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Neurocognitive Dysfunction in Strategic and Non-Strategic Gamblers

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Abstract

Objective—It has been theorized that there may be subtypes of pathological gambling, particularly in relation to the main type of gambling activities undertaken. Whether or not putative pathological gambling subtypes differ in terms of their clinical and cognitive profiles has received little attention.

Method—Subjects meeting DSM-IV criteria for pathological gambling were grouped into two categories of preferred forms of gambling – strategic (e.g., cards, dice, sports betting, stock market) and non-strategic (e.g., slots, video poker, pull tabs). Groups were compared on clinical characteristics (gambling severity, and time and money spent gambling), psychiatric comorbidity, and neurocognitive tests assessing motor impulsivity and cognitive flexibility.

Results—Seventy-seven subjects were included in this sample (45.5% females; mean age: 42.7±14.9) which consisted of the following groups: strategic (n=22; 28.6%) and non-strategic (n=55; 71.4%). Non-strategic gamblers were significantly more likely to be older, female, and divorced. Money spent gambling did not differ significantly between groups although one measure of gambling severity reflected more severe problems for strategic gamblers. Strategic and non-strategic gamblers did not differ in terms of cognitive function; both groups showed impairments in cognitive flexibility and inhibitory control relative to matched healthy volunteers.

Conclusion—These preliminary results suggest that preferred form of gambling may be associated with specific clinical characteristics but are not associated dissociable in terms of cognitive inflexibility and motor impulsivity.

Keywords

cognition; impulsivity; gambling

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1. Introduction

Epidemiological studies estimate that the prevalence of lifetime pathological gambling among adults in the United States is 0.4–1.5% (Cunningham-Williams et al., 1988; Petry et al., 2005; Shaffer et al., 1999). Gambling activities range from informal games of chance to formalized and legal options (Hodgins et al., 2011). Problems with cognitive functions dependent on fronto-striatal circuitry have been strongly implicated in the pathophysiology of the disorder (Clark, 2010). Knowledge of problems with cognitive functions, and how these may differ between gambling subtypes, may be vital in improving neurobiological models and identifying candidate treatments.

Multiple studies have examined cognitive functions in gamblers across a range of domains (e.g., Goudriaan et al., 2005; Hodgins et al., 2011; Petry, 2005). Goudriaan and colleagues compared decision-making functions between pathological gamblers, alcohol dependent individuals, Tourette's syndrome, and healthy controls, using several tasks (including the Iowa Gambling Task, IGT) (Goudriaan et al., 2005). Pathological gamblers showed a range of deficits on the tasks versus healthy controls, as did alcohol dependent individuals, with individuals with Tourette's syndrome being relatively free of cognitive problems. Elsewhere, deficits on response inhibition performance (i.e. increased motor impulsivity) have been reported in pathological gamblers (Fuentes et al., 2006; Goudriaan et al., 2006; Kertzman et al., 2008; Odlaug et al., 2011a). Studies examining cognitive flexibility have been mixed, with most studies reporting deficits on the Wisconsin Card Sorting Test (WCST) or the Intra-dimensional/extra-dimensional (IDED) in pathological gamblers (Forbush et al., 2008; Goudriaan et al., 2006; Marazziti et al., 2008) and a minority showing no deficits (Cavendini et al., 2001) in terms of cognitive flexibility.

