50 SF	100 5K	500 JR	500 RF
0.83	AH,4H,5H,6H	48	38	0	0	0	10	0	0	0	0	0	0
0.75	AH,AD	17296	11559	2592	2781	0	0	228	135	0	1	0	0
0.65	4H,5H,6H	1128	981	27	18	57	38	0	0	7	0	0	0

Table 2: The Payout and Probabilities Under Optimal Strategy for Different Hand Types

Hand Name	Payout($) 1 coin	Payout($) 10 coins	Probability 1-4 coins	Probability 10 coins	Return(%) 1-4 coins	Return(%) 10 coins
Royal Flush	500	10,000	1 in 38,069	1 in 37,615	1.31	2.66
Joker Royal	500	5,000	1 in 8,870	1 in 8,790	5.64	5.69
5 of a Kind	100	1,000	1 in 10,795	1 in 10,794	0.93	0.93
Straight Flush	50	500	1 in 1,603	1 in 1,607	3.12	3.11
4 of a Kind	27	270	1 in 119	1 in 119	22.74	22.75
Full House	5	50	1 in 65	1 in 65	7.69	7.69
Flush	4	40	1 in 55	1 in 55	7.26	7.27
Straight	3	30	1 in 43	1 in 44	7.02	6.87
3 of a Kind	2	20	0.129	0.129	25.84	25.88
Two Pair	1	10	0.107	0.107	10.71	10.73
Nothing	0	0	0.697	0.698	0.00	0.00
			1	**1**	**92.3**	**93.6**

account for the differences in probabilities between 1-4 coins and 10 coins.

With reference from Jensen [7] p166 and Frome [6] p84 a total of 43 different strategies dealt on the initial five cards represent an almost perfect play and are represented by Tables 3 and 4. "Almost" meaning there are situations where we would choose to deviate from optimal play because the increased number of strategies is not worth the small increase in return. Being dealt the JH, 8H, 6D, 3C, 2S we would choose to draw 5 new cards for both 1-4 coins and 10 coins giving returns of 22.6% and 22.7% respectively. The hands are in descending order of play with the corresponding number of cards to draw. For example being dealt AH, AD, 5H, 4H, 6H a player would expect to receive a higher return by holding the 4 Card Flush (6H, 4H, 5H, AH) as opposed to holding the Pair (AH, AD) or the 3 Card Straight Flush (6H, 4H, 5H). This was also outlined in Table 1. Note the strategies given in Tables 3 and 4 are optimal for both the 1 coin and 10 coin payout. The increase in payout for 10 coins does not effect the order of the hands. However as the payout for a Royal Flush continues to grow, as is the case for progressive machines, the order of the hands for optimal return will change.

Clearly optimal strategy for Video Poker is difficult to determine and tabulate. Joker Wild machines are even more complicated to play correctly due to the added Joker. Most players do not read books on Video Poker or access software such as WinPoker. This is further evidence that the actual pay back from Video Poker machines will be less than the pay back for optimum play.

4. PROGRESSIVE MACHINES

Table 3: Optimal Draw Strategies for No Joker Hands in Video Poker

Hand Name	Draw
Royal Flush	0
Straight Flush	0
4 Card Royal Flush	1
4 of a Kind	1
Full House	0
3 of a Kind	2
4 Card Straight Flush	1
Flush	0
Straight	0
4 Card Inside Straight Flush	1
3 Card Royal	2
Two Pair	1
4 Card Flush	1
Pair	3
3 Card Straight Flush	2
4 Card Straight	1
3 Card Inside Straight Flush	2
3 Card Double Inside Straight Flush	2
2 Card Royal	3
4 Card Inside Straight	1
2 Card Straight Flush	3
3 Card Flush	2
2 Card Inside Straight Flush	3
Other	5

Often a group of machines are connected to a common jackpot pool, that continues to grow until someone gets a Royal Flush. When this occurs the jackpot is reset to its minimum value. Let's assume this is the situation for JW and

Table 4: Optimal Draw Strategies for Joker Hands in Video Poker

Hand Name	Draw
Joker Royal	0
5 of a Kind	0
Straight Flush	0
4 of a Kind	1
4 Card Joker Royal	1
4 Card Inside Joker Royal	1
4 Card Straight Flush	1
Full House	0
4 Card Inside Straight Flush	1
3 of a Kind	2
Flush	0
4 Card Double Inside Straight Flush	1
Straight	0
3 Card Joker Royal	2
3 Card Straight Flush	2
3 Card Inside Straight Flush	2
4 Card Straight	1
3 Card Double Inside Straight Flush	2
Joker + Highest Card	3

generally occurs by playing maximum coins i.e $10 per play. As the jackpot increases so does the expected return to the player. When the progressive meter reaches a certain level it can expect to return over 100% of the money gambled. To optimize the return for progressives requires changing strategies to suit the meter. In particular the No Joker hands consisting of 2 Card Royal and 3 Card Royal will have an increase in EV and as a result move up the table. Table 5 represents the returns for different values of the jackpot. As indicated a jackpot of at least $33,700 is needed for this game to be favorable to the player. For this jackpot amount the 3 Card Royal (from Table 3) will be situated just below the 3 of a Kind and the 2 Card Royal just below the 3 Card Inside Straight Flush. If someone adopted the strategy for the non-progressive JW then their return would be less than 100.0%, an unfavorable game.

