

# **A 20 Game Survey of Gaming Machine Volatility in NSW**

**Luke Freeman  
Daniel Mitchell**

Gaming Technology Branch  
Office of Liquor Gaming and Racing  
Communities NSW

10 February, 2010

**Report to the Responsible Gambling Fund Trustees**

## **ABSTRACT**

This paper describes a novel method to categorise game volatility, and the method is then used to look for commonality between the reinforcement schedules of ten popular games in NSW and ten games which are less popular games. The result is that there was no direct correlation between the popular games and the not-so-popular games when taking into consideration the volatility of the games. In other words, there was no ‘magic’ reinforcement schedule found that makes a game popular; however it was observed that a majority of popular games tend to exhibit a moderate level of volatility.

## **INTRODUCTION**

### **Gaming Machine Overview**

About 1,300 different games (i.e. ‘5 Dragons’) operate on approximately 95,000 gaming machines in NSW with five different manufacturers designing most of the products. The games on offer are similar to those which are operating on ‘slot machines’ around the world; however a visit to the USA casinos would show that NSW players prefer the video spinning reels games and don’t take to the physical stepper reel type of machines found in North American casinos.

The basic play of games on gaming machines classically exhibit an intermittent reinforcer type of schedule which the noted psychologist BF Skinner expounded [1957]. Gamblers risk incremental monetary bets in their endeavour to win rewards; and those rewards are provided in the form of various semi regular smaller prizes, with rare large wins.

The precursor to this paper was the *Independent Gambling Authority of South Australia* who commissioned the *Australian Institute for Primary Care, La Trobe University Melbourne* [2008] to produce a research paper that investigated the relationship between gaming machine technology and problem gambling. The research paper reached a number of conclusions including the necessity for further research into the ‘reinforcement schedules’ of gaming machines. The La Trobe University researchers theorised that a game’s reinforcement schedule (its ‘volatility’) is likely to be a key determinant in problem gambling behaviour. And it was surmised that comparisons of ‘high’ performing games (games with high net gaming revenue), with moderate and low performing games, would probably identify a particular volatility characteristic associated with problem gambling. However they were unable to obtain game related reinforcement schedules with which to validate their assertion.

The department of *Communities NSW* in its capacity of participating in the regulation of gaming machine design has the unique ability to identify what games in NSW are popular or ‘less popular’, and what reinforcement schedules operate on those machines. The consulting actuarial firm Taylor Fry was engaged for their mathematical expertise to provide a more accurate method to measure game volatility and to conduct a number of probability related investigations.

The purpose of this paper is to determine if there is a particular type of reinforcement schedule that is common among popular games and conversely to determine if the reinforcement schedules used by less popular games are different to those used by the popular games. The current method to measure volatility is the statistical unit Standard Deviation ‘SD’, and this unit of measure is shown to be inadequate for the purpose of classifying games by their volatility characteristics. Hence an alternate method was used to classify the characteristics of game volatility in order to seek commonality among the reinforcement schedules of popular games and the less popular games.

Note that the words ‘volatility’ and ‘expectation’ have specific meanings in the field of statistics, and both words are used here in a context to communicate general gaming machine operation and characteristics (unless otherwise noted).

### Game Paytables

A game is designed to follow a set of rules and pay out a certain schedule of prizes. The table at **Figure #1** shows the payout specifications for a simplified game where the left-hand column lists the prize values the machine will pay for certain winning symbol combinations, and the right-hand column lists how many ways there are to win those prize values. The ‘Total Wins’ figure is the total number of winning combinations the game has, and the ‘Game Cycle’ is the total possible number of symbol combinations the game is capable of producing. Hence the total number of non-paying combinations (Total Losses) is Game Cycle less Total Wins. The random number generator in the gaming machine is used to select symbols on the spinning virtual reel strips after the game is activated. The randomly selected symbols are then arranged on the screen’s pay-lines for the player to view at the completion of the spin, and any resulting prizes are calculated and paid out to the player.

**Figure #1: Game Reinforcement Schedule (fictitious game)**

| Prize               | Number of hits    |
|---------------------|-------------------|
| 1,000               | 77                |
| 500                 | 444               |
| 300                 | 999               |
| 250                 | 2,444             |
| 200                 | 5,555             |
| 100                 | 25,999            |
| 50                  | 50,555            |
| 40                  | 75,111            |
| 30                  | 100,333           |
| 20                  | 222,222           |
| 15                  | 300,444           |
| 10                  | 500,555           |
| 5                   | 888,888           |
| 2                   | 3,333,222         |
| <b>Total Wins</b>   | <b>5,506,848</b>  |
| <b>Total Losses</b> | <b>38,826,374</b> |
| <b>Game Cycle</b>   | <b>44,333,222</b> |

