UNBALANCED REEL GAMING MACHINES

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ABSTRACT

Electronic gambling machines (EGMs) have gained a notorious reputation for generating problem gamblers. This paper notes that gambling machines developed separately from table games. It examines the standards applicable to table games and carnival games and the gaffs (cheating methods) used by crooked casinos and carnival grifters. It considers historical and modern gambling machines in the context of these standards and cheating methods. There are uncomfortable parallels between some characteristics of reel EGMs and those of gaffed table and carnival games. Bringing reel EGM standards into line with those applied to straight table games and carnival games would make them safer for the players.

NOTICE

Nothing in this paper is to be taken as implying that gaming machines in regulated jurisdictions are operated contrary to gambling legislation or are programmed to pay out less than required minimum percentages

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Introduction

Gambling machine reels are the culmination of over one hundred years of development. They combine a powerful blend of mathematics and psychology. Reel electronic gambling machines (EGMs) have enjoyed a spectacular success. They are spreading throughout the world at a rapid rate. The EGM industry, worldwide, sees them as a legitimate form of entertainment, providing a safe form of gambling for the vast majority of players.

Others, however, have taken a contrary view. In many countries, including Australia and Canada, the population is alarmed at the high amount of problem gambling being generated by the machines. In Victoria, Australia, 95% of respondents to a newspaper vote line were opposed to more EGMs in the State (Herald Sun 7 June 2006).

In Victoria, Australia, 84% of problem gamblers cited EGMs as their favourite form of play (Department of Justice, Victoria 2005 (Loved Ones) p 84). 78.1% of men and 96.2% of women who attended Gamblers Help played EGMs (Department of Human Services, Victoria 2001, p. 15).

Consistent with Australia's experience, in Canada, EGMs also account for a large percentage of problem gambling (Dorion & Nicki, 2001); (Smith & Wynne, 2004). And, citizen groups such as Canada's Gambling Watch Network (CGWN), are calling for reforms in gambling policies, laws and regulations (CGWIN 2004).

What is it about EGMs that makes them so potent in generating problem gamblers?

This question obliges us to take a close look at reel EGMs in the context of other forms of gaming, namely, table games and carnival games.

Separate development of table games and gambling machines

The first thing to note about gambling machines is that they developed along separate paths from table games.

Table games arose out of private gambling

Table games arose out of private gambling which was a legal activity. Before casinos, card and dice games were played between individual players. This still happens in the case of poker rooms where players play against each other and pay a fee or percentage to the operator who simply provides the gambling facilities.

The rules of card games and dice games were thus developed by the players themselves. These rules were fair because they applied to all those who had a stake in the game. Even with a banking game such as chemin de fer (forerunner of baccarat) the bank was passed around.

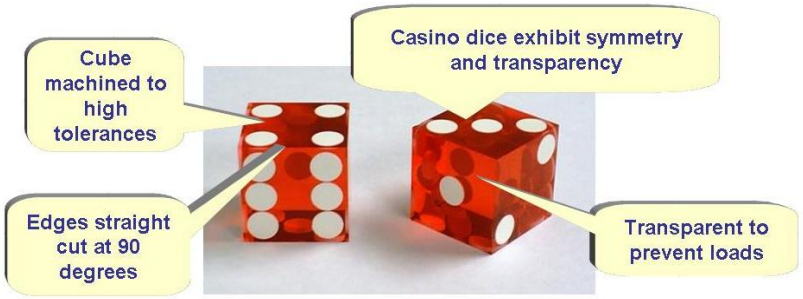
That is not to say there was not a lot of cheating. There was. But the rules themselves were transparent and fair and cheating involved breaches of those rules.

When legalized gambling started up in Nevada in the middle of last century, the casino games were adapted from European casino games and local games. Nevada gambling was conducted honestly (Puzo 1976, pp. 137 – 170) (Scarne 1974, p. 245).

In North America and Australia, the standards and regulatory regimens closely follow those applied in Nevada. Nevada standards are the touchstone of the USA and Australian gambling industries.

There was, and is now, never any question of a large legal casino using anything but a correct deck of cards, an unbiased wheel or straight dice. It just would not be worth the suspension of the casino licence.

The equipment was simple and it could be checked. A deck of cards had 4 suits of thirteen cards with one or two jokers. Dice had six sides numbered one to six with each two opposing sides adding to seven. Roulette wheels had eighteen red pockets, eighteen black pockets and, depending on the country, one or two green pockets.



The casino-quality dice shown above illustrate the point. They embody regularity and transparency. Any gambler playing with these dice can check them and ensure that he or she is not being cheated.

The gamblers knew the equipment and they knew the rules. Even most children are familiar with the characteristics of decks of cards and dice.

Reel gambling machines

Reel gambling machines were not designed by the gamblers themselves. The gamblers never had any involvement in the development of either the equipment or the rules.

The gambling machines originally started in soda bars and pubs. They were either illegal or on the fringe of the law. They were not regarded as serious gambling but rather as amusement machines. They were for small play by unsophisticated players.

From the very start, the gambling machine players played against the house. Certainly, most casino gambling is a house (or banking) game. But, as pointed out above, these games, like blackjack and craps, evolved from, non-house games and the rules and equipment are transparent and known to players. Roulette may never have been a banking game but here the rules and odds are laid out with elegant simplicity for all to see.

Unlike all table games, the mechanism in gambling machines was concealed in a box with the rules (apart from pay outs) known only to the manufacturer. The rules of a game include a description of the equipment, how the equipment is to be used to generate randomness and how payment is to be made. Reel gambling machine gamblers are told only how payment is made.

If you imagine a gambling machine reel as a deck of cards with symbols on, the player does not know how many cards there are in the deck, how many cards of each symbol there are in the deck or, in some jurisdictions, how the cards are dealt.

The fact that the players do not know the rules makes the reel gambling machine unique amongst gaming devices. Not only are the players ignorant of the rules but the rules vary from machine to machine and neither the gaming industry nor the regulators disclose them. As far as transparency is concerned, the standards applicable to reel gaming machines are totally out of step with all other forms of gaming.

Ascertaining Acceptable Gaming Standards by Examining Cheating Methods

House Cheating Methods

In order to gauge whether EGM standards measure up to those applicable to other games it is necessary to ascertain the standards applicable to other games and what constitutes cheating at those games. We are particularly concerned with house cheating methods, that is, cheating methods employed by crooked casinos and carnival stall grifters.

In gambling terminology, a cheating mechanism is known as a "gaff": Gaff, G or Gimmick – *any secret device or method that accomplishes the cheating. A gaff or G-joint is a game that can be operated dishonestly"* (Scarne 1974, p. 559) *"has to depend upon marked cards and other gaffed gambling equipment"* (Scarne 1974, p. 638). And a game that embodies a cheating mechanism is described as "gaffed".

