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Arousal, erroneous verbalizations and the illusion of control during a computer-generated gambling task

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Arousal theories and cognitive theories have been proposed as explanations for both low- and high-frequency gambling. Fifty-four participants were presented with a computer-based gambling task in order to examine the relationship between arousal, erroneous verbalizations and the illusion of control. Participants either won mainly at the start, at the end or randomly throughout the task. Predictions of long- and short-term future success were elicited together with arousal levels and verbalizations throughout the task. The results provide support for the importance of the illusion of control applied to gambling tasks, although these effects only occurred with long-term forecasts. No significant relationships between types of verbalizations and arousal were found, although the task was significantly arousing. Furthermore, no relationships between illusion of control measures and either arousal levels or types of verbalizations were found. Additionally, no differences on any measures were found comparing gambling participants who chase and gamble versus those who do not gamble and/or do not chase. These results are discussed in relation to the explanation of both low- and high-frequency gambling.

Participation in gambling activities is almost universal and involves the majority of the population in the Western world (Walker, 1992). Such participation appears to be anomalous; most forms of gambling are associated with a mean expected financial loss over time, hence the 'rational' organism should not gamble in the first place. Traditionally, theories based on individual differences have been invoked as explanations of gambling behaviour, but as Wagenaar (1988) has noted, these theories seem misplaced given that the majority of people gamble. Two other plausible candidate explanations are arousal theories and cognitive theories. The former brand of theory assumes that the primary motivation for participation is the excitement gambling engenders. Cognitive theories by contrast maintain that financial reward is the primary motivation for gambling, and that gamblers and non-gamblers alike apply heuristics and biases to tasks where these modes of decision making are inappropriate. This paper aims to tease apart the relative merits of these

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theories, and to examine the relationships between arousal, verbalizations while gambling and the illusion of control during a computer-based gambling task. In particular, the paper will focus on the claim that arousal and cognition are linked in gambling (Coulombe, Ladouceur, Desharnais & Jobin, 1992).

Gambling and excitement

Arousal theories have proposed that the reason for gambling lies in the subjective and objective excitement the activity offers. Recently a number of studies have shown that gambling is associated with arousal increases across a range of forms (Anderson & Brown, 1984; Coventry & Norman, 1997; Griffiths, 1993; Leary & Dickerson, 1985). However, despite these findings, two issues remain. The first is that not all forms of gambling are exciting, although people still play. The second is that arousal theories cannot explain why some people continue to play in the face of systematic losses while others stop.

Dickerson (1993) notes that impaired control in gambling must be examined on a form-by-form basis. While arousal increases may be evident in some forms of gambling (e.g. roulette) reports of arousal increases in forms such as fruit machine play have been equivocal (e.g. Dickerson, 1993; Coulombe *et al.*, 1992). It is likely that computer games are even less arousing, although they have addictive potential (Brown, 1996).

In gambling forms which are associated with significant increases in arousal over baselines, arousal theories have difficulty explaining why some people turn into high-frequency gamblers while others stop or continue to gamble at lesser levels.[1] It has been argued that high-frequency gamblers become more aroused during gambling than low-frequency gamblers (Brown, 1986; Dickerson & Adcock, 1987), but the evidence for this hypothesis is controversial. While Leary & Dickerson (1985) found significantly greater heart rate (HR) increases during poker machine play in high-frequency versus low-frequency players, Coventry & Norman (1997), Dickerson, Hinchy, Legg England, Fabre & Cunningham (1992), Coulombe *et al.* (1992) and Griffiths (1993) did not find any differences between low- and high-frequency gamblers across a range of gambling forms, suggesting that Leary & Dickerson's study is the exception (see Coventry & Norman, 1997, for a methodological discussion).

A second theoretical position on the role of arousal and continued gambling is that of sensation-seeking (Zuckerman, 1979, 1983). Zuckerman originally predicted that gamblers should be high sensation-seekers where sensation-seekers are defined as those with the need for high states of arousal. Furthermore, those who have the greatest need for high states of arousal should be those who persist. However, this hypothesis has received little empirical support (see Coventry & Brown, 1993 for a review).

It would appear that arousal theories on their own do not provide an adequate

[1] This paper follows the model proposed by Dickerson (1993) where gamblers do not cluster into discrete groups (such as 'pathological' gamblers) but rest on a continuum of involvement from non-gamblers through to high-frequency gamblers and those with problems.

theory of gambling persistence and increased involvement. However, in tandem with cognitive explanations it has been claimed that arousal does play an important role (Coulombe *et al.*, 1992). This explanation will be considered after an examination of cognitive theories on their own.

Cognitive approaches to gambling explanation and the illusion of control

Cognitive approaches to gambling assume that gamblers are 'motivated by a way of reasoning, not by defects of personality, education or social environment' (Wagenaar, 1988, p. 3). Originally, Kahneman, Slovic & Tversky (1982), and Hogarth (1981) catalogued 38 heuristics and biases which illustrate the reasoning processes people use across a range of everyday situations. While these modes of reasoning work quite well in most situations, Wagenaar (1988) notes that 'epistemic reasoning does not work when outcomes are controlled by randomising devices' (p. 117).

