Choose six numbers, any numbers

Eileen Hill and Janis Williamson

Many people gamble regularly on the UK National Lottery. **Eileen Hill** *and* **Janis Williamson** *discuss the decisions players make when participating in the Lottery draw, and explain the psychological principles underlying those decisions.*

MARK Griffiths, in his article 'The National Lottery and scratchcards' (*The Psychologist*, January 1997), claims 'the lottery phenomenon has gripped the nation's psyche'. Although the Lottery is well into its third year of operation, ticket sales and the media suggest that interest has not diminished. This article complements Griffiths' article, in that it reviews the Lottery *draw* to date, and discusses decision making relating to participation, expenditure and Lottery number selections. The intention is also to explain the psychological principles probably used by a large proportion of the UK population who began to play, and continue to participate, in a gamble with a negative expected value.

Gambling games are structured in such a way that players should not expect to win, yet a great number of people embark on a particular gamble, and then continue to gamble even though the majority will lose. In psychology, excitement and arousal have been commonly accepted as the key to regular gambling (Griffiths, 1991; Walker, 1992). However, over the last few years a number of cognitive psychologists (e.g. Griffiths, 1990; Wagenaar, 1988; Walker, 1992) have begun to look at people's belief structures, accepting that excitement does have a role, but suggesting that an interaction of mistaken beliefs plays a major part in persistence in gambling.

The National Lottery is a game of chance, in that the draws cannot be predicted, or the results influenced by the player (Bolton, 1993). Participation in the Lottery appears to be socially acceptable, is easy, is widely available, and everyone has an equal chance of winning irrespective of skills; but the odds against winning are far greater than any other form of average gambling return. The odds of winning anything are about 54-to-one, and 14 million-to-one for winning the jackpot. Yet 90 per cent of the population is reckoned to have bought at least one Lottery ticket, with 65 per cent claiming to play on a regular basis (Camelot, 1996*a*).

Before the launch, it was estimated 40 per cent of UK adults would regularly buy Lottery tickets (Kent-Smith & Thomas, 1995), with possibly two players sharing the jackpot of around £2 million. However, the first draw, with a jackpot prize of over £7 million, showed this to be a vast underestimation. Almost 49 million tickets were sold in each of the first three weeks, suggesting far more people than expected were taking the risk, and were also buying multiple tickets. In the fourth week, a roll-over week, sales jumped dramatically to £61.5 million. Ticket sales then regularly increased, most noticeably after each roll-over, until they steadied at around £68 million; the usual outcome being jackpots of over £9 million, unless there is a roll-over when a temporary rise can be seen in ticket sales and the size of the jackpot, and probably the number of players.

Wagenaar (1988) suggests the explanation for lottery participation lies in the fact that players are not interested in the actual properties of lotteries. They are attracted because only 'fair play' is considered, this being a chance to win a highly desirable prize for the low cost of a ticket. Yet lottery play appears not to be totally fair because, although the tickets are not expensive, less than half the money staked is returned as prizes, and the chances of winning any decent sized amounts of money are so remote.

Heuristics and biases

Judgements and decision-making relating to lottery play can be explained within the framework of 'heuristics and biases' (which are useful as a descriptive device, but because heuristics are so numerous and several can be applied to any one particular situation, they have no 'predictive value' — Griffiths, 1995; Wagenaar, 1988). When an outcome is uncertain, decisions tend to be based on heuristic principles, which are useful in reducing the difficulties involved in assessing probabilities, but can lead to certain cognitive biases (Tversky & Kahneman, 1982). Some of the best known heuristics and biases that can be used to explain participation in the National Lottery, and continuance in the face of negative outcomes, are summa-