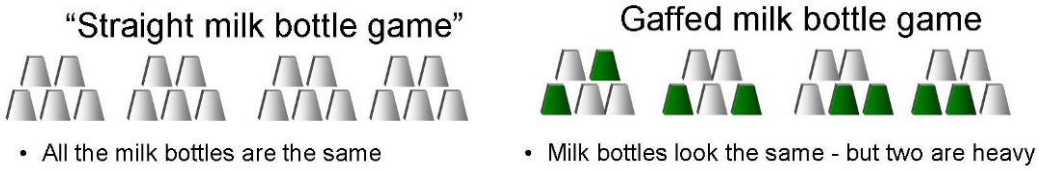
What is cheating? Cheating is described in Webster's Dictionary of Synonyms (Webster 1978) as follows: "*Cheat vb – to obtain something and especially money … from an advantage over another by dishonesty and trickery … Cheat suggests deceit and usually, tricks that escape or are intended to escape the observation of others <cheat at cards>".*

The Gaffed Milk Bottle Game

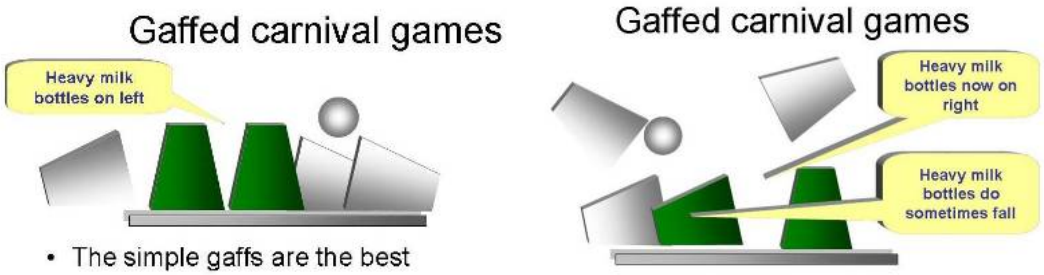
One of the oldest gaffs is the carnival milk bottle game.

This game involves knocking over a stack of five or six wooden milk bottles with a ball. It looks easy.

But it is not as easy as it looks. No matter how hard you try, you just cannot knock over all the bottles.



The diagram on the left shows a straight milk bottle game. The diagram on the right shows a gaffed one. The milk bottles look the same, but two are heavy.



The heavier bottles are harder to knock over. The heavy bottles are moved about. Sometimes a heavy bottle will fall if hit directly.

Scarne, a casino consultant and expert in cheating methods, wrote about the milk bottle game: "*It looks easy, but it's another two-way store. Three of the bottles are heavy, three are light.*" (Scarne 1974, pp. 611 - 613). Similarly, in the case of the cat rack game where balls are thrown at stuffed cats on a shelf: "*The cat rack game can be gaffed in many ways. The commonest is to use two light and two heavy cats, the latter being weighted at the bottom.*" (Scarne 1974, pp. 612 - 613).

Now there are five things to bear in mind about the milk bottle game.

First, it is simple. (Scarne admired simple gaffs, *"I know it sounds obvious, but card cheats know from experience that the obvious device is sometimes the one least likely to be detected.")* (Scarne 1974, p. 663).

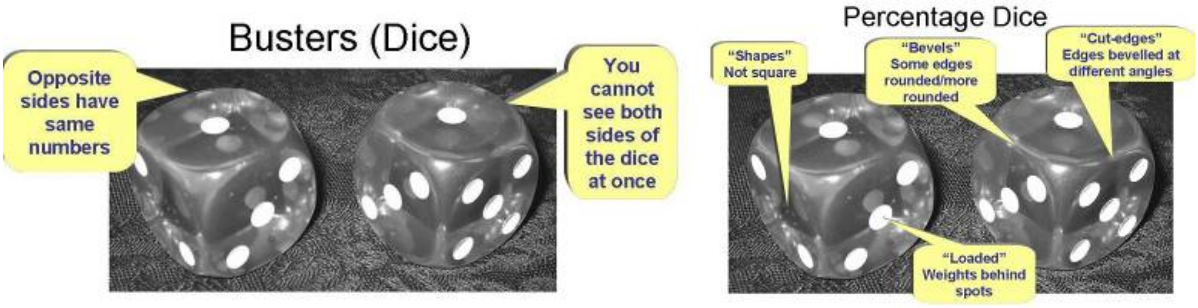
Secondly, the gaffed bottles keep moving around so the player does not "get wise".

Thirdly, sometimes even the weighted milk bottles will be knocked over, just less often.

Fourthly, a crooked operator will not let the player examine the bottles.

Finally, it is very exciting playing gaffed games because they look easy and the player gets very frustrated when the game just seems to be defying the rules. Scarne gives excellent accounts of the player's excitement and anguish playing three-card monte (Scarne 1974, pp. 619 - 623) or razzle dazzle (Scarne 1974, pp. 582 - 588), both gaffed games.

Crooked Dice



There are basically two types of false dice: busters and percentage dice.

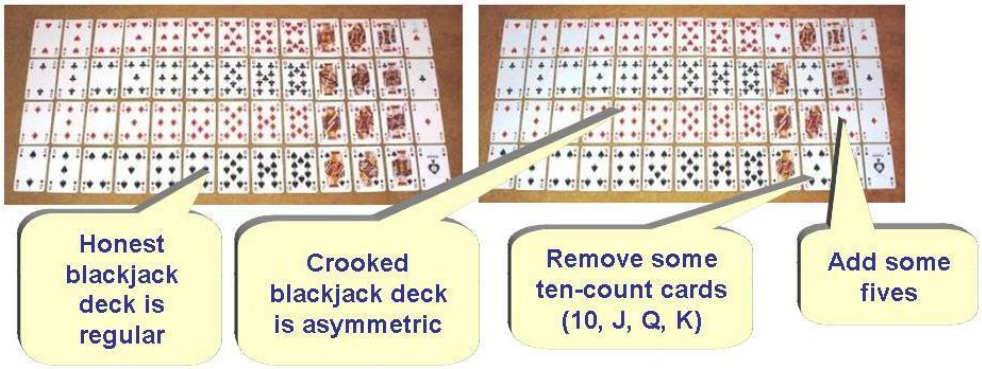
Busters rely on the fact that players cannot see more that three sides of the dice at once (Scarne, 1974 pp. 313-320). (Note that gambling machine players can only see a small part of each reel at once.) The device is elegantly simple and extremely effective. Of course, the dice have to be switched in and out of the game without the player noticing.