Of all the heuristic and biases, the illusion of control offers one of the most direct applications to gambling tasks. Originally investigated by Ellen Langer (summarized in Langer, 1983), the illusion of control is defined as 'an expectancy of a personal success inappropriately higher than the objective probability would warrant'. In a classic study, Langer & Roth (1975) manipulated the sequence of wins and losses that participants experienced on a coin-tossing task. While all participants experienced 15 wins and 15 losses over 30 trials (thus winning a chance number of times), participants either won predominantly at the beginning of the trials (descending condition), predominantly at the end (ascending condition) or evenly throughout the 30 trials (random condition).

Langer & Roth found that those in the descending condition rated themselves as more skilful, remembered more wins and thought that over future trials they would be more successful than those in the other two conditions. There was also an effect of an actor–observer manipulation; those participating thought that they would do better than those observing but not participating directly. Finally, participants believed that practice and distraction would influence performance on the task, again, mostly in the descending condition. These effects have been replicated in a number of laboratories using gambling tasks (Ladouceur, Tourigny & Mayrand, 1985; Reid, 1986; Wolfgang, Zenker & Viscusi, 1984), and the importance of early wins as a precursor to problem gambling in the field is widely recognized (Custer & Milt, 1985; Moran, 1970; Shubin, 1977).

While the application of normal reasoning principles to gambling may have validity in the explanation of normal gambling, the approach fairs no better than arousal theories as to why only some people develop high levels of gambling behaviour. It could be that those who continue despite systematic losses are more dependent on particular heuristics and biases than others, or are more happy to switch heuristic in the face of losses. Alternatively, as Coulombe *et al.* (1992) have argued, there may be an important relationship between erroneous perceptions and arousal which is the key to the explanation of persistence and increased frequency of play.

Erroneous perceptions and arousal during gambling

Aside from behavioural data from the heuristics and biases literature, the verbalizations produced by participants during gambling have been cited as evidence for the importance of cognitive explanations. Using a version of protocol analysis, Coulombe *et al.* (1992), Gaboury & Ladouceur (1989), Gaboury, Ladouceur, Beauvais, Marchand & Martineau (1988), Griffiths (1994), Ladouceur & Gaboury (1988), Ladouceur, Gaboury, Dumont & Rochette (1988) and Walker (1992) all provide evidence of erroneous perceptions across a variety of gambling forms. In the 'think-aloud' method, gamblers are trained to speak as they process during a task. The subsequent verbalizations (transcribed and coded) have produced estimates of the percentages of erroneous beliefs ranging from 14 per cent for regular gamblers to 2.5 per cent for non-regular gamblers on fruit machines (Griffiths, 1994) and to 87 per cent for a group of roulette players (Ladouceur & Gaboury, 1988).

Using this method Coulombe *et al.* (1992) also recorded arousal during poker machine play (using HR as the measure). Not only do high-frequency gamblers appear to produce more erroneous verbalizations than low-frequency gamblers, but Coulombe *et al.* (1992) report a significant correlation between arousal and the number of erroneous perceptions in the high frequency group, which they interpret as evidence for an important relationship between arousal and cognition.

While this study appears to provide the first link between arousal and cognition during gambling, a number of problems need to be addressed. To begin with, one can question whether the verbal 'irrational' strategies produced by gamblers are revealing about the beliefs and strategies the gambler employs. Coulombe *et al.* coded verbalizations into those that are rational and those that are not (as was the case in the other studies cited above). Some of these so-called 'irrational' verbalizations may well be commentaries in terms of what has happened, rather than real beliefs about the task. If a tennis player swears at his/her tennis racquet after a bad shot, it does not follow that the he/she believes that the racquet caused the bad shot. Instead, the player is apportioning blame in a convenient way at the time. It must be remembered that protocol analysis, as originally criticized by Nisbet & Wilson (1977) and supported as a method by Ericcson & Simon (1984), is only reliable on tasks where verbalizations occur *during* the problem-solving process. By its very nature, most of the verbalizations that are classed as irrational in gambling are produced after decisions are made, and the results of those decisions are known. Clearly, a better coding scheme needs to be adopted to avoid these problems, and such a scheme was devised in the study to be reported below.

The finding that more erroneous verbalizations are produced by high-frequency versus low-frequency gamblers needs to be examined in this context. One might expect that gamblers used to playing gambling tasks need to use less attentional resources playing than those who are less familiar with such tasks. Consequently, the practised players will be able to allocate more resources to talking about the task. It is also likely that the verbalizations produced by occasional players would be about the task itself as they are less familiar with it. In light of these likely possibilities, the results of these studies look rather different, and the results of Griffith's (1994) study support this interpretation. Regular gamblers produced more percentage verbalizations in only two categories as compared with non-regular players; personifying the machine and referring to the number system. By contrast, non-regular players produced significantly more percentage verbalizations relating to statements and questions of confusion and non-understanding, and miscellaneous utterances.

The claim of a link between arousal and the number of erroneous verbalizations in the high-frequency gambler group is also problematic. Although heart rate can be a useful measure of arousal (see Coventry & Norman, 1997), Fahrenberg, Foerster & Wilmers (1993) report significant increases in heart rate as a function of free speech. It is likely that those who speak most on a task will be those with the greatest arousal increases. Hence, the association between the number of erroneous perceptions and arousal is likely to be confounded as a consequence. An examination of the ratio of erroneous to non-erroneous perceptions is a more appropriate measure to adopt for this reason.