Heuristic	Application to lottery participation
Availability bias — the ease with which specific instances can be brought to mind, affecting probability judgements (Mumpower, 1988).	Wide publication of winners, and pleasant memories of an occasional small prize, make winning more salient than losing.
Randomness bias — not expecting a random sequence to have any apparent biases and regularities (Teigen, 1994).	Difficulty in generating a random selection of six numbers from 49.
Representativeness — judgment of the probability of an event is based on the degree to which the sample is similar to the population from where it is drawn (Tversky & Kahneman, 1971).	A tendency to choose numbers that appear 'random' (irregular or a pattern), and avoid those which appear less random (adjacent numbers and repeating digits).
The gamblers' fallacy — the belief that subsequent events will cancel out previous events, to produce a representative sequence (even in the short run) (Holtgraves & Skeel, 1992).	Choosing numbers which have been least drawn (they are therefore 'due'), and overestimating their chances of winning.
Illusory correlations — the use of superstitious behaviours when it is believed variables correlate, when they do not (Wagenaar, 1988).	Choosing 'lucky numbers' — birthdays, house numbers. etc. — which causes players to discard statistical probabilities.
Flexible attribution — the tendency to attribute success to personal skill, and failures to some external influence (Wagenaar, 1988).	Preference for choosing own numbers rather than buying 'lucky dips', so that any win is due to player's own skill, and losses are due to features of the game, etc.
Illusion of control — an expectancy of success which is greater than the objective probability would warrant (Langer, 1975).	Being able to choose own numbers induces skill orientations, which cause players to feel inappropriately confident.
Sunk cost bias — to continue an endeavour once an investment has been made (Arkes & Blumer, 1985).	Continuing to buy lottery tickets whilst experiencing losses.

Table 1: Heuristics and biases which may be used by lottery players

rized in Table 1.

The biases of *randomness*, *representativeness* and *the gamblers' fallacy* are linked to elements of choice, whereas the *illusion of control* and *flexible attribution* are implicated in evaluating outcomes based on false perceptions of reality. *Availability* and *illusory correlations* affect probability judgments, and together with *the illusion of control* and *sunk cost bias*, are involved in persistence in gambling.

The chance to become an instant multi-millionaire most likely tempted lots of people to play the Lottery in the beginning, and buy more than one ticket. As suggested by Shapira and Venezia (1992), the size of the roll-over jackpots possibly increased the demand for the Lottery. In addition it is possible that wide media coverage, together with advertising by Camelot in the national press, on television and on billboards, and the then Government's hypocritical position regarding 'non-stimulation' of gambling, have played a part in the formation of inappropriate beliefs about the probabilities of winning (Griffiths, 1997), and have encouraged even more to begin, and then continue playing.

'Availability' — If the judgemental heuristic 'availability' is operating, the probability of an event is assessed on the basis of how easily it can be brought to mind (Mumpower, 1988). Consequently because television and the press show only the winners of the Lottery, and players appear to discuss only their wins and never their losses, the probability of a win is likely to be evaluated on salient, positive outcomes (a few wins), which are reached faster and better than concealed, negative outcomes (many losses) (Walker, 1992). In this way people may be led to believe that winning is easy and occurs more frequently than it actually does.

The odds of winning anything on the National Lottery are so poor that many players would perhaps think it not worth risking more than £1. However, surveys (e.g. the Family Expenditure Survey, 1995) suggest that players on average buy two, sometimes three tickets, and that roll-over weeks entice many players to raise their Lottery stakes by a third. Ticket sales have reached 88 million for roll-over weeks, and 128 million for a double roll-over, which is double an average week; yet even with multiple tickets the odds are not reduced materially, the increase in expenditure only highlighting the poor expected value of the Lottery. Players, as well as buying their own Lottery tickets, are also joining syndicates in order to increase their chances of winning, although a win would have to be shared, and possibly by many.

'Randomness' — Because the Lottery numbered balls are drawn mechanically and at random, it might be expected that players would pick numbers by a similar system. However, according to Haigh (1995) many appear to be trying to *predict* the numbers that will be drawn. Furthermore, they seem to be doing this in the same way, forming certain patterns, which often consist of evenly spread combinations of the six numbers. The result is that for most weeks there are fewer jackpot winners than might be expected by chance. After studying the winning combinations, Haigh suggests that players are inclined to avoid selections which include adjacent, and nearly adjacent numbers. When winning combinations do appear with adjacent numbers, the two numbers are mostly found on different lines on the playslip. It looks as if those who believe they are choosing their numbers *randomly* are more often than not under the impression this means equally spread out over the 49 numbers, which would explain why the drawn combinations shown in Table 2, which do not fit into this lay

Draw no.	Winning nos (bonus in brackets)
3	11 17 21 **29 30** 40 (31)
8	02 05 **21 22** 25 32 (46)
19	04 17 **41 42 44** 49 (24)
23	08 **18 20** 33 **36 38** (46)
27	15 **16 17** 28 32 46 (22)
29	01 21 29 **31 32** 40 (27)
33	05 **07 08** 25 44 48 (03)
39	11 25 28 **33 34** 47 (48)
43	02 12 20 22 41 45 (47)
58	06 11 34 40 **47 49** (16)
59	06 32 39 **42 43 45** (36)*
61	21 29 **31 32 34** 48 (25)
62	05 **23 25** 30 33 37 (03)*
72	12 **26 27 28** 37 49 (43)
76	04 06 11 18 31 48 (41)
83	13 18 25 44 **46 47** (34)
86	13 26 **43 44 45** 47 (36)
101	10 13 31 34 39 48 (33)
115	01 24 28 31 35 47 (09)
129	13 **16 17** 29 40 48 (32)+

(From Eileen Hill's analysis of winning combinations. Jackpot winning numbers, adjacent and nearly adjacent on the playslip, are shown in bold;
* = roll-over; + = Wednesday draw.)