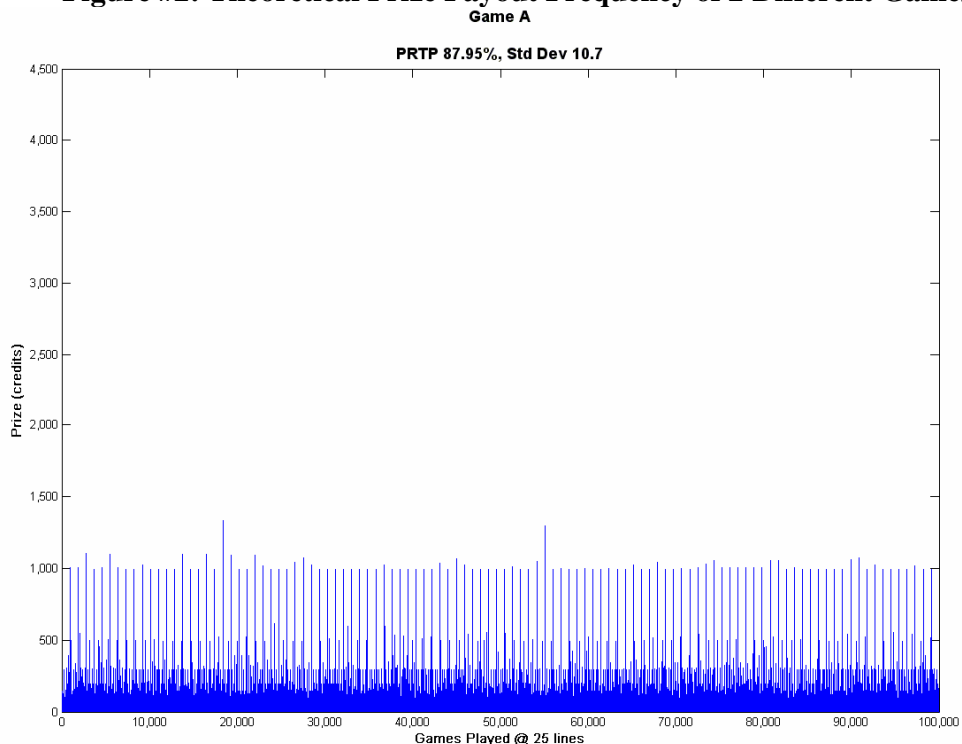
A game’s payout schedule is typically called a ‘hit table’ and it determines the game’s Return to Play and volatility characteristics.

## Game Volatility

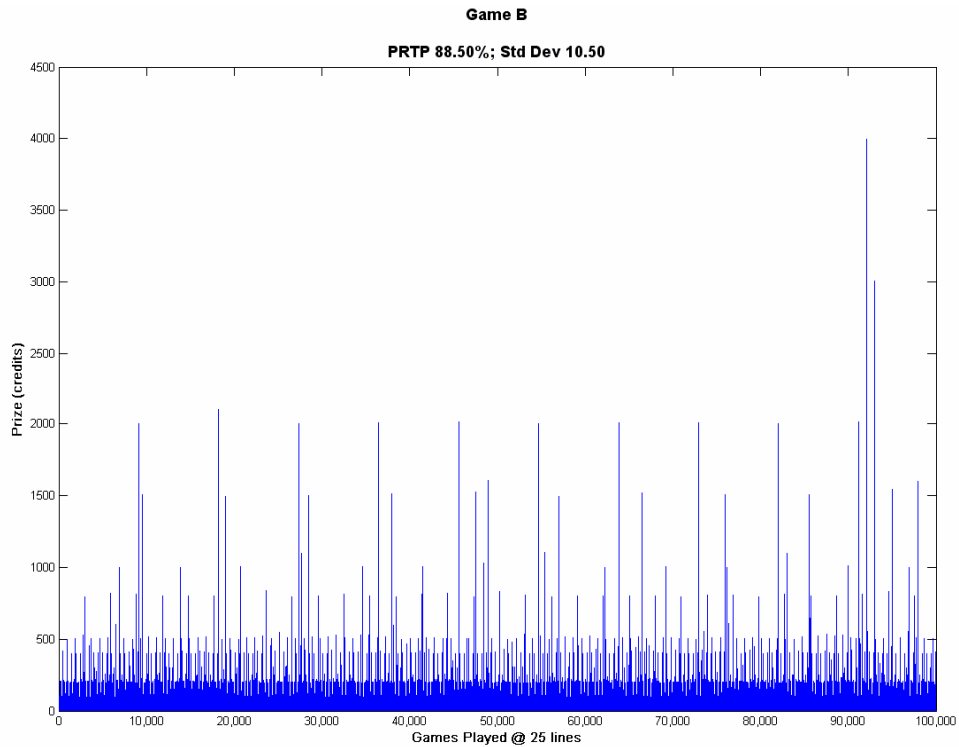
Game volatility is the expression used to describe the frequency of prize payouts based on the hit table. A low volatile game provides the player with a steady flow of smaller prizes whereas a game with high volatility typically gives the player higher value and more erratic prizes. **Figure #2** provides two needle graph plots that show the difference the player experiences when playing a low volatile game versus a high volatile game. Note that one graduation along the horizontal axis is 10,000 games played, which would take about 14 hours of continuous play at five seconds per game. The limitations of using the SD as a unit of measure for game volatility is apparent in the needle plots, since both games have a similar SD (Game A has a SD of 10.7 and Game B has a SD of 10.5), and it is evident when looking at the plots that the payout characteristics from the player's standpoint are quite different.

The prime intent of this paper is to utilise a more descriptive method to measure and categorise the complex nature of game volatility so that games with a similar SD but different payout characteristics can be differentiated. The needle plots below detail the theoretical payout frequency when playing the games at 'all lines' bet; but the probability calculations in the paper are based on a play of 1 line, which is standard industry practice when calculating a game's SD for testing purposes.

**Figure #2: Theoretical Prize Payout Frequency of 2 Different Games**



**Game A** is a fictitious game with a Standard Deviation 10.7 and the game is expected to produce a steady award of prizes over 100,000 games played.