Given the objections to the methods and conclusions reached in the relevant studies, the present study aims to address these issues using an improved methodology. If erroneous perceptions are more frequent in high frequency gamblers, then this may be a result of the early experiences those gamblers have had on the task. Therefore, it may be the case that the manipulation of order of wins (the illusion of control) may lead to an increase in the ratio of irrational to rational verbalizations as a function of where the wins occur. In addition, if cognitive variables and arousal are linked, one might expect to find significant associations between order of wins and arousal as well as arousal and ratio of rational to irrational verbalizations. The present experiment tests these hypotheses while correcting the problems with categorization of verbalizations used in previous studies.

Method

Participants

Participants were 54 undergraduate students from the University of Plymouth (27 males and 27 females) recruited through advertisements placed around campus. They were distributed equally to three conditions, with nine males and nine females in each condition. Participants were paid a small fee for their participation.

Design and materials

The experiment employed a between-subjects design consisting of ascending, random and descending conditions. In the ascending condition, participants won mainly towards the end of the task. In the random condition, participants won randomly throughout. In the descending condition, participants won mainly at the start of the task (in fact this was the mirror image of the ascending condition sequence). The order of wins and losses by condition is illustrated in Fig. 1.

The task used was a computer-generated gambling task called the 'turtle task'. The screen displayed four coloured turtles placed equidistant in the middle of a large circle. On each trial participants had to predict which turtle they thought would leave the circle first. After selecting a turtle (by depressing the relevant key, labelled by colour of turtle), the race would start with the turtles moving around the screen. When the participant won, their chosen turtle would leave the circle first, and the text message 'You have won!' appeared in large letters across the screen. When the participant lost, the message 'You have lost' appeared in the same fashion.

Descending condition

WWLLWLWLLWWLWLLWLLLLLLLLLLLLLLL

Ascending condition

LLLLLLLLLLLLLLLWLLWLWWLLWLWLLWW

Random condition

LLWLLLWLLLWLLWLLLLWLLLWLLLWLLWLL

Figure 1. Sequences of wins and losses used in the experiment.

In order to elicit natural behaviours from participants during the task, the experiment was presented using the cover of a psychokinesis task where participants were instructed that they had to influence the outcome of the race where possible without making physical contact with the machine. The psychokinesis cover was used so that participants would not realize that the focus of the study was the manipulation of wins and losses. Additionally, pilot work using the task indicated that participants found it very involving—a feature that has been missing from many laboratory based studies (see Anderson & Brown, 1984 and Ladouceur, Gaboury, Bujold, Lachance & Tremblay, 1991 for a discussion).

In order to encourage verbalizations during the task, participants were instructed to give a confidence rating on each trial (expressing the likelihood on a 100-point scale that the next trial would be a win, where 0 = 'certain I'll lose' and 100 = 'certain I'll win'), and to say which turtle they had chosen on each trial.

At the end of the task all participants were asked to complete a questionnaire consisting of the Sensation-seeking Scale (Form V; Zuckerman, 1979), a question on chasing during gambling ('If you are losing do you increase your bet size to win back your losses?') and questions relating to gambling frequency and involvement (adapted from Coventry & Brown, 1993).

Before and during the task HR was monitored continuously using a small ambulatory HR monitor (TYPE TP-200). This monitor employed a photo-plethysmograph clipped to each participant's earlobe, and provided a beat-to-beat output display. Artifactual readings were indicated (via a red error signal) as those outside the upper and lower HR limits. In particular, errors are produced as a result of sudden movements and changes in light. A movement baseline was established prior to commencing the task by getting participants to press the computer keys for a period of three minutes. The monitor display was video-recorded for later analyses.

Procedure

Participants were tested individually in a sound-proof darkened room in order to help concentration and to keep the cover of a psychokinesis experiment plausible. Participants were seated in front of the computer and given a set of instructions informing them that the study was designed to examine psychokinetic ability and prediction on a computer task. Participants were given a general induction about psychokinesis (including a question tapping their belief in psychokinesis), followed by instructions about the task.

The specific instructions focused on a description of the task and implementation of the 'think-aloud' method. The training procedure used (adapted from Ladouceur *et al.* 1988 and Griffiths 1994) was as follows:

> Say everything that comes to mind at any point. Do not censor any of the thoughts that you have even if they appear irrelevant or trivial to you. Do not try to justify any of your thoughts. Keep talking continuously, even if you feel like you are rambling. Don't worry about speaking in complete sentences; it doesn't matter. Speak clearly.

Participants were instructed to give a confidence rating and predicted winner (by colour) just before the start of each race. The scale for giving confidence ratings and a note reminding participants to verbalize the colour of each turtle chosen were displayed in front of participants at all times. Of course, participants were instructed which coloured keys to press in order to choose their predicted winning colour of turtle.