Table 2: Winning combinations in the first 130 draws that have resulted in jackpots not being won

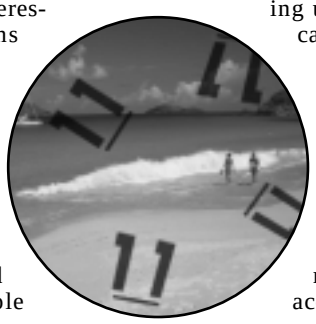
Draw no.	Winning nos (bonus in brackets)	No.of jackpot winners
9	07 17 23 32 38 42 (48)	133
14	16 19 21 29 36 45 (43)	9
24	09 15 22 31 34 48 (02)	14
44	02 10 14 25 37 41 (05)	8
45	05 10 19 24 34 46 (28)	10
53	04 07 18 33 45 48 (01)	20
70	02 12 19 28 38 48 (45)	57
71	05 07 14 18 30 43 (28)	9
78	07 10 12 22 34 48 (11)	8
84	**03 04** 07 11 17 40 (20)	9
87	05 10 **11 12 41 42** (02)	12
103	07 23 32 35 43 48 (25)	11
111	**08 10** 20 27 31 39 (30)	8
112	**11 13 14** 27 40 41 (23)	10
116	12 16 20 28 36 48 (34)	9
119	05 14 23 29 38 45 (47)	18+
120	07 14 21 34 38 47 (13)	19
122	01 05 **08 09** 23 27 (22)	8
124	02 08 23 33 42 49 (14)	20
126	05 12 20 29 39 42 (22)	15

(Jackpot winning numbers, adjacent and nearly adjacent on the playslip, are shown in bold; + = Wednesday draw. Information courtesy of Camelot's phone line 0645 100 000.)

Table 3: Winning combinations in the first 130 draws that have produced eight or more jackpot winners

theory of randomness, were not chosen by any players when five winners would be predicted by chance.

'Representativeness' — When choosing combinations of numbers, because of a misunderstanding of the idea of randomness and an underestimation of deviations from what are perceived as random, probabilities of runs and clusters are not always considered (Teigen, 1994). A player using heuristics in order to make judgements would understand a sample drawn at random from a population to be highly 'representative' of that population; in other words all crucial characteristics of the population would be found within the sample (Tversky & Kahneman, 1971). Therefore a 'random' selection of six numbers from 49 would be expected to include one chosen from one to nine, and one from each of the 10s, 20s, 30s and 40s.



Each week huge numbers of possible combinations are not chosen by anyone, the effect in the first 130 draws being 18 roll-overs when four might be expected, and two double roll-overs within three weeks when only one would be forecast for every three or four years. The analysis in Table 3 indicates the opposite is also true in that many choose the same combinations and share the jackpot prizes. For instance, in week nine the winning combination turned out to be relatively evenly spread in the *middle* of the block of 49 numbers, and an unusually large number of players shared the jackpot, each receiving £122,510 when they most probably expected several millions.

'The gamblers' fallacy' — Some players may use *evidence* from previous draws to assess the likelihood of numbers turning up. Those treating chance as a cause may commit the 'gamblers' fallacy' (Holtgraves & Skeel, 1992), which is another inference from the 'representative' heuristic. Chance is misconceived as fair if unpredictable, a 'self-correcting process' which manages to restore equilibrium (Kahneman *et al.*, 1982); accordingly each ball is expected to be drawn an equal number of times, even in the short run. As a result, the combination shown in Table 4 might be avoided for the 131st draw, and that in Table 5 consciously chosen in an attempt to *balance* the outcomes should unexpectedly high frequencies of particular numbers be noticed. In doing so players are not basing their predictions on *realistic* evidence; it may take many years before each number is found to have been drawn an almost equal number of times. Just as importantly, they are failing to treat each draw as an independent event, and are acting as if the balls have some sort of 'memory and moral sense' (Tversky & Kahneman, 1971).