Percentage dice are, in Scarne's words, *"gaffed in such a way that some numbers will come up more than probability predicts. … The dice cheat merely makes his bets according to the bias of the dice and usually shows a profit on every game."* (Scarne, 1974 pp. 310-312)

These technique are not new, Cotton (1674, p. 13) writes, *" … the old ways are by drilling them and loading them with Quicksilver … others have made them by filing and rounding … ."* The advantage with percentage dice is they can be left in the game and they do not need an expert bust-out man to work them. They still generate all combinations but they favour one or some more than probability would predict in the case of straight dice. "Strong" dice have a heavy bias.

The percentage dice cheat, to mask or obfuscate his style of play and constant winning, can have a confederate and the two can take turns at having small losses and big wins (Scarne 1974, p. 310). One of the hallmarks of a good gaff, if it is to last, is something which breaks up the pattern which would draw attention to the gaff.

Crooked Blackjack Decks



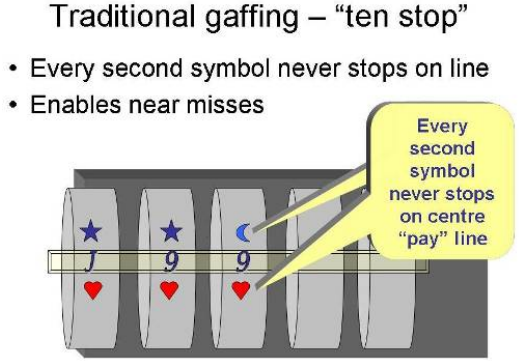
Scarne writes, *"The most common method used in crooked casinos when making use of four decks (208 cards) is to remove a number of ten-count cards and to replace them with five count cards."* (Scarne 1974, p. 388). In Blackjack the dealer sits on 17 and above so the dealer must draw on 16. Having more fives and less ten-count cards reduces the chance of the dealer busting and increases the casino's percentage. This is a percentage gaff. Like percentage dice it requires no skill on the part of the person cheating and the gaff remains in place indefinitely.

Both percentage dice and crooked Blackjack decks still embody randomness. The cheating arises out of the fact that the randomness is biased in a manner the player does not suspect.

Gambling machine Design

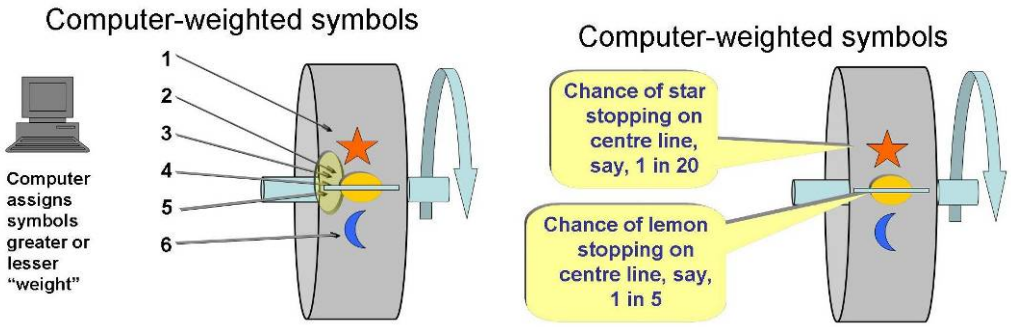
Ten-stop machine

Mechanical near-miss machines were used prior to 1940. They worked very simply. They were known as "ten-stop machines". Each reel had twenty symbols. (Note that in these conceptual illustrations the right hand reel details have been omitted for simplicity.)



However, each reel only had ten stops; that is, they only stopped on every second symbol. Accordingly, the alternate, dummy, symbols were rich in winning symbols and players would often get winning combinations above or below the pay line (Scarne 1974, pp. 437 & 438). Scarne considered the ten-stop machines as gaffed: "*modern machines are all 20-stop machines and no longer gaffed in this way*" (Scarne 1974, p. 439). The near miss machine gave players a false expectation of their chances of winning. A player who sees combinations of winning symbols or even high-paying symbols above or below the centre line gains a mistaken impression that he has just missed out on a payout or that it is easier to win a payout than it really is. This is a trick, a deception, intended to escape the observation of the gambler and intended to keep him playing so as to obtain more money from him.

Virtual Reel Mapping



In the mid-1980s, the Nevada Gaming Commission allowed computer-weighted symbols on mechanical reel slot machines, which is possible through a computer process called "Virtual Reel Mapping". U.S. Patent #4,448,419 describes the intent of virtual reel mapping (Telnaes, 1984): *"it is important to make a machine that is perceived to present greater chances of payoff than it actually has within the legal limitations that games of chance must operate."* These computer-driven machines, with their biased, virtually mapped, weighted symbols, share much in common with percentage dice. With dice, the player assumes that each face of the dice has an equal chance of coming up. If the dice are shapes or loads, this is not so and this false impression enables the innocent dice player to be cheated. Mario Puzo writes: *"If the casinos wanted to cheat, here's how they could do it. At the dice table it would be simple enough. They could just run in loaded or angled dice. A lot of this was done in the gambling hells of England in the 1700s and onward."* But it is certainly no answer to a casino charged with using loaded dice that the loaded dice are still, up to a point, random; the use of loaded dice is a very serious offence for a casino.

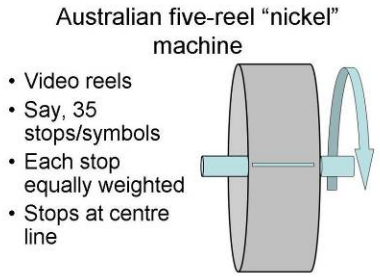
Cotton (1674) at pages 13 and 14 regarded the practice with fury, *"They are sold in many places about the Town [London]; price current (by the help of a friend) eight shillings, whereas an ordinary Bale is sold for six pence; for my part I shall tell you plainly, I would have those Bales of false Dice to be sold at the price of the ears of such destructive Knaves that made them."* As Mario Puzo pointed out: *"If a player sneaks a loaded pair of dice onto the crap table and the Gaming Commission finds them in play, the casino gets its licence suspended. Even though it is a victim, the casino is responsible."* (Puzo 1976, 165)

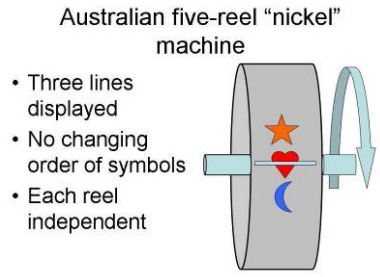
In Australia and New Zealand, the gaming regulators do not allow virtually mapped reels with biased symbols. Each symbol must have the same weighting; if there are 25 symbols on the reel, for example, each symbol must have a 1 in 25 chance of stopping on the centre line (Australian and New Zealand Gaming Machine National Standard version 7.01 clause 3.9.62). However, virtual reel mapping that allows for biased symbols is still in widespread use in most other gaming jurisdictions.