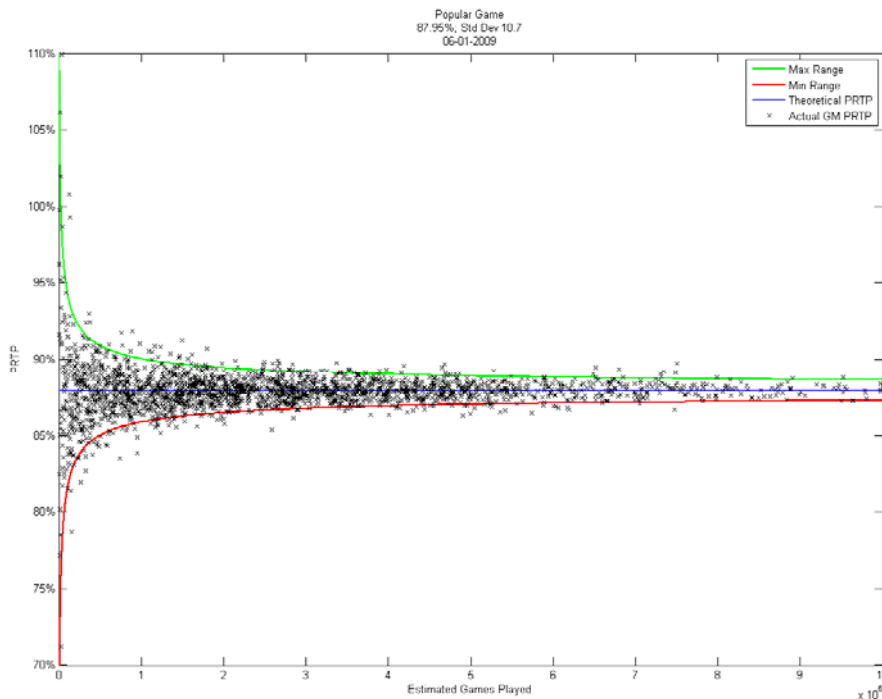
**Game B** is a fictitious game with a Standard Deviation 10.5 and the game is expected to produce an erratic series of prizes over 100,000 games played. Both games have a similar SD but their volatility characteristics are quite different.

The low volatile Game A has been designed to operate at a theoretical Return to Play ‘RTP’ of 87.95%, and the high volatile Game B is designed to operate with a slightly higher RTP of 88.50%. Due to Game B’s erratic prize structure, the RTP a player would get during a 5,000 game session on this game (one half a graduation on the horizontal axis), would in fact probably be less than Game A; unless the player won one of the Game B larger erratic prizes. This is due to the statistical concept of skewness, which will be described further on.

### Return to Play of Games

The Return to Play of a game is the theoretical measurement of a game’s payback to the player over the long term (i.e. ‘all Wins’ / ‘all Bets’) over the lifetime of a game expressed as a percentage. **Figure #3**, where one graduation is equal to one million games played, shows the RTP of a popular game operating in NSW. The game has a theoretical RTP of 87.95% and each ‘point’ in the plot represents the cumulative recorded play on a machine operating in the field. The collection of machines follows an expected statistical behaviour where the longer the game is played, the closer its actual RTP comes into accordance with its theoretical RTP. The player’s expected RTP for a three hour play session would be virtually at the zero point at the left-hand side of the horizontal axis.

**Figure #3: RTP of a Game in the Field**



This plot shows the RTP of the same game operating on a number of different machines in the field with up to 10 million games played. The boundaries are the theoretical tolerance where the games should be operating within (when using a 95% confidence interval for the statistical analysis).

Gaming machines are designed so that the RTP of a game can be selected at the time the game is installed into a gaming venue. For example, a game may have four different internal RTP settings it can be configured at as follows: 87%, 89%, 91% and 92%; and the setting is configured at installation time or upon a machine's reconfiguration thereafter. A reason for the different RTP settings is that if the game is installed in the field as a \$1 denomination machine, players would expect it to operate at a higher RTP as compared to a one cent denomination machine.

In addition, some machines are connected to a progressive jackpot link that adds an additional RTP contribution to the game's RTP. For instance, if a progressive jackpot controller contributes a 5% RTP to the connected gaming machines participating in the link, the venue might choose the minimum game RTP setting of 85%, and the player's expected overall RTP would be 90%. Note that in NSW there are two barriers for venues wanting to change RTP settings that promote daily 'happy hour' type of gambling promotions:

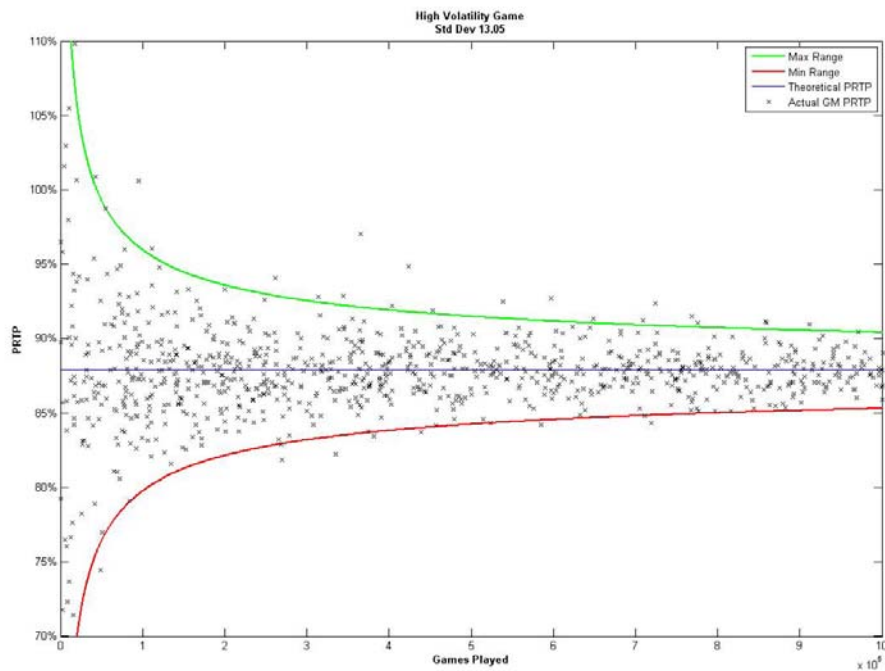
- 1) Business rules permit RTP setting changes only once in a 24 hour period,
- 2) There is an authorisation fee payable to change a game's RTP setting, and a licensed technician needs to change the setting in the game on-site at the venue.