Gambling activities have historically been divided into two groups: strategic and non-strategic. Non-strategic games involve little or no decision making or skill, and gamblers cannot influence the outcome of the game (e.g., slot machines, pull tabs, bingo, and keno). By contrast, strategic games allow gamblers to attempt to use knowledge of the game to influence or predict the outcome (e.g., poker, blackjack, dog and horse racing, sports betting, and craps/dice games) (Odlaug et al., 2011b). Studies examining preferred style of gambling have found that high rates of "action" or arousal-seeking behavior are reasons for men preferring strategic forms while escaping from emotional trauma may underlie the non-strategic preferences of women (Ledgerwood and Petry, 2006; Potenza et al., 2001). Whether or not these putative subtypes differ in terms of cognitive dysfunction, and by implication underlying neural dysfunction, has received little attention. In the Goudriaan et al. (2005) study, a subgroup analysis in the pathological gambling group found that slot machine gamblers performed significantly worse than casino gamblers on the decision-making tasks. Myrseth and colleagues have reported that gamblers preferring skill games or both skill and chance games scored higher in terms of the cognitive distortion of 'illusion of control' compared to gamblers preferring chance games alone (Myrseth et al., 2011). Studies indicate gambling preference may be clinically significant and provide a means of subtyping individuals with pathological gambling (Potenza et al., 2001). The goal of the current study was to significantly expand on the above work by examining clinical and cognitive characteristics (response inhibition and cognitive flexibility) of gamblers based on preference of gambling activity. Understanding cognitive differences in these subgroups of gamblers may allow for more targeted treatments. Two translational computerized neurocognitive paradigms that have been widely utilized elsewhere, the stop-signal test (SST) and intra-dimensional/extra-dimensional (IDED) set-shift test, were used in this sample. Computerized tests such as these offer potential advantages in that the neural and neurochemical substrates have been explored in translational models across species (Chamberlain et al., 2011). These two tests were selected since response inhibition and set-

shifting had not been studied as a function of preferred gambling type, despite past research finding pathological gamblers may have impairments in these two cognitive domains. Based on existing findings for other tasks (Goudriaan et al., 2005), we hypothesised that non-strategic gamblers would show disproportionately greater impairment than strategic gamblers in terms of response inhibition and set-shifting; and that both these groups would be impaired compared to healthy controls.

2. Method

2.1. Subjects

Patient participants included 77 adults aged 18 years meeting current (past-12-months) DSM-IV criteria for pathological gambling using the Structured Clinical Interview for Pathological Gambling (SCI-PG) (Grant et al., 2004). Subjects were enrolled in a clinical research trial investigating the effectiveness of memantine hydrochloride (Grant et al., 2010) or n-acetyl cysteine (in progress) for pathological gambling. Inclusion criteria were a current DSM-IV diagnosis of pathological gambling and the ability to provide written informed consent. Subjects with lifetime psychotic or bipolar disorders were excluded as were subjects with current (past 12-months) substance abuse or dependence. If taking psychotropic medication at the time of screening, subjects were required to have been on a stable dose of medication for at least six-weeks. Current class of psychiatric medication being taken were: Non-strategic (SRI=6; stimulant=1); Strategic (SRI=4).

Healthy controls were recruited using media advertisements in the local community. From this pool of normative data, a sample of age- and gender-matched healthy controls (n=28) was identified by a researcher independent of the current study, in order to provide a comparator for neurocognitive performance in patients. Controls were required to have no current or lifetime DSM-IV Axis I or II psychiatric illness.

The study procedures were carried out in accordance with the Declaration of Helsinki. The Institutional Review Board of the University of Minnesota approved the study and the consent procedures. All assessments were conducted by board certified psychiatrists and psychologists familiar with pathological gambling. After complete description of the study to the participants, voluntary written informed consent was obtained.

2.2. Assessments

At the intake interview, board-certified psychiatrists (JEG, SWK) assessed each subject using the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I; Frist et al., 1995) and the Structured Clinical Interview for Pathological Gambling (SCI-PG), a valid and reliable diagnostic instrument (Grant, 2004). In addition to a psychiatric assessment, a semi-structured rater-administered questionnaire was used to collect detailed information on demographic and clinical features of pathological gambling (e.g., preferred types of gambling, amount of money lost, problems related to gambling). All subjects included in this analysis were drawn from a sample of outpatient individuals responding to an advertisement for “*gamblers seeking treatment*” in Minnesota where multiple types of gambling (i.e., both strategic and non-strategic) are available.

To determine preferred form of gambling, subjects were asked as part of the semi-structured clinical interview, which form of gambling they preferred. Strategic gambling was defined as games (e.g., cards, sports, and dog/horse-race wagering) in which skill or knowledge may have some impact on outcomes (Petty, 2003) and is based upon previous research (Nozer & Blaszczyński, 2006; Potenza et al., 2000; Odlaug et al., 2011b). Other games such as slots, lottery, and pull tabs, require little concentration and no skill. In the case of slot machines, although the choice of machine is made by the user, the choices the gambler makes

thereafter have little to no impact on the outcome of the game. The same holds true in lottery and pull-tab play. Consequently, these are categorized as 'non-strategic' gambling.