Multi-line video slot design

Let us now look at the design of games on Australian machines.

The game on a modern standard Australian machine is the virtual reel, five line, multi-line video slot game. These games have gained in popularity around the world and are now also predominant in many North American casinos and on North American Video Lottery Terminals and will surely be introduced into the United Kingdom as they deregulate gambling.

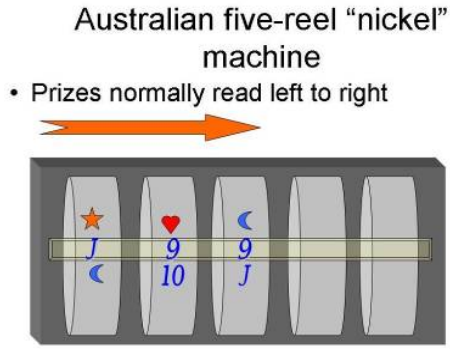


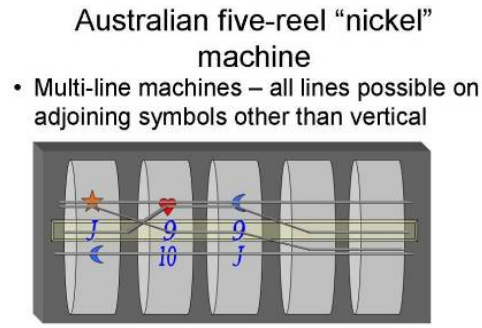


The Australian machine does not have physical reels but it works as though it had. Imagine five reels each with, say, 35 symbols. Each symbol must have the same weighting; if there are 35 symbols on the reel, for example, each symbol must have a 1 in 35 chance of stopping on the centre line (Australian and New Zealand Gaming Machine National Standard version 7.01 clause 3.9.62).

The computer notionally spins each of the reels independently and, using a random number generator, chooses the centre-line symbol.

The reel is then displayed on the screen with the selected symbol in the centre and its neighbouring symbols above and below.



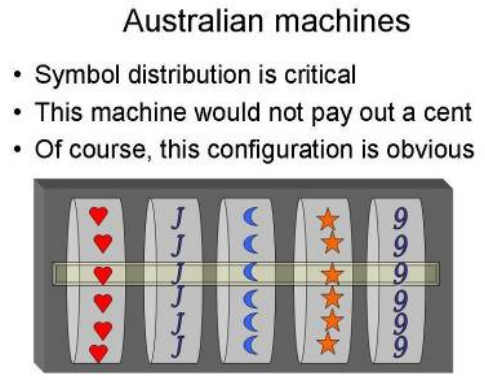


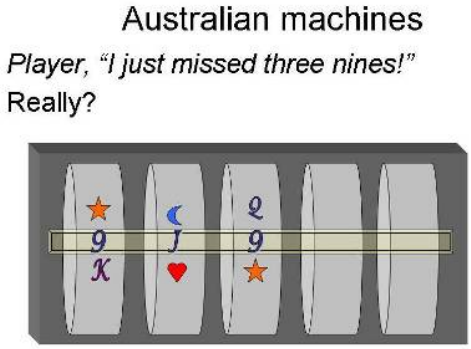
Traditionally, reel gaming machines pay out on the centre line reading the symbols from left to right. Thus, if we take king symbols, KKKKK gives five kings. If there is any break, only the kings to the left count. Thus KJKKK is only one king; normally, any "miss" on any of the left three reels results in no payout. Modern machines allow multiple pay lines, not only horizontal but also diagonal with combinations of over 20 paylines. For example, if the player elects to play three lines, the player would be paid for winning combinations on any of the three lines. On the new machines players can select not only straight lines but diagonal and zig-zag combinations, up to twenty and more lines.

Multi-line video slot machines - Unbalanced reel machines

In the case of Australian machine standards and machine standards in any regulated jurisdiction, there is one glaring omission. There is no standard requiring balanced (symmetrical) reels. Put another way, there is no requirement that each type of symbol appear at the same frequency on each reel.

A standard for balanced, or symmetrical, reels has never been a requirement for gambling machines. But, as has been pointed out, there were never any standards for reel gambling machines in the first place. By the time they were starting to make big money for the casinos their basic design had been fixed for thirty or forty years.



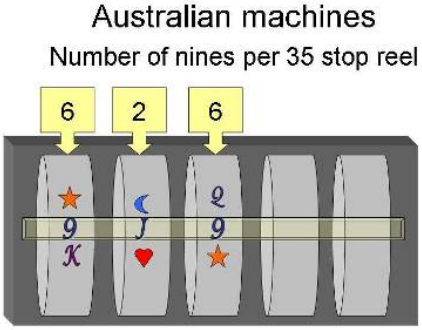


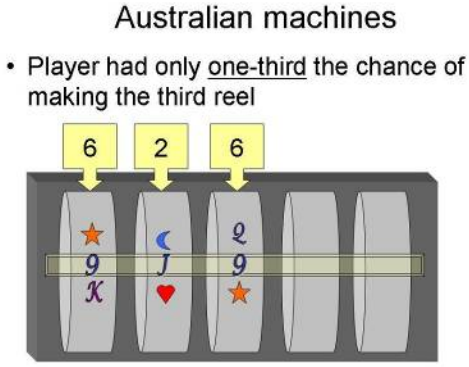
The first diagram shows just how critical symbol distribution can be. This machine is full of high paying symbols, only five types of symbol and each reel full of them. And it would not pay a cent.

However, a subtler version, for example, starving each of the three left hand reels of one type of winning symbol which is more plentiful on the others would give somebody playing the machine in the expectation the reels were identical the impression that their chances were much better than they really were.

Look at the right-hand diagram. The player gets nines on reels 1 and 3. He says, *"I just missed three nines!"* Did he really?

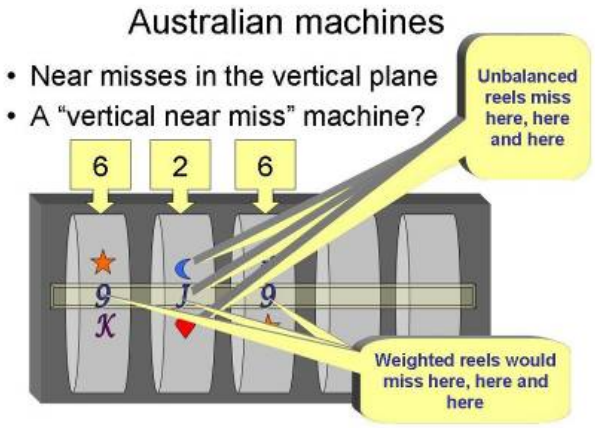
The player assumes that the chance of getting a Nine on reel 2, is the same as getting a Nine on reels 1 and 3.