However it is considered an unresolved player fairness issue when two identical games are operating side-by-side; and one machine's RTP is set lower than the other, as players do not know the RTP setting of the game.

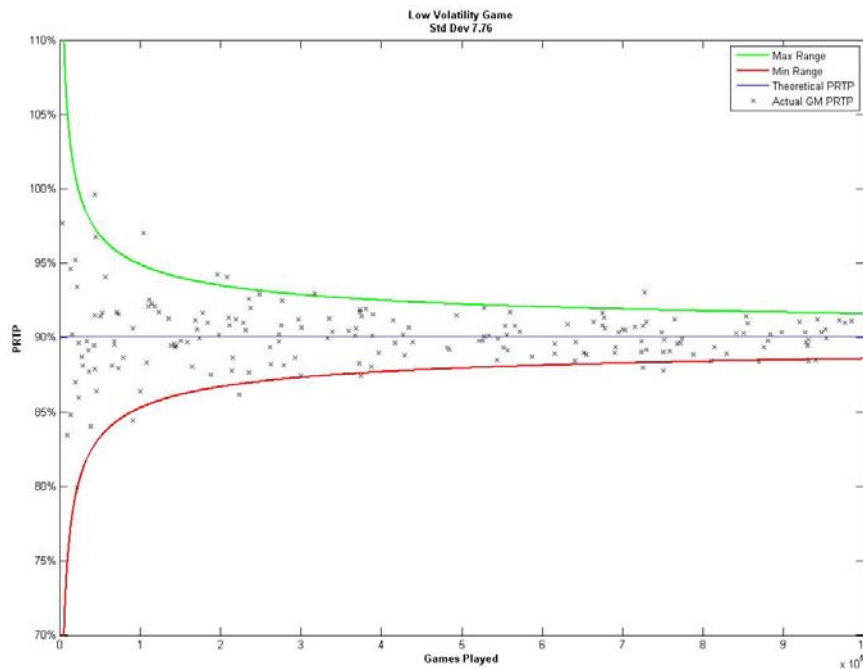
### Volatility Together with Return to Play

The volatility of a game affects the RTP of a game in that a game's expected minimum and maximum RTP range (its tolerance) will be affected because a game with a high SD will produce a wide RTP tolerance. **Figure #4** below shows the difference between the RTP of two different games operating on a number of gaming machines in the field; one game is designed to produce high volatile payouts and the other game is a low volatility game. The player experiences the least amount of RTP tolerance with the low volatility game.

**Figure #4: High and Low Volatile Game Play**



**Game C** has a high volatility SD value of 13 which produces a wide RTP tolerance over 1 million games played. The centre line which runs horizontally between the upper and lower boundaries is the game's theoretical approved RTP.



**Game D** has a low volatility SD value of 7.7 that produces a more narrow RTP tolerance when compared to Game 1 above (1 million games played).

### Basic Nature of Gaming Machine Play in NSW

This paper concentrates on the reinforcement schedules of gaming machines (the theoretical prize payout frequency and prize magnitude) that games are designed to produce. The authors are putting forward that players tend to gravitate towards a moderate level of game volatility, but there is no direct correlation between the construction of reinforcement schedules that operate in the popular games as compared to the less popular games. In the game volatility survey, there are popular low volatility games and popular high volatility games (as well as less popular low volatile games and less popular high volatile games); but in general there are more popular games that are classified as having a higher level of volatility than the less popular games.

The factors that determine the popularity of a game in NSW are varied as there are a symphony of events that take place when playing a gaming machine; and while the reinforcement schedule is a core element of a game's operation, this paper asserts that it is still just one of many elements that combine to make a game attractive to players. As long as the reinforcement schedule of a gaming machine is in-line with the player's expectation of a 'good experience' the overall popularity of a game is determined by a range of stimuli, functionality and 'character'. For example, gaming machines provide a wide and complex range of ways to wager money on games prior to the reels being spun, where different betting patterns suit different players. Play is further prolonged with the awarding of free games and pick-a-box style feature games that award a range of bonus prizes, and the omnipresent lights and sounds heighten the player's anticipation of a win,



and prolong the celebration of rewards. In summary, the overall theme of a game and knowledge that the next spin has the potential to award 'the jackpot' combine with the above game characteristics (in addition to the reinforcement schedule) to create a popular game.

## **A NEW VOLATILITY ANALYSIS CONCEPT**

The consulting actuarial firm Taylor Fry were engaged to find a more descriptive method to measure and categorise game volatility, since the current Standard Deviation measurement unit is limited to one dimension (i.e. 10.5). The new categorisation method (a two dimensional method) was then used to sort the payout specifications of 20 different approved NSW games into separate categories of volatility, where 10 games were popular games, and 10 were less popular games.

The selection of the 10 popular games was based on the population of each individual type of game operating in NSW as well as the amount of Turnover (bets placed) on those games. There was no intent to include other supporting criteria such as the demographics of where the games were located or the profit that the games generated; the selection was simply based on numbers of machines and the total amounts bet on those machines. A visit to a number of hotel and club gaming venues in NSW would give the reader a general idea of what games were included in the top 10 category. The selection of the less popular games was also based on the number of games operating in the field as well as the amounts bet on those games, with the level of both being considered mid-range. The intent here was not to choose unpopular games, but rather less popular games.