Current pathological gambling symptom severity was assessed using multiple valid and reliable measures: The Yale-Brown Obsessive-Compulsive Scale Modified for Pathological Gambling (PG-YBOCS), a clinician-administered scale used to assess symptom severity over the past seven days (Pallanti et al., 2005); the Gambling Symptom Assessment Scale (Kim et al., 2009), a self-report measure of gambling severity for the previous week; and the Clinical Global Impression-Severity scale (Guy, 1976), a 7-item Likert Scale assessing clinical severity.

Subjects' mood and anxiety symptoms were assessed using the Hamilton Depression Rating Scale (HAM-D; Hamilton, 1960) and the Hamilton Anxiety Rating Scale (HAM-A; Hamilton, 1959). Psychosocial functioning was examined with the Sheehan Disability Scale (Sheehan, 1983).

2.3. Cognitive Assessments

Subjects underwent two computerized cognitive paradigms from the Cambridge Neuropsychological Test Automated Battery (CANTABclipse, version 3, Cambridge Cognition Ltd, UK) quantifying aspects of motor impulse control and cognitive flexibility. We focused on these two tests given that dysfunction in the cognitive domains they quantify are potentially dissociable and have been implicated in gambling across multiple studies. Patient testing took place at baseline prior to initiation of any new treatment (placebo or active). Healthy controls were tested in the same environment using the same equipment, and same researchers, as for the patients.

The Stop Signal Task (SST) quantifies the ability of participants to suppress already-initiated motor responses (Aron et al., 2004; Logan et al., 1984). On this task, subjects observe a series of directional arrows (left or right facing) appearing on a computer screen, one at a time. Subjects make quick responses depending on the direction of each arrow - hitting a left button for a left arrow, and vice versa. On a subset of the trials, the computer sounds a 'beep' soon after presentation of the arrow, signalling to the subject that they should try to withhold their response for that particular trial. By varying the time delay between presentation of the directional arrow and the auditory 'stop signal' dynamically, this task calculates the 'stop-signal reaction time', which is a sensitive measure of the time taken for that individual's brain to inhibit a response. Longer stop-signal reaction times represent poorer response inhibition (i.e., greater impulsivity). The other primary outcome measure is the median reaction time on 'go' trials, i.e. the average time taken to make a button response after seeing an arrow that was not associated with the stop-signal tone. Translational research indicates response inhibition as a cognitive function to be dependent on distributed fronto-striatal circuitry particularly the right inferior frontal gyrus (Aron et al. 2004).

The intra-dimensional/extra-dimensional (IDED) set-shift task was derived from the Wisconsin Card Sorting Test of frontal lobe integrity (Lezak et al., 2004). On each trial, subjects observe two stimuli on the computer screen: each is made up of two 'dimensions' (pink blobs and a number of white lines). Through trial and error, subjects attempt to learn an underlying rule about which stimulus is 'correct'. After making a selection of one of the two stimuli by touching it, the computer indicates whether this choice was 'right' or 'wrong'. Eventually, subjects work out the underlying rule governing which stimulus is correct. When learning criterion is obtained, this rule is changed, requiring the volunteer to rethink their strategy and show flexible behaviour in order to work out the new rule. The primary outcome measure is the total number of errors made throughout the task (selection of incorrect stimuli), corrected for stages not attempted. Where there is a main effect of group

on this measure, errors for particular stages of the task can be considered, since it measures dissociable aspects of inhibitory control and flexibility. Reversal learning refers to 'low level' cognitive flexibility, whereby one switches from choosing the stimulus with particular white lines to different white lines; or particular pink blob to different pink blob. Extra-dimensional shifting refers to 'high level' cognitive flexibility when subjects must ignore a previously relevant stimulus dimension and instead shift their attention to a previously irrelevant dimension. Reversal and set-shifting are thought to be dissociable in terms of their neural substrates with the former being more dependent on the orbitofrontal cortices and the latter more dependent on lateral prefrontal cortices (see e.g. Hampshire & Owen, 2006).