Before starting the task, the HR (movement) baseline was taken for a period of three minutes while participants pressed computer keys. All HR readings were recorded (together with events on screen) by a video-camera placed behind participants. Participants could not see the HR readings during the experiment, and were told that the video-camera was there to record any psychokinetic events should they occur.

After the 32 trials participants were again asked the question regarding belief in psychokinesis. In addition they were asked the following: (*a*) How many trials do you think there have been? (*b*) How many trials do you think you won? (*c*) How many trials do you think you will win out of the next 100? (*d*) How good do you think you are at predicting these outcomes? (*e*) Do you think you would improve with practice? (*f*) Imagine you are trying to watch your favourite TV programme at the same time as completing this experiment. How many trials do you think you would win out of the next 100? (*g*) Imagine you are watching your friend complete this experiment. How many trials do you think they would win out of the next 100? (*h*) How keen are you to continue with the experiment?

After all participants were run, arousal levels during the decision-making phase, the start of the race and the end of the race together with all speech produced were transcribed and time-coded from the videotape of each session.

The transcribed verbalizations were parsed into propositions by a rater and were then categorized according to a piloted coding scheme which is a development of the schemes used previously by Ladouceur *et al.* (1988) and Griffiths (1994). The scheme was developed through systematic analysis of the types of verbalizations produced in these previous studies with a view to isolating the verbalizations which are clearly associated with a misunderstanding of influences of outcomes on the task. Importantly, the coding scheme developed was more discerning than those used previously in relation to the identification of 'irrational' perceptions as discussed above. 'Irrational' verbalizations were defined as those that demonstrated a lack of understanding of probability theory. For example, 'I haven't won for a while, so I must be about to win' is an example of this. 'Rational' verbalizations by contrast were those that did reflect an understanding of probability theory, such as 'It doesn't matter whether I have just won or lost—the task is still chance'. The 'other' category included verbalizations regarded as 'irrational' in previous work such as 'This machine doesn't like me', as well as verbalizations with nothing to do with probability theory such as 'I'm getting tired doing this task'. In order to further facilitate the interpretation of verbalizations, a time-frame scheme was also used partitioning verbalizations into those that have to do with future events, those that refer to past events and those that don't obviously refer to past or future events (atemporal verbalizations).

Once the first rater had used the scheme (i.e. the nine categories) to categorize the verbalizations, a second blind rater was given 20 per cent of the verbalizations to categorize. Of these verbalizations, the independent raters categorized 87 per cent identically. This figure indicated that the scheme is reliable and consistent, and therefore the scheme was retained in the subsequent analyses.

Results

Arousal and sensation seeking analyses

Preliminary analysis was performed on the HR data to establish whether the task was physiologically exciting for participants. A three-way analysis of variance was performed on condition (descending, ascending or random), gender and period of measurement (HR during baseline, while making a decision on which turtle to bet, at the start of the race or at the end of the race). No main effects of condition ($F(2, 48) = 1.51, p > .05$) or gender ($F(1, 48) = 0.88, p > .05$) were found. The effect of period was marginal ($F(3, 144) = 2.59, p = .05$). The mean HR for the baseline was

80.8 compared with 83.5 for HR while deciding what to bet on, 83.0 at the start of the race and 83.1 at the end of the race. Least significant difference planned comparisons revealed that the baseline HR was significantly lower than HR during any of the other periods ($p < .05$). There were no significant differences between the other periods. Additionally, none of the interactions approached significance.

Given that the task was exciting, further analysis of HR throughout the task was undertaken to see whether the increases were sustained throughout the task or relatively short-lived at periods during the task. A three-way analysis of variance on condition, gender, trial (1–32) and period during the task (making decision, start and end of race) did indeed reveal a main effect of trial position ($F(31, 1488) = 15.51$, $p < .0001$). Follow-up analysis (using Tukey tests) revealed that the first few trials were significantly more arousing than later trials. In fact, arousal levels started off at a relatively high level and tailed off quite rapidly after the first few trials. None of the other effects or interactions were significant.

Arousal levels after winning and after losing were compared within-subjects by condition and gender using a three-way mixed analysis of variance. No main effects for condition or gender were found. There was a main effect of winning versus losing on arousal ($F(1, 48) = 10.82, p < .01$). The mean HR after a win was 84.52 compared with 83.13 after a loss. The only significant interaction between variables was between condition and winning and losing ($F(2, 48) = 38.40, p < .0001$). Follow-up analysis using Tukey (HSD) tests revealed that winning was significantly more arousing than losing in the random condition, and significantly less arousing in the descending condition. No significant difference was apparent in the ascending condition.

The sensation-seeking data are similar to those observed in previous studies (e.g. Coventry & Brown, 1993), and are therefore not reported here. However, no significant correlations were found between sensation-seeking (total or subscales) and arousal experienced during the task.

The importance of chasing as a variable associated with high levels of gambling is highlighted in this study with significant correlations between chasing, gambling, hours spent gambling and number of gambling forms participated in.