The current method used to quantify game volatility is a one dimensional, where typically a game has a SD between 7 and 15. Taylor Fry proposed a two dimensional method where the volatility of a game is communicated based on a game's point location in any one of four quadrants in a target 'bullseye' type of orthogonal graph. The horizontal 'X' axis is a relative measurement of the game's volatility (SD), and the vertical 'Y' axis adds a new measurement of the game's skewness; with the graph centre point indicating a medium level of volatility. Skewness is a statistical measure that is an integral part of volatility, but different levels of skewness can be found in games that have an identical measure of volatility (SD).

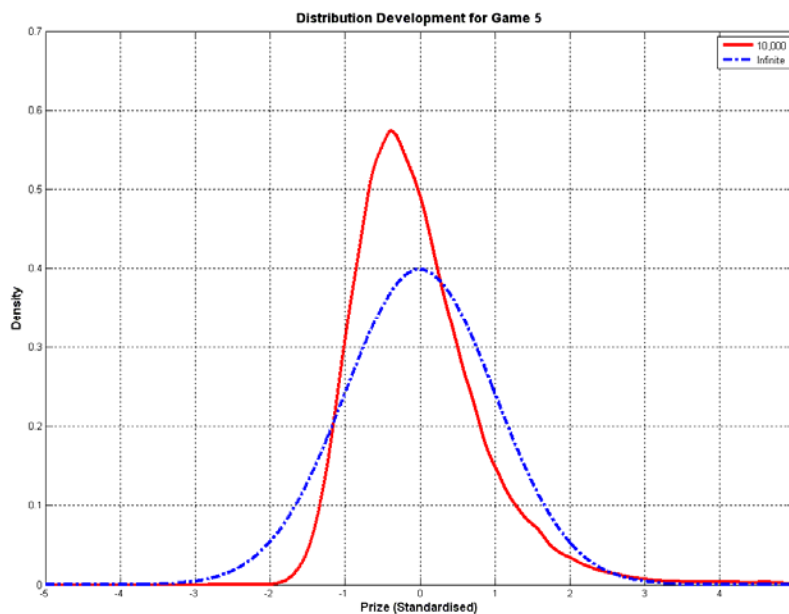
### **Concept of Skewness**

The statistical measurement of skewness is introduced to give an indication of what Return to Play a player can expect during their play session on an individual gaming machine. Referring back to the needle plots in Figure 2, from the player's perspective Game A (which has the lower RTP) will give the player a steady RTP during their play session with 1,000 credit prizes being paid out on a regular basis. Whereas Game B (which has the higher RTP) pays out 500 credit prizes on a regular basis, with irregular 2,000 credit prizes being paid out once in approximately 10,000 games played. This results in the expectation that Game B (the higher RTP) will play at a lower RTP than Game A during a 10,000 play session (unless they win one of the higher value erratic

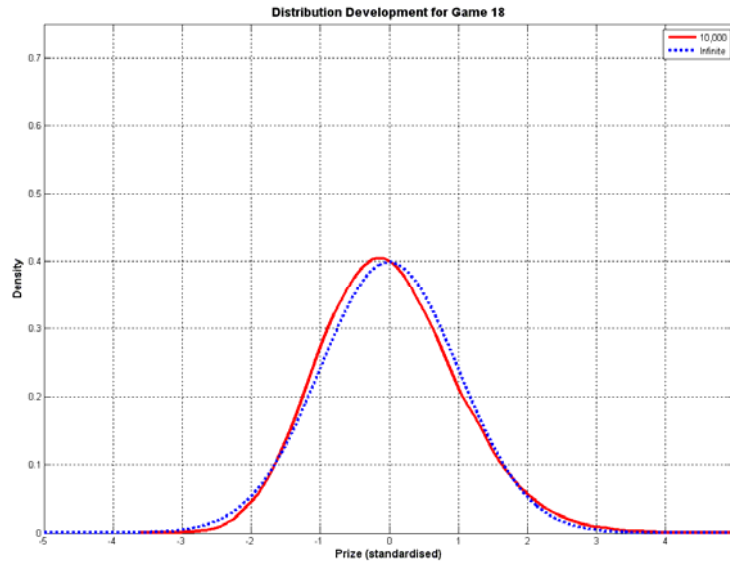
prizes). This scenario has always been a concern associated with showing players what RTP a game is set at, since a game set at the higher RTP isn't always the best choice for a particular player.

When taking a game's skewness into account, there is the expectation that a game will play below its theoretical RTP during a player's game play session. **Figure #5** shows the theoretical characteristics of Game 5 in the survey which has high skew and high volatility characteristics, where at 10,000 games played (red line) there is the expectation that the player will probably get a lower RTP than the theoretical RTP. In the graphs for the two games below, if a game has its curve centred around the 'zero' point marked on the horizontal axis, it shows that the actual RTP a player experiences will probably be in accordance with the game's theoretical RTP at a sample of 10,000 games played. If however the curve is skewed to the left of the zero point, the actual RTP the player experiences during their play session is expected to be less than the theoretical RTP.