'Illusory correlations' — Alternatively, players may use preferences when choosing numbers. A belief in *personal luck* may mean probabilities are discarded and a person is influenced to choose combinations incorporating numbers of special significance, such as family birthdays (Cornish, 1978). This could result in a choice of several low numbers and few, if any, numbers in the high 30s and in the 40s. Haigh (1995) suggests lottery gamblers are reluctant to choose selections of high numbers, in particular several numbers over 40. Whereas chance events are seen as passive and wholly uncontrollable, *luck* encourages the feeling of control through the action taken, with the *action* having some effect on the outcome. Therefore perceiving the National Lottery as a *game of luck* rather than a *game of chance* will affect the way it is played. Psychologically, games of luck are analogous to games of skill, in that the players believe the result to be dependent on the extent to which they possess the necessary skills, and on the competence with which they are able to use such skills (Friedland, 1992).

Lotteries are thought not to be particularly associated with any cognitive skills (Wagenaar, 1988). However, some players may believe an element of skill to be involved. They may see the National Lottery as a challenge, study the numbers each week, and so devise a strategy aimed at beating the system and, if not winning the jackpot, at least coming out on top. Such players could be those who frequently bet on horses or cards, and other games preferred by serious gamblers because they involve knowledge, skill and chance (Walker, 1985). On the other hand, serious gamblers may participate because they are driven by the size of the prizes, and so choose numbers at random, knowing

No.	Total frequency	Jackpot	Bonus
5	29	24	5
44	26	22	4
48	24	21	3
28	23	18	5
45	23	18	5
16	22	19	3

Table 4: The six most frequently winning numbers in the first 130 draws

No.	Total frequency	Jackpot	Bonus
37	10	8	2
19	10	8	2
39	13	12	1
8	13	12	1
10	13	11	2
27	14	13	1

Table 5: The six least drawn winning numbers in the first 130 draws

that a win will only result from a chance outcome. Others may avoid the Lottery altogether, rejecting the risks because of the odds.

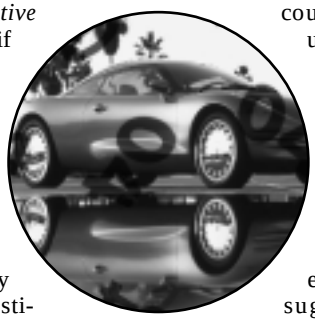
Those wishing to win the whole of a jackpot may find it useful to study the combinations regularly used, and work out those not likely to be chosen by others. If everyone else's selections are sufficiently non-random, a player able to choose combinations avoided by other players will not have to share the money, should they win (MacKinnon, 1994). The most popular sequence of numbers chosen is 1-2-3-4-5-6 (Camelot, 1996*b*), even though the majority of players avoid adjacent numbers. Almost 30,000 players made this particular selection for the 63rd draw (a double roll-over, total ticket sales being around 128 million), possibly in an attempt to choose a sequence that others will avoid, and for which each would have collected a mere £1,400 if these numbers had happened to be drawn. However, as can be seen in Table 6, the probability of six adjacent numbers being drawn is infinitesimal, and there is the added problem of choosing the right combination from the 44 that are possible.

'Flexible attribution' — The introduction of the 'lucky dip' facility in March 1996, whereby random combinations of numbers are generated for the players, appears to have had little effect on the distribution of prize monies. Within the first year of its availability there were seven roll-overs (one from a mid-week draw), and seven draws when the jackpot was shared by 10 or more winners (including 18 winners of a mid-week draw, when two or three might be expected by chance). Around 12 per cent of ticket sales currently come from 'lucky dips' (Camelot, 1997), suggesting that most of the 40 per cent of players who choose different combinations of numbers each week are reluctant to alter the strategies they use. Our preliminary research intimates that a great number of those who say they choose numbers randomly still prefer to make their own selections, because they desire to have some sort of control over the event, or they believe more satisfaction would be gained by the knowledge that they had chosen the numbers, should they win. Others feel that the outcome should not be left to chance alone and an element of personal luck should also be included. Such players would be reluctant to hand over their *active* part to an external power, even if it did appear to be the rational action to take.

Those who choose Lottery numbers randomly may feel they are more rational than those who try to exercise control over the outcome of the National Lottery draw by choosing *lucky numbers*, or by using some other equally superstitious practice. However, at the end of the day their chances of winning are no better than those of the other 30 million people who regularly buy tickets, although should these players happen to win they would stand a chance of sharing a jackpot prize with fewer people, providing there is no misunderstanding regarding the concept of randomness and they *succeed* in selecting actual random combinations of numbers.