Illusion of control data

The measures previously used by Langer & Roth were analysed individually using a series of two-way ANOVAS for each measure by condition and gender. Main effects for condition were found for predictions of future success over the next 100 trials ($F(2, 48) = 9.81, p < .001$), the ratio of trials participants thought they had won ($F(2, 48) = 9.10$, $p < .001$), how good participants thought they were at predicting outcomes ($F(2, 48) = 5.02$, $p < .05$), how good they thought they were when distracted ($F(2, 48) = 11.46$, $p < .0001$), and how well participants thought a friend would do on the task ($F(2, 48) = 6.63, p < .01$). In each case, follow-up analysis using Tukey (HSD) tests revealed that the figures for the descending condition were always significantly higher than those for the ascending condition and significantly higher than the random condition in most cases. In every case the descending figures represented overestimates (higher than the probability of the task would warrant).

None of the interactions between variables were significant, and the only other main effect present was for gender with the ratio of trials participants thought they had won ($F(2,48) = 4.80$, $p < .05$). Women thought they had won a significantly higher proportion of trials (0.31) than men (0.25).

The analysis for whether participants thought they would improve with practice produced no significant effects of condition or gender on this variable.

The analysis for how keen participants were to continue with the task produced no main effects of condition or gender, but the interaction between condition and gender was significant ($F(2,48) = 3.30$, $p < .05$). This is displayed in Fig. 2. Women are more keen to continue than men in the ascending condition, less keen in the random condition and no different in keenness in the descending condition.

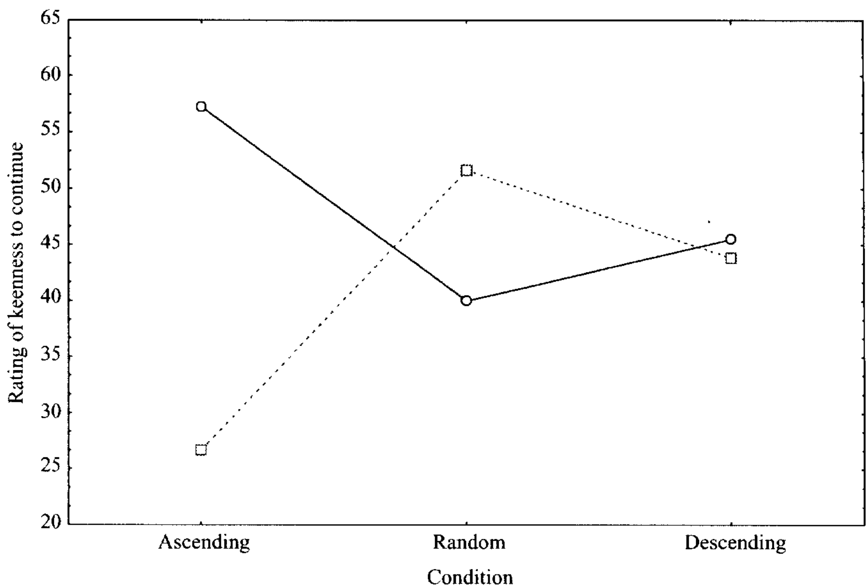

Figure 2. Keenness to continue by gender and condition. Female, —O—; male, ---□---.

Confidence ratings after 32 trials (i.e. on the 33rd trial) were analysed by condition and gender. A two-way ANOVA revealed no main effect of condition or gender. There was a significant interaction between condition and gender ($F(2,45) = 3.28$, $p < .05$). This interaction is displayed in Fig. 3. Women are more confident than men in the ascending condition, less confident in the random condition and no different in confidence in the descending condition.

Confidence ratings throughout the task were analysed using a three-way ANOVA (condition × gender × trial position). No main effects were found for condition, gender or trial position. However, the interaction between condition and trial position was significant ($F(62,744) = 1.48$, $p < .05$). Figure 4 displays the average confidence ratings for each block of eight trials. Clearly, confidence ratings are highest during the first block in the descending condition and fall off towards the end,

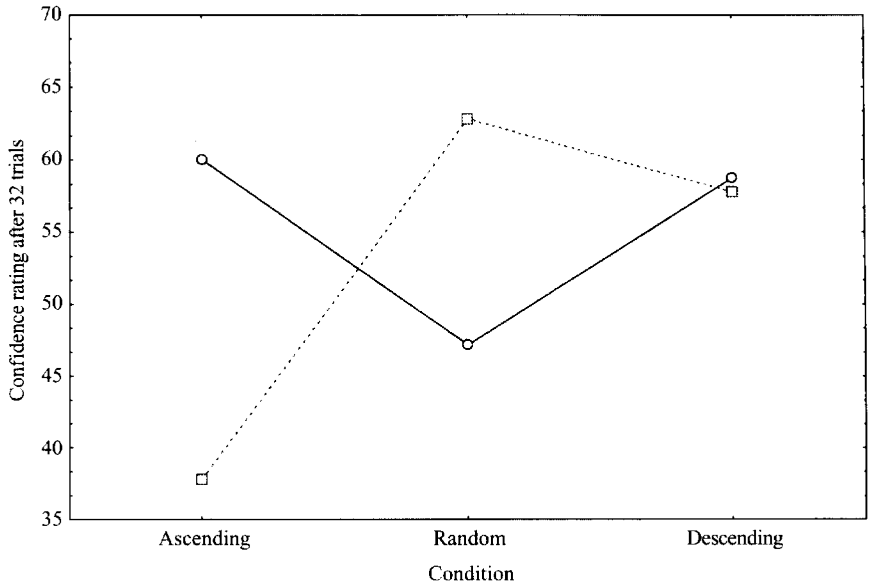

Figure 3. Confidence rating on trial 33 by gender and condition. Female, —○—; male ---□---.