**Figure #5: Game Volatility Measurement**



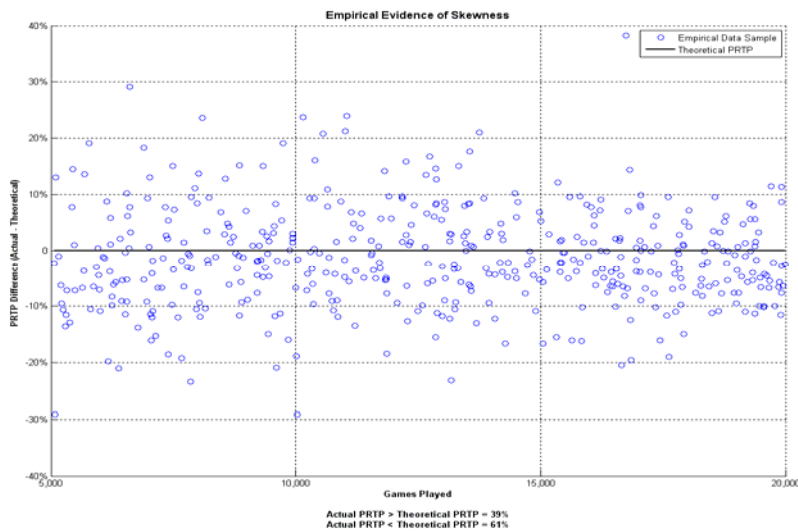
**Game 5:** The dotted line shows a hypothetical game that has the expectation to play at its theoretical RTP. The red line in the plot line shows that due to Game 5's high level of skewness, its actual RTP is not expected to approach its theoretical RTP at 10,000 games played.



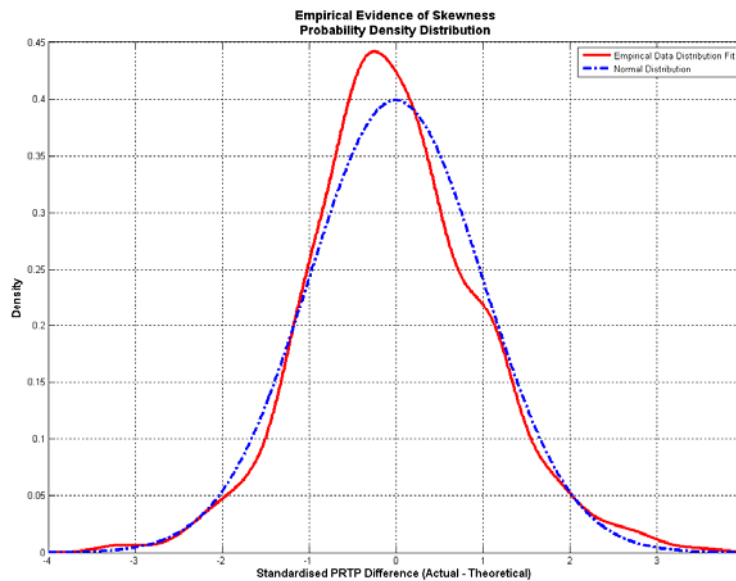
**Game 18:** The red line in the plot shows that due to Game 18’s low level of skewness, its actual RTP is expected to approach its theoretical RTP at 10,000 games played.

The empirical evidence for game skewness is evident when examining a sample of all games in NSW that have accumulated between 5,000 and 20,000 games played, and then determining what percentage are operating above their theoretical RTP and what percentage are below. Refer to **Figure #6** below where the vertical axis of the graph shows the correlation between the theoretical RTP of 471 games operating in the field and the game’s actual RTP; with the horizontal axis showing the number of games played. It is noted that 39% of games are operating above their theoretical RTP and 61% are operating below.

**Figure #6: Empirical Evidence of Game Skewness**



**Figure #7: Game Skewness Results From the Field**



**Figure #7** above is extrapolated from the Figure #6 data where the red line shows the amount of negative aggregated skewness for the 471 games in the field, with between 5,000 and 20,000 games played.

In NSW, a game’s minimum allowable theoretical RTP is 85%. Note that as only 4% of all games operating in the State are set to an RTP of between 85% and 86%, the effect of skewness in terms of games operating below their minimum RTP is believed to be minimal. However this a regulatory issue that will be further explored in being able to quantify how close to the minimum RTP a game with a high degree of skewness should be allowed to operate.

**Four Quadrant Volatility Classification Technique**

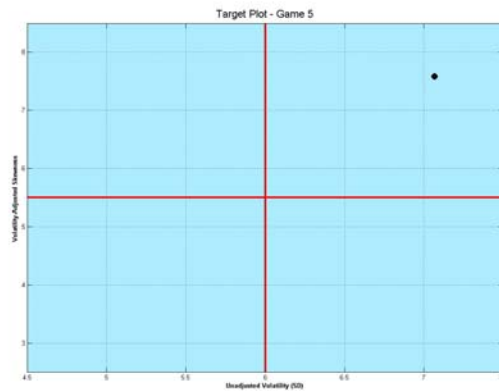
The classification method used to sort games by their volatility characteristics into four different volatility categories is described here. The purpose is to look for commonality between the 10 popular games and 10 less popular games that were chosen for the survey. The classification technique puts a game point location into one of four quadrants that that classifies the game in having the following characteristics:

|                                 |                                  |
|---------------------------------|----------------------------------|
| High Skew / Low Volatility (SD) | High Skew / High Volatility (SD) |
| Low Skew / Low Volatility (SD)  | Low Skew / High Volatility (SD)  |

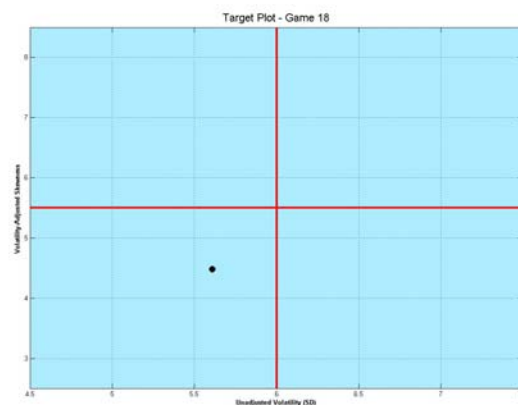
Hence the Upper Right ‘UR’ quadrant would indicate the highest overall level of volatility, the Upper Left ‘UL’ and Lower Right ‘LR’ quadrants both indicate a moderate overall level of volatility, and the Lower Left ‘LL’ quadrant indicates the least level of overall volatility.