Let us suppose this machine is a thirty-five stop machine with six Nines on reel 1 and six on reel 3. There is no rule whatever to say that reel 2 might not have only two Nines. If that were the case the player did not have an equal chance of getting the third nine – he only had one-third of the chance.

The virtual decks of cards on video poker machines (machines that emulate draw poker) have to be genuine and the same standard should be applied to reel machines. Crevelt (1991, p. 25) writes that USA regulators took action when it was discovered one manufacturer was programming its machines to avoid royal flushes. Why do we impose normal gambling standards for video poker yet abandon these standards for reel machines? In both cases, unlike with table games, the customer is powerless when it comes to verifying the design parameters of the game; the games should be designed to play in accordance with the natural appearance of the games and the expectations of the ingenuous gamblers who play them.



On one analysis the unbalanced reel machines generate "vertical near misses", near misses but in the vertical rather than the horizontal plane as happens where symbols on reels are "weighted". Asymmetric weighting of symbols – as opposed to asymmetric reels - is prohibited in Australia. On multi-line machines this does not matter in any event as horizontal near-miss machines would not work because players get paid for combinations above and below the centre line if three or more lines are selected. We are using the term "near miss" in its natural sense to include randomized near misses which would appear as near misses to machine players and not confining the term to illegal near misses "pasted" on to screens from lookup tables – i.e. sets of losing combinations held in the machine. Near misses look exactly the same on the screen whether they are produced from lookup tables or asymmetric reels.

Gaming standards and player expectations

Casinos are fastidious about the regularity of their gaming equipment. Any casino would be outraged if it was alleged that it was using shaved dice or stacked decks. Imagine what would happen if the Nevada casinos announced they were developing a new craps game. The casino could re-calculate all the odds and the dice would be loaded, some weak and some strong but the casino did not have to say how much because the uncertainty would make the game more exciting. Or suppose the Nevada casinos were allowed to alter their Blackjack decks by adding varying numbers of fives and taking out varying numbers of ten-count cards. The gamblers would be sprinting for the doors!

Gamblers have come to expect that casino equipment is of the highest quality and that things that look the same, act the same. Gamblers expect a dice to have six numbers, to be a near-perfect cube and, statistically have an equal chance of producing any of the six numbers. Gamblers, seeing a deck of cards in a casino, assume that there are fifty-two cards made up of four suits of thirteen cards from Ace through to King.

The government reinforces this belief in standards. Because the government knows that if gamblers lose faith in the integrity of the equipment, they will stop playing. Not only the casino will lose but also the government will lose its tax stream.

Look at these dice.

In the first picture, you can only see one side of these dice, just as you can only see part of the reel on a gambling machine. But that should not matter because you assume that everything is regular, everything is the same.

The second picture shows the same dice looking from the side. They are not the same – and neither are gambling machine reels. But no government regulator would allow a casino to use dice like these!

The point is that players expect the reels to be the same. Just as a dice player expects the dice to be numbered from one to six, a blackjack player expects the dealer to be drawing from a properly constituted 52-card deck and the player at the carnival expects the milk bottles to be the same weight – so the gambling machine player assumes the reels are equal.

Our conversations with problem gamblers and treatment providers confirm gambling machine gamblers assume the reels are symmetrical. For example, one of the co-authors (Falkiner) explained the situation to a woman who played the machines to two and three o'clock in the morning and who lost hundreds of thousands of dollars; she turned to him exclaiming, *"What! Are you saying the reels aren't the same?"* The other author (Horbay) recently spent an intensive weekend assisting a treatment program by educating staff and 70 problem gamblers and their loved ones ... Not a single person knew or heard of asymmetrical reels. They all became very angry as they slowly realized the fact of the asymmetric design and its implications.

AGMMA description of multi-line video slot machines

The Australian gaming industry player information booklet published by the Australian Gaming Machine Manufacturers' Association states EGMs use unbalanced reels (AGMMA, pp. 15 & 16):

> *… In this example, then, there are 6 "King" symbols placed on the first reel in the positions mentioned. Other symbols are assigned to other positions on the reel so that all 35 stopping positions have a symbol assigned. …*
>
> *In almost all instances, the symbols will be assigned differently to the first reel.*
>
> *For example, there may be only two "Kings" on reel 2 on stopping positions 15 and 19. …*

It is clear the machines described are unbalanced (or asymmetric) reel machines. Since the Australian concept EGMs are now available in North America, it is assumed most, of not all, multi-line video slot games operate in the same fashion.

Professor Philip G. Fox, a teacher of statistics at Wisconsin University. Fox (1959, p. 142) wrote of the "devilish cleverness" of asymmetric reels,

"I'm told the three dials clicking to a series of stops build up suspense far more effectively that the simultaneous halting of all dials. A glance at the arrangement of the symbols, given above, reveals the devilish cleverness of the setup. There are three bars on the second dial to raise hopes of a jack pot, but only one bar on the last dial. On the second dial there are no lemons which ruin a player; but four lemons on the third dial lower the boom on him.

Fox's analysis was cited with approval by Dr. Warren Weaver, former Vice President, Alfred P. Sloan Foundation and former mathematics teacher (Weaver (1964, pp. 157 – 160).

Professor Jerome K. Skolnick, who studied the Nevada gaming industry, noted that asymmetric reels, referred to as "differential placement of jackpot symbols" had misled generations of players with near misses (1978, p. 64):

Generations of players have pulled slot machine handles and produced jackpot symbols on the first and second reels, seemingly just missing out on the jackpot. What happens is this: because of the differential placement of jackpot symbols players wrongly - though not necessarily consciously – believe that jackpot odds are something like 4 x 5 x 5 (100 out of 8000), while, in fact, the odds are 4 x 5 x 1 (20 out of 8000.) …"

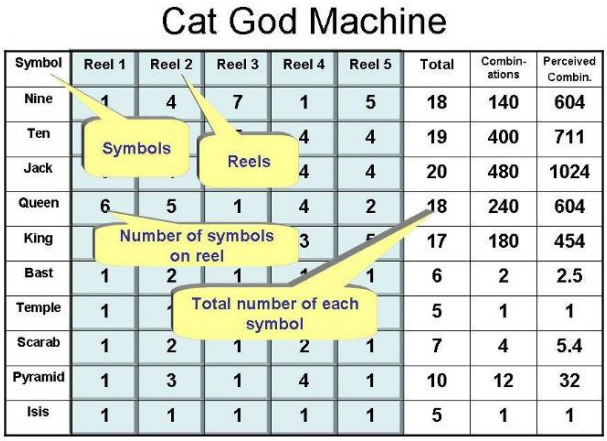
Examining a Hypothetical Machine

In order to see what can be done with unbalanced reels let us imagine a theoretical machine, which we can call the "Cat God of Sidi Barani" machine.