2.4. Data analysis

Based on subject self-report of preferred gambling type and previous research (Odlaug et al., 2011b), the subjects were divided into two groups: strategic gamblers (i.e., preferred cards, sports betting, and horse/dog track) and non-strategic gamblers (i.e., preferred slots, lottery, pull-tabs) (Table 2). Group demographic and clinical characteristics, along with cognitive outcome variables were compared using t-tests or chi-squared tests as appropriate. Since the non-strategic gambling group was significantly older ($p<.001$) and more female ($p=.013$) than the strategic gambling group (see below), these two variables were entered as covariates into an analysis comparing cognitive functions between the two clinical groups. We also conducted a follow-up analysis using ANOVA between the strategic gamblers, a subgroup of the non-strategic gamblers matched for age/gender, and matched healthy controls to clarify the existence of any neurocognitive deficits in patients. Selection of age/gender matched individuals for this follow-up analysis was undertaken by a researcher independent of the current paper.

Significance was defined as $p<0.05$ uncorrected.

3. Results

Seventy-seven adults with pathological gambling (45.5% females; mean age = 42.7 ± 14.9) were included and subsequently separated into the following two groups: strategic ($n=22$; 28.6%) and non-strategic ($n=55$; 71.4%). The non-strategic gambling group was significantly older, more likely to be female, and more likely to be divorced, separated, or widowed ($p<0.05$) (Table 1). No significant differences in demographic/clinical features were noted between those taken stable doses of medication at the time of testing versus those free of medication.

In terms of gambling symptoms, strategic gamblers reported significantly earlier age when gambling first became a problem (26.7 compared to 35.9 years; $t\text{-test}=3.081$; $p=0.003$) (Table 3). Strategic gamblers were also significantly more likely to have a lifetime psychiatric disorder other than pathological gambling (95.5% compared to 70.9%; Fisher's exact=.03). Non-strategic gamblers reported significantly greater scores on the PG-YBOCS ($p=.044$), but not on other measures of gambling severity (i.e., money lost gambling, G-SAS, CGI).

There were no differences on measures of motor impulsivity or cognitive flexibility between strategic and non-strategic gamblers (Table 4). In the follow-up analysis versus healthy controls (mean age of 33.1 ± 9.9 years) both strategic and non-strategic gamblers showed deficits in both of these domains (Table 5).

4. Discussion

This study objectively compared clinical characteristics and key aspects of cognition in pathological gamblers based on preferred gambling activity. Our clinical findings that non-strategic gambling was more common among older female gamblers are remarkably consistent with prior research on the topic (Potenza et al., 2006; Tavares et al., 2001). Clinically, the non-strategic group had higher overall scores on the PG-YBOCS, a clinical measure of severity. This may be due to the lower overall betting limit required for non-strategic gambling such as slot machines, allowing the gambler to engage in the behavior for a much longer period of time. From a cognitive perspective, contrary to our hypothesis, the two clinical groups did not differ significantly in terms of motor response inhibition or cognitive flexibility. However, consistent with our other predictions, both groups did show deficits in these domains versus healthy controls, consistent with the majority of the extant literature on cognitive dysfunction in pathological gambling.

Problems with cognitive functions dependent on cortico-subcortical circuitry have long been implicated in pathological gambling (Odlaug et al., 2011a). Behaviors in people with pathological gambling are often repetitive, hard to suppress, and impulsive in that they result in negative long-term outcomes. Furthermore, people with this disorder often have difficulty shifting their thoughts and behavior away from gambling towards other areas of life that may be less damaging (Odlaug et al., 2011a). Therefore, we were particularly interested in two cognitive domains often reported in past literature to be deficient in patients compared with controls: response inhibition and cognitive flexibility. The findings from the current study suggest that while strategic versus non-strategic gamblers differ on certain demographic and clinical characteristics, they share common dysregulation of neural circuitry mediating flexible behaviour and suppression of repetitive responses, counting against the notion of distinct neurobiological involvement and instead supporting common pathways of dysfunction.