**Figure #8** below shows how two games in the survey, which have the most opposite extremes of volatility, are categorised using the classification technique as proposed by Taylor Fry.

**Figure #8: Game Volatility Measurement**



**Game 5:** The UR quadrant game point location indicates a high volatile and high skew game



**Game 18:** The LL quadrant game point location indicates a low volatile and low skew game.

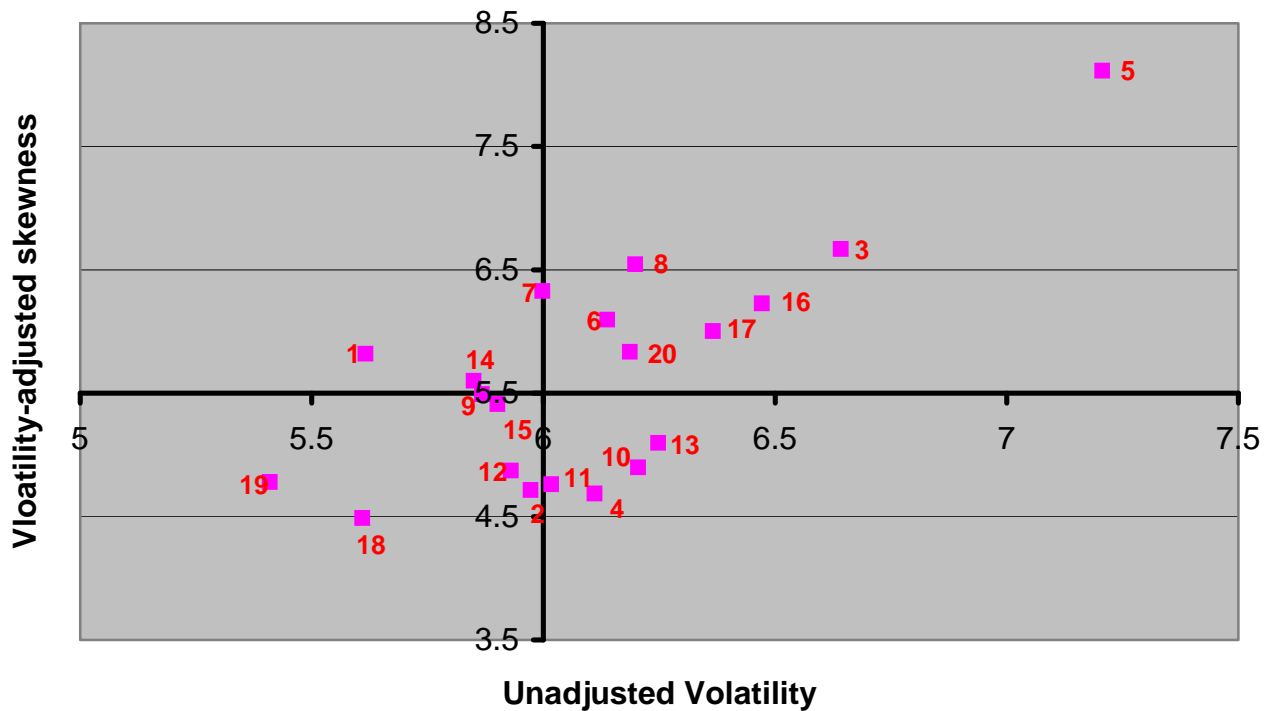
Games located in the upper left or lower right hand quadrants are considered to have a moderate level of volatility characteristics.

## **VOLATILITY CLASSIFICATION, DISCUSSION AND CONCLUSION**

The purpose of this paper is to categorise the 10 popular games in NSW as well as 10 less popular games by their magnitude of volatility, and then look for commonality in their classification in terms of popularity. **Figure #9** shows the 20 games chosen for participation in the survey where they are displayed by order of their volatility magnitude (skewness and volatility (SD)). Note that there is no correlation between the games unique number and their popularity.

Figure #9: Game Volatility Survey Classification

### Sample values of alternative game metric



The 20 games in the survey are plotted together in-line with their skewness and volatility (SD) magnitudes. The LL quadrant indicates a decreasing level of skewness and volatility (SD) while the UR quadrant indicates an increasing level of skewness and volatility (SD). The games centred around the target centre are considered to have a moderate level of volatility.

### Survey Results

This paper does not reference which game numbers in Figure #9 are popular or less popular. However observations on the location of the popular and less popular games are such that:

1. There is at least one popular game in each of the quadrants, and there are less popular games located in all the quadrants;
2. There are an equal number of popular and less popular games centred around the target area;
3. There are a greater number of popular games located above the horizontal axis and to the right of the vertical axis;
4. The most popular games in the survey aren't necessarily the most volatile; and

- There are numerous instances where 2 games have similar reinforcement schedules, but only one is popular.