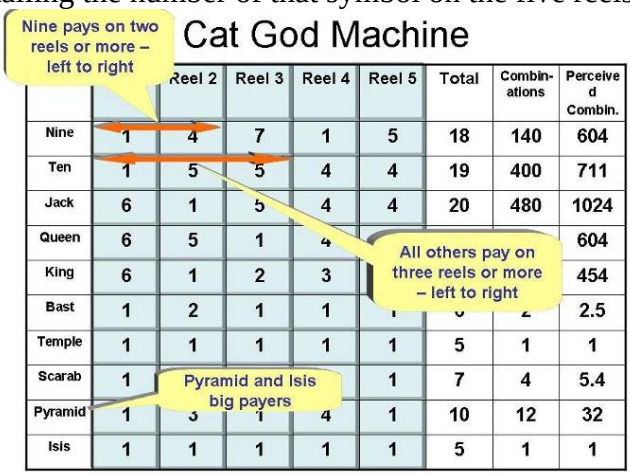
Cat God Machine

Symbol	Reel 1	Reel 2	Reel 3	Reel 4	Reel 5	Total	Combin-ations	Perceived Combin.
Nine	1	4	7	1	5	18	140	604
Ten	1	5	5	4	4	19	400	711
Jack	6	1	5	4	4	20	480	1024
Queen	6	5	1	4	2	18	240	604
King	6	1	2	3	5	17	180	454
Bast	1	2	1	1	1	6	2	2.5
Temple	1	1	1	1	1	5	1	1
Scarab	1	2	1	2	1	7	4	5.4
Pyramid	1	3	1	4	1	10	12	32
Isis	1	1	1	1	1	5	1	1

Its reels look like this.



The first column shows the symbols. The next five columns represent the reels and show the numbers of each symbol on each reel. The "Total" column shows the total number of each symbol by totalling the number of that symbol on the five reels.



For our purposes say the payout is:

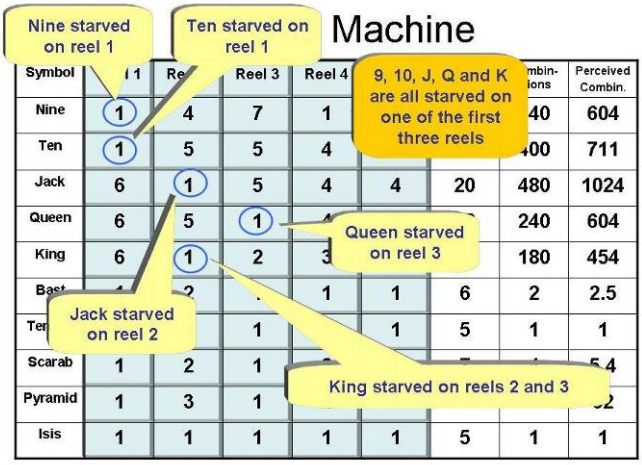
- Nine pays on 2 and above
- All others pay on 3 and above
- Pyramid and Isis big payers

Starving, Puffing and Dithering

We need to introduce some terms:

- *Starving* severely limiting the number of symbols on a reel, particularly reels 1, 2 and 3
- *Puffing* associated with starving, putting large numbers of symbols next to starved reels
- *Dithering* mixing up the pattern of starving; fuzzing it to make it less obvious

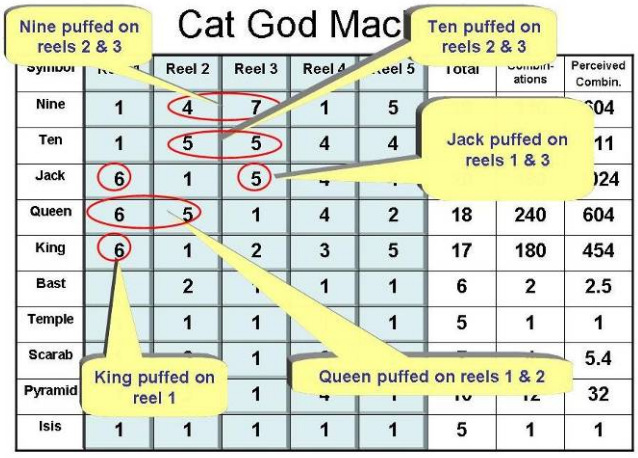
My analysis of the Cat God machine is as follows.



Symbol	Reel 1	Reel 2	Reel 3	Reel 4	Reel 5	Total	Combin-ations	Perceived Combin.
Nine	1	4	7	1			40	604
Ten	1	5	5	4			400	711
Jack	6	1	5	4	4	20	480	1024
Queen	6	5	1				240	604
King	6	1	2	3			180	454
Bast		2		1	1	6	2	2.5
Temple		1	1		1	5	1	1
Scarab	1	2	1					5.4
Pyramid	1	3	1					32
Isis	1	1	1	1	1	5	1	1

Starving

All 9, 10, J, Q and K are starved on one of the first three reels – 9 and 10 on 1, J and K on 2 and Q on 3. Queens would be the most frequent two-line symbol but the starving of reel 3 would limit combinations. It need hardly be pointed out that because payouts read from left to right, the starving of reels on the left side of the machine severely limits payouts.



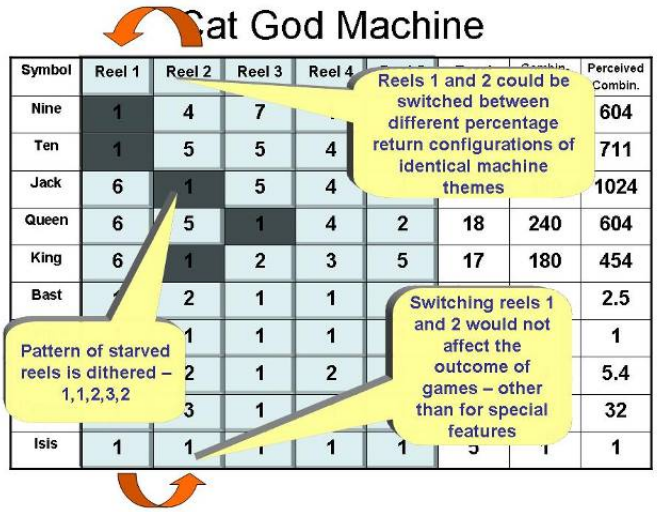
Symbol	Reel 1	Reel 2	Reel 3	Reel 4	Reel 5	Total	Combin-ations	Perceived Combin.
Nine	1	4	7	1	5			604
Ten	1	5	5	4	4			711
Jack	6	1	5					1024
Queen	6	5	1	4	2	18	240	604
King	6	1	2	3	5	17	180	454
Bast		2		1	1	6	2	2.5
Temple		1	1		1	5	1	1
Scarab			1					5.4
Pyramid			1					32
Isis	1	1	1	1	1	5	1	1

Puffing

J and K are puffed on reel 1.