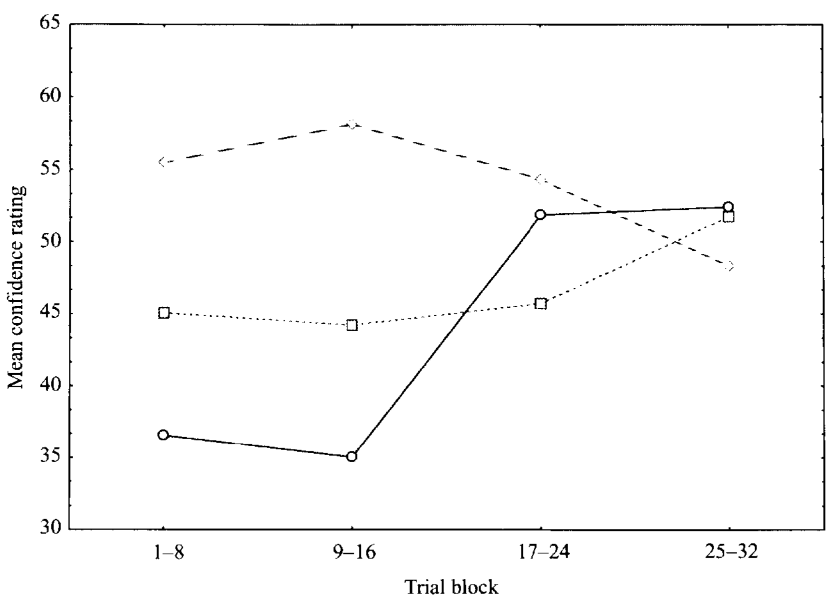

Figure 4. Interaction between trial block and condition. Ascending, —○—; random ---□---; descending --- ◇ --- .

whereas the opposite appears to be the case in the ascending condition. The random condition is in the middle, although a small but steady increase in confidence throughout the task is still present.

Confidence ratings on trials after wins and losses were compared between conditions during periods when both wins and losses were experienced. In the case of the descending condition, the first 16 trials were taken (where eight wins and eight losses occur) rather than all 32, given that long runs of losses may have the effect of reducing confidence levels. Similarly, in the ascending condition the last 16 trials were examined. In the case of the random condition, trials before and after a win were taken in order to calculate the confidence ratings for wins and losses. A two-way ANOVA revealed a main effect of winning versus losing on confidence rating on the next trial ($F(1, 40) = 4.53$, $p < .05$). The mean confidence rating after a win was 55.23 as compared with 52.55 after a loss. There was no effect of condition or interaction between condition and winning/losing.

The confidence ratings across a block of losses in the ascending and descending conditions were examined. In the ascending condition, the run of 16 losses occurred at the start of the task, and in the descending condition the run of 16 losses occurred after eight wins and eight losses. An independent t test revealed that the mean confidence rating during the run of losses was indeed different between conditions ($t(21) = 2.22$, $p < .05$). The mean for the ascending condition was 38.32 and the mean for the descending condition was 50.95.

Erroneous verbalizations

The verbalizations produced by participants were transcribed and coded according to the scheme described above. Initially a four-way ANOVA was performed on the data (condition × gender × type of verbalization × time-frame of verbalization). No main effects were found for condition and gender. However, there were significant main effects for both type of verbalization ($F(2, 96) = 37.05$, $p < .0001$) and time-frame of verbalization ($F(2, 96) = 19.95$, $p < .0001$).

Turning to the types of verbalizations first, the majority produced were in the 'other' category (mean $N = 9.4$), compared with a mean number of irrational verbalizations of 3.3 and 0.3 for rational verbalizations. Follow-up analyses using Tukey (HSD) tests revealed that all three types differed significantly from one another.

In relation to time-frame of verbalization, significantly more atemporal verbalizations (mean $N = 7.2$) were produced than either past (mean $N = 4.6$) or future (mean $N = 1.1$) verbalizations (again using Tukey tests). The difference between past and future verbalizations was also significant.

The only significant interaction in the analysis was between type and time-frame of verbalization ($F(4, 192) = 14.85$, $p < .0001$). This is displayed in Table 1. Follow-up analysis using Tukey tests revealed that there were significant differences between all levels of time-frame for the 'other' verbalization type. The majority of verbalizations in the other category were atemporal.