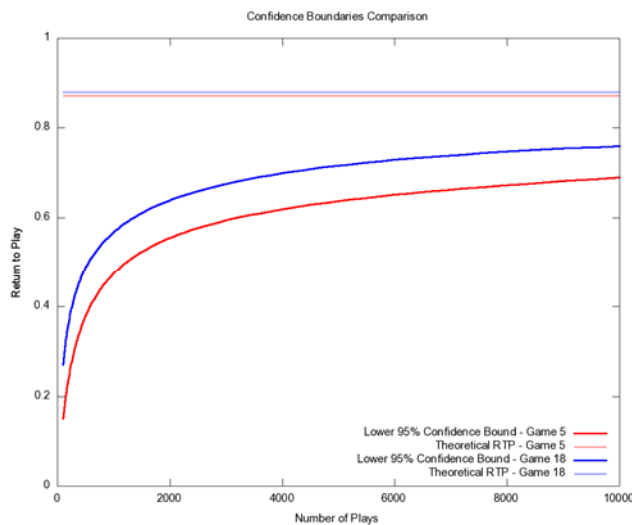
**Note** that point #3 above suggests that in general most players in NSW prefer games with a higher degree of volatility characteristics; but to link the level of game volatility with problem gambling is difficult because it is not known which games problem gamblers prefer.

### Peripheral Observations Associated with Volatility and Skewness

There are a number of Return to Play comparisons that can be made which highlight differences in the probable RTP characteristics a game will produce when taking into consideration the placement of the different game point locations in the four quadrants of Figure #9.

For example, the approved RTPs of Game 18 and Game 5 are similar, and **Figure #10** shows a comparison between the probable RTP characteristics of Game 18 and Game 5.

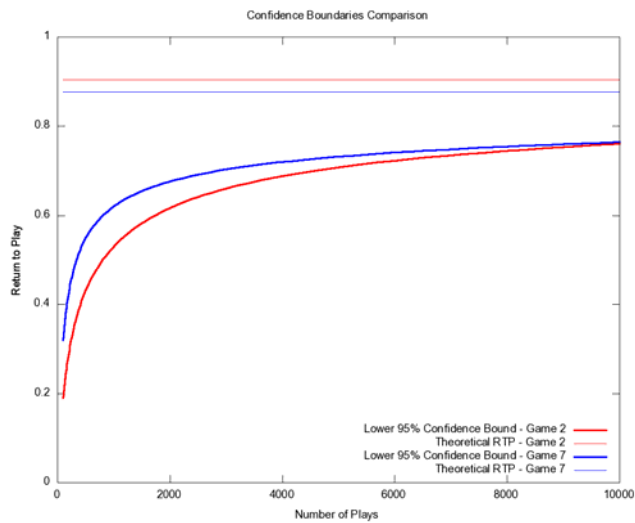
**Figure #10: Games 5 and 18 – high volatility (SD) & high skewness versus low volatility (SD) & low skewness**



Although Game 5's (red line) approved RTP is similar to Game 18's, the lower 95% confidence limit on its RTP is below that of Game 18 (for well beyond 10,000 games played).

**Figure #11** shows a comparison between Game 2 and Game 7 where both games have a similar volatility (SD) level but a different level of skewness.

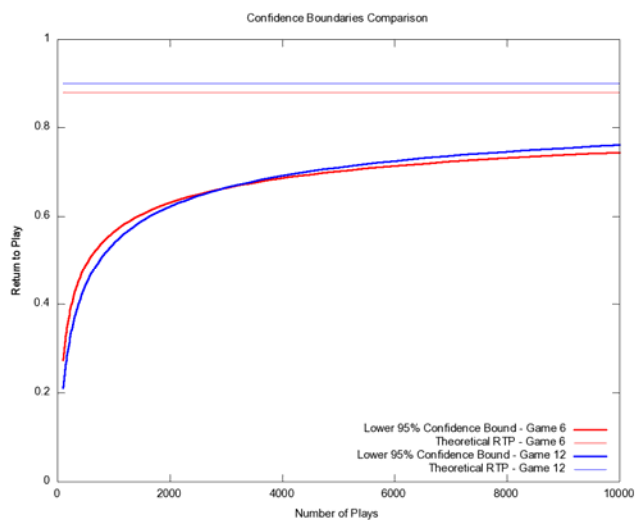
**Figure #11: Games 2 and 7 - equal volatility (SD) versus different skewness**



Although Game 2's (red line) approved RTP is materially higher than Game 7's, the lower 95% confidence limit on its RTP is below that of Game 7 (unless there are more than 10,000 games played).

**Figure #12** shows a comparison between Game 6 and Game 12 where one game has moderate level of skewness and volatility (SD), and the other a low level.

**Figure #12: Games 6 and 12 – moderate level of skewness and volatility (SD) versus low level of skewness and volatility (SD)**



The lower level 95% confidence limit on the probable Return to Play of Game 12 is below that of Game 6 when the number of plays is small, but above when the number of plays is large (the cross-over point is at about 3,000 plays).



Note that in the above examples, the level of skewness is not the determining factor in which game is expected to produce a lower Return to Play characteristic; it's the combination of both volatility (SD) and skewness.

## **Conclusion**

When using the Taylor Fry method to categorise games by their components of skewness and volatility (SD), it is evident that there is no type of specific reinforcement schedule that makes a game popular in NSW. As long as the game's reinforcement schedule meets a player's expectation of a good experience when playing the game, it will be adequate for the purposes of conducting the game in accordance with the game rules. The reinforcement schedule is but one component in a symphony of events that makes a game popular with players, however it is noted that overall, players in NSW gravitate towards games that provide a medium amount of volatility.

Financial assistance for this project was provided by the New South Wales Government from the Responsible Gambling Fund. The views expressed in this publication however, are solely those of the authors.

## **REFERENCES**

Australian Institute for Primary Care, La Trobe University Melbourne [2008], for the Independent Gambling Authority South Australia  
<http://www.iga.sa.gov.au/pdf/0801/Final%20report.Print.Feb08.pdf>

Fester CB, Skinner BF (1957) Schedules of Reinforcement. Englewood Cliffs NJ: Prentice-Hall