The 9 is puffed on reel 3 before reel 4 is starved limiting combinations of four and above.

Scarab and Pyramid are puffed on reel 2 and Pyramid on reel 4.



Dithering

The starving is dithered: two on reel 1, two on reel 2 and one on reel 3. Queens, not the lower cards are the most frequent reels 1+2 symbol (but require 1+2+3 for a payout). Pyramid is puffed on line 4.

Making starved reels less discoverable

Starving of reels is masked by a number of factors:

- the player does not expect it and so does not look for it – the expectancy of the player that the equipment is regular has been discussed above,
- just as a dice player cannot see the numbers on the opposite side of a dice, the EGM player cannot see the concealed symbols on the reel,
- even the starved reels do generate the starved character, just less often – this resembles percentage dice or the crooked Blackjack deck,
- the starving is dithered; different reels are starved of different characters – the pattern is obfuscated – this is like the percentage dice cheat who varies his pattern of play, and
- the player's attention is continually being diverted from one symbol to another - in the gaffed milk bottle or cat rack game, the operator keeps moving the weighted bottles or cats around so the customer will not twig to the difference – this is similar to the gaffed milk bottles and gaffed cats.

Notwithstanding these factors, it would make sense to switch the starved reels around as much as possible to avoid the player either consciously or unconsciously discerning the pattern.

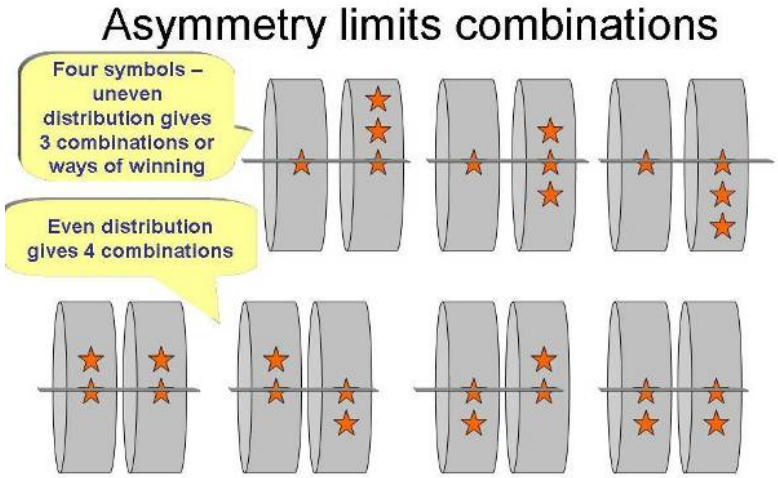
Switching starved reels between machines/coins/lines played

There is nothing to stop the different versions of this machine having a different allocation of starved reels which would enable switching starved reels between individual machines which have the same external appearance – another application similar to the gaffed milk bottle/cat technique. If permitted by the regulator, it would be possible for switching to occur where different reel design/payout tables were activated depending on the number of coins or lines chosen by the player.

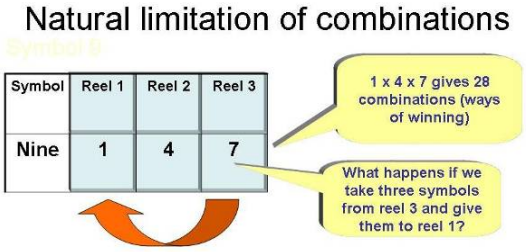
If technology is installed to enable reconfiguration of machines by remote instruction over the lines, starved reels could be rearranged at will. This in a physical reel machine would be akin to a mechanic coming in and swapping reels on the machine between button pushes without the player being aware of it. It would be only a small step to program each machine to automatically switch reels between plays or every few plays without the need for any external instruction; this would enable even higher levels of reel starving without any pattern becoming apparent.

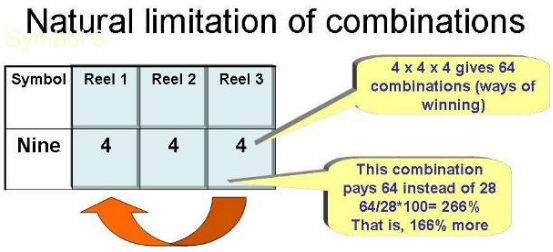
Asymmetry naturally limiting combinations

Not only does starving left-hand reels drastically restrict winning combinations but unbalanced (asymmetric) design has another effect, quite fascinating in its simplicity.



Asymmetric design automatically limits combinations of characters by the operation of simple arithmetic.



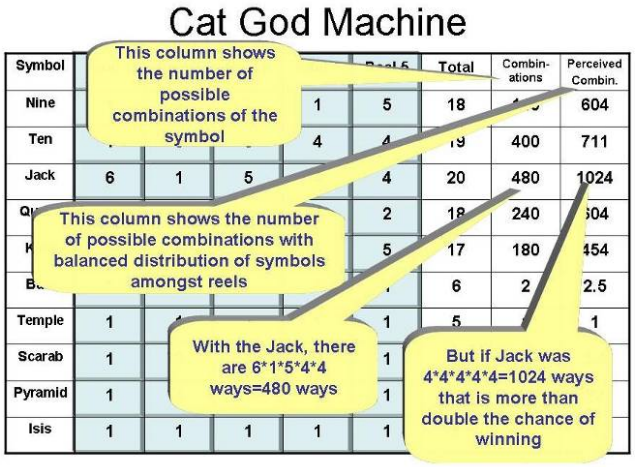


To take an example from the machine, symbol Nine is distributed 1, 4 and 7 on reels 1 to 3 respectively. This gives 28 combinations – ways of winning.

If symbol Nine were distributed evenly, as 4, 4, 4 instead of 1, 4, 7 there would be 64 ways of getting three instead of only 28 and 16 ways of getting two instead of 4.

It is little wonder that players who unconsciously assume the reels are identical feel they should be winning. If the numbers of symbols were symmetrically distributed the machines would be paying out heavily in favour of the player. This effect is in addition to misplaced excitement at the "vertical near misses" caused by starved reels.