Table 5: The Expected Returns to the Player for Different Jackpot Levels

Jackpot($)	Return to player(%)
15,000	94.9
20,000	96.3
25,000	97.6
30,000	99.0
33,700	100.0
35,000	100.4

Progressive machines are ideal for both the player and the house. Players will be enticed to the machines by the high jackpots and so the machines will turn over more money than just being idle. The amount in the jackpot pool is already lost to the casino and won't affect the overall house margin for the game. Some players will adjust their playing strategies to suit the jackpot meter. When this occurs the machines will return a smaller percent of the non jackpot prizes to the players, even though the players can expect a return over 100%. The casinos percentage take from the new money will increase. This means the casinos are making more money per play from the skilled players who are changing their strategies to suit the meter. This gambling paradox will continue to larger extremes providing the jackpot is increasing. Thus we have a situation favourable to both the casino and the gambler.

The casinos must decide what percentage of the money gambled goes towards the jackpot pool. This will affect the overall house margin and how fast the jackpot grows. The casino should be reluctant to put more than 6% of the money gambled into the jackpot pool for JW. We have an optimization problem here for the casinos. If not enough money is contributed to the jackpot pool, the players might be turned away by the jackpot meter not being high enough. If too much money is contributed to the jackpot pool, then the house margin might not be satisfactory for the casino.

The probability the jackpot increases by a certain amount is given by $f(y) = (1-p)^y$ where $p =$ probability of hitting the jackpot on a single game, $y =$ number of games played. Although p differs depending on the strategies each player adopts at different jackpot levels, we will take $p = \frac{1}{37,615}$ from Table 2 as the optimal strategy when playing 10 coins on a minimum jackpot level. Table 6 represents these probabilities when 2% of the money gambled is added to the jackpot pool and also for 3%. For 2%, only 4% of the time will a player have the odds in their favour. For 3% this increases to 12%.

Table 6: The proportion of time the jackpot reaches a certain level for different amounts of money added to the jackpot pool

Jackpot Level($)	2%	3%
15,000	0.51	0.64
20,000	0.26	0.41
25,000	0.14	0.26
30,000	0.07	0.17
33,700	0.04	0.12
35,000	0.04	0.11

5. OTHER APPLICATIONS OF JACKPOTS

Greed, Sale of the Century and Quiz Master are quiz shows that have all used progressive jackpots as prizes. Quiz shows rely heavily on ratings from the viewers to continue their broadcasting. What attracts viewers to watch the show is the possibility of a high monetary payout to the winner. The use of jackpots can be very effective to achieve this objective. Instead of having a fixed amount $A as a prize, by having a progressive jackpot the prize can reach beyond $A a proportion of the time even though the show on average is still only giving away $A. The jackpot used in Sale of the Century will illustrate this.

For this game three or four players competed by answering a series of questions. The winner for each night was shown a board containing cards, each bearing either a prize or the word "WIN". The player called out numbers until two of the same prize was revealed. The "WIN" card was wild and served to match the next card turned over. The player then had to make a decision to either leave with the prize on the stage and retire, or risk losing the prize and return the next day, to obtain further prizes. This cycle repeated itself until a player had won six successive nights and then had the chance to go for the jackpot.

The jackpot starts at \$x and accumulates by \$y each night until someone won seven consecutive nights and then returns back to \$x and starts all over again. Sale of the Century are prepared to give away \$z in prize money each night. They must decide on values for \$x and \$z to calculate \$y: how much to increment the jackpot each night. Let p = probability of a player winning the jackpot on a night (assuming the chance of winning the jackpot on any night is equally likely). This gives the equation:

$$y = \frac{z - xp}{1 - p}$$

p can be estimated from past performances. Let's say $p = \frac{1}{40}$. If the quiz show decided to give away \$4,000 each night, with a minimum jackpot level of \$75,000 then the jackpot would need to increment by \$2,179. Notice \$A=$\frac{\$z}{p}$, is fixed at \$160,000, but with a progressive jackpot the prize can accumulate well past this amount. Table 7 represents the probabilities of reaching different jackpot levels. There is a 2% chance the jackpot level will reach \$400,000 which hopefully should keep enough viewers watching the show for future broadcasting.

Table 7: The proportion of time the jackpot reaches a certain level

Jackpot Level(\$)	Probabilities
200,000	0.23
250,000	0.13
300,000	0.07
350,000	0.04
400,000	0.02

As previously mentioned jackpots are regularly used in lotteries. This can also result in positive returns to investors in lotto type games, and in the past syndicates have attempted to purchase all possible combinations of tickets. Operators have tended to discourage or ban this practice. Cross and Markowski [2] outline a strategy for determining when to purchase all possible combinations. Jackpots are also used in sport to increase spectator interest. Skins in golf is an example.

6. CONCLUSIONS

What entices players to a casino is the variety of games available. Video Poker machines complement the regular slots as another source of entertainment for computer operated machines. When the player gets bored pressing a button on the slots they could switch over to Video Poker which requires a certain level of mental stimulus, and vice versa.

The strategies involved in Video Poker to optimize the returns make it an interesting game to analyze. Furthermore the high jackpots generated by progressive machines make them attractive to play for the possibility to obtain an edge over the house. The optional multi-play feature, where up to 10 games can be played at the same time, make them even more attractive for the player to capitalize on favorable situations. As indicated throughout this paper the house will always obtain their percentage of the money gambled. In fact the house margin increases as the jackpot continues to increase as paradoxically gamblers alter their strategy to increase their return. The use of progressive jackpots can also be applied to other situations as shown by an example in quiz shows.

7. REFERENCES

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