Levels of gambling and measures

As in previous studies, chasing was used as a means to partition participants into high- and low-frequency gamblers as chasing is significantly correlated with time spent gambling in the present study and has been associated as a characteristic of

Table 1. Mean number of verbalizations produced by category

	Past	Atemporal	Future	Grand mean
Rational	0.11	0.48	0.04	0.21
Irrational	3.52	4.02	2.46	3.33
Other	10.17	17.19	0.87	9.41
Grand mean	4.60	7.23	1.12	4.32

Table 2. Pearson product-moment correlations between arousal, confidence rating, type of verbalization and illusion of control measures

Variable	Next 100 trials estimate	Ratio won	How good ?	No. irrat. verbs.	No. rat. verbs.	No. other verbs.	Mean HR
Ratio won	.61***						
How good?	.21	.35*					
No. irrational verbs	.08	.04	.00				
No. rational verbs	−.06	−.06	.03	.60***			
No. other verbs	.28	.20	.14	.22	−.05		
Mean HR	.18	.32	.05	.15	.00	.18	
Mean conf.	.30	.04	.05	.26	.13	.05	−.03

*$p < .05$; **$p < .01$; ***$p < .001$.

problem gambling in previous studies and existing diagnostic tools (Coventry & Brown, 1993; Coventry & Norman, 1997; Dickerson, 1993; Lesieur & Bloom, 1987). Partitioning produced 14 participants who chased and 40 who didn't. These participants were compared on arousal experienced during the task, numbers of types of verbalizations produced and illusion of control data.

A three-way ANOVA on arousal levels (chasing × trial position × period) revealed no main effect of chasing ($F(1,52) = 0.37$, $p > .05$), or interactions between chasing and trial and period. Similarly, no interaction was found between chasing and HR after wins versus losses ($F(1,52) = 0.05$, $p > .05$).

A two-way ANOVA on confidence ratings throughout the task produced no differences in chasing/no chasing groups in average confidence levels throughout the task ($F(1,28) = 0.01$, $p > .05$), or interaction between chasing and trial. Similarly, no interaction was found between chasing and confidence ratings after wins versus losses ($F(1,41) = 0.11$, $p > .05$).

Turning to illusion of control questions at the end of the 32 trials, independent t tests were performed comparing chasing versus no chasing groups on each measure. None of the differences between groups approached significance.

A three-way ANOVA was performed on the numbers of types or time of erroneous perceptions for those who chase and do not chase. No main effect of chasing was found ($F(1, 52) = 0.06, p > .05$), and chasing did not interact with either of the other variables.

Relationship between variables

Correlations were initially performed in order to examine the relationship between arousal, erroneous verbalizations and confidence ratings/illusion of control measures. Although different measures of the illusion of control correlated significantly with one another, and arousal at different points correlated with one another (as one would expect), no significant correlations were found between any of the three variable sets (see Table 2). To examine the case that arousal and erroneous perceptions may only be linked in those who gamble more frequently, correlations were performed between arousal and confidence rating for those who chase and those who do not chase and/or do not gamble separately. The correlation matrix in each case was almost identical to that presented in Table 2. The results therefore fail to support the findings of Coulombe *et al.* (1992).

Discussion

For the first time the experiment examined the relationship between arousal, erroneous verbalizations, and forecasting measures using rigged sequences controlling the position of wins and losses. Although the participants were students, numbers were sufficient to tap participants along a gambling continuum from non-gamblers to high-frequency players, consistent with the framework proposed by Dickerson (1993). Comparisons between partitioned groups will be discussed later.

The task itself did not involve staking money, but did involve the elicitation of confidence ratings throughout the task. Given that there is no reason to believe that confidence ratings and bet size are unrelated (indeed it is likely that they are highly related) the important factor in the study was whether the task was involving for participants. A psychokinesis cover was employed for this purpose, and all participants, after debriefing, acknowledged that they experienced a high level of involvement in the task, and that they didn't realize that the psychokinesis presentation was a cover. Thus, the methodology appeared to be successful in maintaining high levels of involvement. An analysis of the datasets produced by participants supports this view.

An examination of the arousal data during the task revealed that the task was significantly arousing although the HR increases observed were slight. These findings are not inconsistent with the sizes of increase reported by Coulombe *et al.* (1992). Additionally, there was a main effect of winning versus losing on HR levels, consistent with previous findings in the field (Coventry & Norman, 1997). For a task to be involving, winning must be associated with some kind of change in the participant, be it physiological, cognitive, or both. Clearly, arousal levels do change as a function of winning and losing, although this was found to be a feature of all participants, not just those who gamble the most.

No effects of condition on mean HR levels during the task were found, indicating that arousal and order of wins and losses are not linked (although arousal levels after wins and losses did interact with condition). Arousal also did not correlate significantly with sensation-seeking, or any other variables previously associated with gambling behaviour. It would appear that arousal levels are a direct reflection of the immediate events experienced during the task rather than more global characteristics across sequences or individual differences the players bring to the gambling situation. This pattern of findings is identical to those found betting with real money in the field (Coventry & Norman, 1997).

The illusion of control effects observed in this study mirror those originally discovered by Langer & Roth (1975). At the end of the task participants in the descending condition thought they had won a significantly higher proportion of trials than those in the other conditions, and also gave higher estimates of future long-term success as well as how good they thought they were at the task. The estimates in all cases were overestimates in the descending condition and underestimates for the ascending condition. Estimates went down as a function of distraction and participation, again consonant with the results of Langer & Roth. However, the confidence ratings elicited throughout the task reveal a different picture.