Combinations and Perceived Combinations

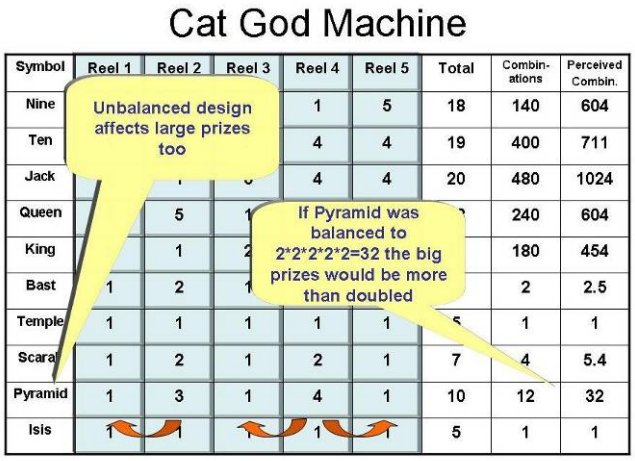


Symbol						Total	Combin-ations	Perceived Combin.
Nine				1	5	18		604
Ten				4	4	19	400	711
Jack	6	1	5		4	20	480	1024
Qu					2	18	240	604
K					5	17	180	454
Ba						6	2	2.5
Temple	1				1	5		1
Scarab	1				1			
Pyramid	1				1			
Isis	1	1	1	1	1			

In the table above, the column C shows the number of combinations possible for each symbol. With the Jack, there are 6x1x5x4x4 = 480 ways of getting five symbols.

The column PC stands for "perceived combinations" and is a calculation of the number of combinations possible where the symbols are distributed amongst the reels equally. This is done by taking the number of each symbol, dividing by five and raising to the power five. Once again, to take the Jack, with twenty symbols that would be 20 divided by 5 equals four and thus 4x4x4x4x4 = 1024 ways of getting five symbols. (Decimals are used where the number of symbols is not a multiple of five.)

Asymmetric design even radically affects the big prizes



Symbol	Reel 1	Reel 2	Reel 3	Reel 4	Reel 5	Total	Combin-ations	Perceived Combin.
Nine				1	5	18	140	604
Ten				4	4	19	400	711
Jack				4	4	20	480	1024
Queen		5	1				240	604
King		1	2				180	454
Bast	1	2	1				2	2.5
Temple	1	1	1	1	1	5	1	1
Scarab	1	2	1	2	1	7	4	5.4
Pyramid	1	3	1	4	1	10	12	32
Isis	1	1	1	1	1	5	1	1

Even with the Pyramid, if the four Pyramids on reel 4 were redistributed to even up reels 3, 4 and 5 and one of the Pyramids on reel 2 was given to reel 1, the ways of getting a Pyramid would increase from 1x3x1x4x1 = 12 to 2x2x2x2x2 = 32. Given this is a large prize, even puffing/starving reels on the right hand side can have a significant effect on the larger payouts.

Need for Uniform Standards

Uncomfortable parallels between reel EGMs and gaffed casino and carnival games

The average EGM player who either consciously or unconsciously assumes the reels are identical is in a position akin to the player of a gaffed milk bottle or cat rack game in that the game is made to look much easier than it is because things that look the same are not: the

reels in the case of the EGM and the weighted milk bottles or cats in the carnival games. A carnival game operator is regarded as cheating if he weights his milk bottles or cats differently. A casino operator is cheating if it uses percentage dice or filleted Blackjack decks. The same standard should be applied to the EGM industry.

Lower standards constitute unacceptable risk

The failure of regulatory authorities to apply the strict standards applicable to other casino games to reel EGMs exposes players to a totally unacceptable risk. Unbalanced reel design enables EGMs to present to the player screens which are rich in symbols but which are designed to limit winning combinations in a manner incommensurate with the appearance of the screen.

Lowest standards – Highest problem gambler numbers

Government gaming regulators are applying widely disparate standards to table games and reel EGMs.

Reels, like honest milk bottles, cats, decks of cards and dice must exhibit uniformity and reel design must be transparent to the player. It cannot be emphasized enough that the reel EGM, which has the lowest standards, also has the worst reputation for generating problem gamblers (Department of Justice, Victoria 2005 (Loved Ones) p 84).

EGMs, if they are to remain a legal form of gambling, should equal or exceed the standards of casino games and carnival games because:

- They have an infamous reputation
- Problem gambling data demonstrates their hazard
- They are played by the most ingenuous players.

Major factor in problem gambling behaviour

Unbalanced reel design must be a major factor, if not the major factor, in the maintenance of problem gambling principally because the gambler unconsciously believes he or she cannot lose. And the gambler would be quite correct - if the reels were balanced.

If the reels were balanced these machines would, looking at the example above, be paying out double the money put in – instead of taking 10% to 13%. That is, for every $100 put in the player would get back about $200. Put another way, the machines would be returning about 200% instead of about 90%. This is calculated by comparing the actual numbers of winning combinations with the numbers of winning combinations which would occur if the symbols were evenly distributed over the reels – as shown in the "C" and "PC" columns. To this would be added the additional effect of the placement of starved reels in the left hand columns.

Implications for treatment providers

Unbalanced reels give players false perceptions of the chance of winning. In a sense, the treatment providers have been wrong and the problem gamblers have been right. The treatment providers are saying to the problem gamblers, *"You can't win!"* and the problem gamblers are sitting there saying to themselves, *"I've seen the reels – and I can!"* And the problem gambler's judgment is correct, or would be if the symbols on the reels were

balanced. The treatment providers have been treating the problem gamblers unfairly and assuming that there is something wrong with the problem gamblers' cognitive skills.

Rectification

Discontinue virtually mapped biased machines

In Australia and New Zealand, the EGM standards do not allow reels with biased symbols. As a start, this Australian standard should be adopted by regulators worldwide and applied to ban virtually mapped, biased reels on both mechanical reel EGMs and video reel EGMs.

Balance the Reels

Video reel EGMs worldwide should be converted to ensure all reels are balanced. The conversion could be carried out most quickly and costs can be minimized by converting existing machines. Existing machines can be brought into compliance by simple on-site replacement of chips and payout graphics.

Require Transparency

The honest stall holder of a straight game will allow customers to inspect his milk bottles or cats so they may satisfy themselves the games are on the level. Casino gamblers may call for the inspection and examination of dice and decks of cards. Applying the same standards, if reel EGMs are to be retained as a legal form of gambling, EGM manufacturers should exhibit, on each machine, a table showing balanced reels with the numbers of each symbol on each reel and the size of the reels used. This information should be certified by the government regulator.

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Mr. Horbay is also a recognized expert in the fields of iGaming and Electronic Gaming Machines and how the technology may contribute to the development and maintenance of pathological gambling. He also acts as an Expert Witness and consultant in legal cases involving gambling. He is also a problem gambling consultant for the gaming industry, working on innovative prevention and problem gambling management and player protection strategies, policies, programs and features.

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