The fact that people usually lose does not seem to deter them. Gaboury *et al.* (1989) claim most people know that all types of lotteries have negative expected value, but they want to win and so keep on buying the tickets. According to Cornish (1978), they persist if they are comfortable with the form of gambling, if they feel competitive and involved, and believe play is associated with skill.

'Illusion of control' — Because players can choose their own numbers, some of which are their lucky numbers, many possibly believe they have some sort of control over the outcome, and as a consequence may feel more confident that they will one day win. With the creation of an 'illusion of control', they then fail to act in accordance with their knowledge of the chances of winning, treating chance events as if under personal control (Langer, 1975). Perceived control acts to make the game more attractive, with players believing they are able to select the numbers that can win, even though the control is not real, as the outcome is pure chance (Walker, 1992).



The structure of the game could account for continued play in the face of negative outcomes. To choose correctly two of the numbers drawn, or to choose combinations of numbers similar to those drawn, implies a *near miss*, which may encourage the player by suggesting success is within their reach, and act at a 'low cognitive level' to produce some of the excitement that will normally be experienced for a win (Griffiths, 1991; Reid, 1986).

'Sunk cost bias' — Continued participation, in the absence of reinforcement through winning, could also be due to the 'sunk cost bias'. The effect is a tendency to continue a project once money, time and effort has been invested (Arkes & Blumer, 1985). The higher the sunk cost incurred, the more likely people are to continue investing and to inflate their estimations of success.

As many as 60 per cent of players are believed to choose the same numbers each week. Each draw means the player is more committed to *their* numbers. In a situation analogous with 'sunk cost bias', they are 'entrapped' and become even more so as the weeks go by (Brockner & Rubin, 1985), for to miss a week, or to decide to change your numbers is risky because it might mean missing a big win.

The recent launch of the mid-week National Lottery draw to boost falling sales, will have increased the power of *sunk cost bias* and *entrapment* in players who are convinced they will one day win, and those who believe they possess 'knowledge of the lucky properties of numbers' (Walker, 1992). As a result of the new draw, Saturday on-line sales have fallen slightly (now about £62 million), possibly because some players are apportioning their stake money. Wednesday sales account for approximately one third of total weekly ticket sales (Camelot, 1997), suggesting many players are buying tickets for both draws in order to double their chances of winning a share of a jackpot prize. However our preliminary results indicate that many of those who use the same numbers each week are doubling their initial outlay because they are reluctant, or even afraid, to miss any draw where their selection might be a possible jack-

Combination	Expected probability for each draw	Expected mean occurrence time	Actual mean occurrence time
Pair (not three)	0.4474	1 per 2.2 weeks	1 per 2.2 weeks
Triple (not four)	0.0446	1 per 22.4 weeks	1 per 23.2 weeks
Quad (not five)	0.00298	1 per 6.5 years	-
Five (not six)	0.000135	1 per 142 years	-
Six	3×10^{-7}	1 per 6,000 years	-

(Expected probabilities and expected means taken from Haigh, 1995, *Bulletin of the IMA*, **31**, 132-136. Actual means from Eileen Hill's own analysis of drawn numbers.)

Table 6: The expected probabilities of adjacent numbers being drawn in combinations of six numbers, and their occurrence in the first 116 weeks (before the introduction of the mid-week draw)

pot winner. The likelihood that many feel forced to double their initial outlay, and the prospect of many more roll-overs because fewer tickets are bought mid-week, should ensure the continuing success of the National Lottery.

In psychology, a belief in *human rationality* often forms the basis on which people's decisions and choices are predicted and explained. Therefore to continue with the Lottery, an activity with a negative expected value, implies that the majority of people in the UK are in some ways irrational thinkers. Cognitive psychologists (e.g. Griffiths, 1997; Wagenaar, 1988; Walker, 1992) would agree that irrational or biased thinking plays a major part in maintaining the gambling behaviour, but would

Many do not view the lottery as random

also suggest that the desire to win the jackpot and become a millionaire overnight is likely to be the most powerful motive for playing the Lottery.

Uncovering the false beliefs that lie behind the mistakes people make when becoming involved in a risk situation will assist in reducing the irrational thinking of a potential gambler (Griffiths, 1990; Walker, 1992). The gambler can then enjoy a 'flutter', aware that there is only a slight chance of a win, but more importantly without becoming committed to wagering unreasonable amounts on a regular basis.

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