Confidence ratings at the end of the task did not differ between conditions, but a significant interaction between condition and trial position was found. This pattern of results suggests that short-term confidence ratings elicited throughout the task appear to be influenced by recent wins.[2] In the descending condition, participants were most confident at the beginning of the task, whereas those in the ascending condition were more confident towards the end. The finding that overall confidence ratings were significantly higher (within-subjects) after a win as compared to after a loss is support for this interpretation. Interestingly, in the random condition confidence levels fluctuated less, but steadily increased throughout the task, supporting the finding that participation itself can lead to increased betting behaviour if one is to equate bet size and confidence levels (Ladouceur, Mayrand & Tourigny, 1987; Ladouceur *et al.*, 1985).

It should be noted that the study produced interactions between gender and condition for the 'keenness to continue' rating at the end of the task and the confidence rating at the end of the task. While men and women behave the same way in the descending condition, they differ when reacting to the random and ascending sequences. While it is premature to draw any conclusions from these findings, future studies need to take gender into account when order effects are being examined.

Turning to the verbalization data, it should be noted that participants found it difficult to produce verbalizations, although they did produce verbalizations throughout the task. The more rigorous categorization scheme (developed for the study) significantly diminished the number of verbalizations in the 'irrational' category compared with previous studies. The majority of verbalizations could be classified as neither 'irrational' or 'rational', although participants still produced significantly more 'irrational' than 'rational' verbalizations. In this sense, even with the more rigorous scheme adopted here, the findings relating to the number of irrational verbalizations reported in previous studies have been replicated, albeit in

[2] It should be noted that the observed difference between short- and long-term estimates may be a function of the fact that confidence levels were elicited throughout the task, whereas long-term estimates were not (see Hogarth & Einhorn, 1992, for a discussion).

significantly reduced numbers. However, no differences in the number of types of verbalizations were found between conditions or by comparing gamblers who chase with those who gamble and do not chase or do not gamble. These results are inconsistent with the results of previous studies, although this is likely to be a consequence of the tightened classification scheme used. In particular, the verbalizations Griffiths (1994) coded as 'personifications', for example, were coded in the 'other' category in this study. If the central phenomenon in continued gambling is the failure of gamblers to apply the principle of independence between events (Ladouceur, Dubé, Giroux, Legendre & Gaudet, 1996), then verbalizations do not pick up this difference comparing gamblers at differing levels of involvement. It may be that the failure to understand the principle of independence between events (of which the illusion of control is an example) maybe a precondition for continued gambling, rather than a route to loss of control. Alternatively, it may be the case that frequent gamblers understand this principle well enough, but that implicit learning takes over in the case of gambling (see below).

Gamblers who chase versus those who do not chase did not differ on any other variables either. Of particular interest were the lack of differences in arousal levels, or any of the illusion of control measures used. Chasing did correlate with other variables related to frequency of gambling, however, which is typical of previous studies (Coventry & Brown, 1993; Coventry & Norman, 1997). An examination of the percentage of types of erroneous verbalizations and arousal in the chasing and no chasing participants produced no correlations in either group, failing to support the finding of Coulombe *et al.* (1992).

By the end of the task, estimates of future likelihood of success differed between conditions, but no significant associations were found between arousal during the task, verbalization type and illusion of control measures. While there were more 'irrational' than 'rational' verbalizations overall, and while the task was significantly arousing, it would appear that the results of sequence manipulations are independent of these two variable sets. Although both confidence and arousal levels were found to be affected by recent wins and losses, there were no significant correlations between the two measures. The implications of this are twofold.

The data suggest that long-term forecasting behaviour is not a function of the explicit verbalizations that are produced during a task, but instead is predicted by the order of wins and losses experienced which appear to be processed at an unconscious level. These data fit with the distinction made by Reber (1989) between implicit and explicit learning. Implicit learning, the key process in gambling, can be defined as the unconscious development of intuitive knowledge about the underlying structure of the complex stimulus environment. The order of wins and losses experienced during the task is one factor influencing this process, and the heuristics and biases already documented in the gambling literature are the consequence of this process (e.g. Wagenaar, 1988). Verbalizations, on the other hand, are available to consciousness, and are therefore likely to be explicit processes acting on the results of implicit processes. The fact that significantly more of the verbalizations in the 'other' category in the present study were direct comments relating to what has just happened rather than comments relating to what will happen in the future supports this view.

Secondly, it follows that a new type of gambler hitherto unrecognized in the gambling literature needs to be acknowledged. This type of gambler is the one who develops into a high-frequency player as a function of perceived early success on the task alone. Thus, continued gambling behaviour may have to do with an implicit decision-making mechanism which verbalizations do not clearly tap. The differences between high and low frequency players, which appear to be in categories such as 'personification of the machine' in previous studies are likely to represent the gambler's response to events that have occurred as a result of the conflict between what gamblers know about the objective odds on gambling forms and implicitly how they make decisions which may be beyond conscious grasp. The existence of this type of gambler does not deny that there may be other types of gambler, and that gamblers cannot be regarded as a homogeneous group (Coventry & Brown, 1993; Dickerson, 1993). However, the data presented here indicate the need for a detailed exploration of the possibility that continued participation on tasks may be a function of experience during the task alone, rather than any differences in arousal, personality or indeed reasoning abilities gamblers bring to the gambling situation.

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