4.1. Limitations and future directions

This study has several limitations. It should be noted as a caveat that our categorization approach relied on 'preferred' type of gaming but that many gamblers play a variety of games. There is currently no standard subtyping method for pathological gambling and thus, our subtyping criteria were based on reported gambling preference and whether the subject could potentially influence the outcome of the game through choice or whether the outcome was completely left to chance (as in slot play). Since a treatment-seeking sample was used, it is unclear how generalizable the results are to non-treatment seeking individuals with pathological gambling. Also, it should be noted that although current treatments were listed, we did not have access to historical treatment information, i.e. past treatments received. We only examined a subset of cognitive functions in this preliminary study, in the interest of time constraints in the clinical trials concerned. Future studies should examine whether gambling subtypes differ on other domains examining dissociable fronto-striatal circuitry. Finally, a number of subjects were currently taking psychoactive medications which may influence executive function and confound the neurocognitive assessments. Despite the limitations, the study has multiple strengths, including the use of sensitive neuropsychological testing, a large sample of treatment-seeking pathological gamblers, and the use of both self-report and clinician-administered gambling measures with strong psychometric properties and established norms.

4.2. Conclusion

These preliminary results suggest that the preferred form of gambling may be associated with specific clinical characteristics. There may be a common pathway of cognitive

dysfunction in pathological gamblers as a whole, but that cognitive dysfunction in terms of response inhibition deficits and cognitive inflexibility does not seem to differ based on preferred method of gambling. These results provide useful information for clinicians to improve treatment for pathological gamblers.

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Highlights

- Non-strategic gamblers were significantly older, female, and divorced
- Pathological gamblers had impairments in cognitive flexibility and inhibition
- Cognitive function did not differ between strategic and non-strategic gamblers
- Preferred gambling type might be more related to specific clinical characteristics

Table 1

Demographics of Pathological Gamblers based on Preferred Form of Gambling

Demographic	Strategic (n=22)	Non-Strategic (n=55)	Statistic ^a	df	p-value
Age					
Mean ($\pm$ SD), years	32 (15.1)	47 (12.6)	4.453t	75	<.001
Gender, n (%)					
Female	5 (22.7)	30 (54.5)	f	n/a	0.013
Ethnicity, n (%)					
Caucasian	15 (68.2)	39 (70.9)	f	n/a	0.791
Other	7 (31.8)	16 (29.1)			
Education, n (%)					
High school or less	6 (27.3)	15 (27.3)	0.03c	2	0.985
Some college	10 (45.4)	26 (47.3)			
College degree or more	6 (27.3)	14 (25.4)			
Marital Status, n (%)					
Single	17 (77.3)	24 (43.6)	7.41c	2	0.025
Married	1 (4.5)	11 (20)			
Divorced/Separated/Widow	4 (18.2)	20 (36.4)			
Work Status, n (%)					
Employed	10 (45.4)	32 (58.2)	1.25c	2	0.535
Unemployed	8 (36.4)	17 (30.9)			
Other	4 (18.2)	6 (10.9)			

p-value = two-tailed t-test

Strategic gambling = poker, sports, cards, dice, blackjack, track (horses, dogs)

Non-strategic gambling = slots, lottery, pull tabs, bingo, keno, video poker

^aStatistic: c=Chi-Square; t=t-test; f-Fisher's exact

Table 2

Preferred Form of Gambling

Gambling Type	N (%)
Non-Strategic (n=55)	
Slots	46 (83.6)
Lottery	5 (9.1)
Pull tabs	4 (7.3)
Strategic (n=22)	
Blackjack	11 (50)
Poker	4 (18.2)
Sports betting	4 (18.2)
Horse/dog track	3 (13.6)

Table 3

Clinical Characteristics of Pathological Gamblers based on Preferred Form of Gambling

Clinical Variable	Strategic (n=22)	Non-Strategic (n=55)	Statistic ^a	df	p-value	Effect Size
Amount of money lost to gambling during past year	15,004 (24,548)	17,472 (21,486)	0.414t	63	0.68	
Age when gambling became a problem, yrs	26.7 (12.8)	35.9 (11.4)	3.081t	75	0.003	0.76d
Time lag between started gambling and when it became problematic, yrs	6.7 (7.3)	7.8 (7.2)	0.611t	75	0.543	
Clinical Global Impressions, Severity	4.78 (0.83)	4.61 (0.75)	-0.617t	58	0.54	
PG-YBOCS, total score	18.6 (7.5)	21.7 (5.1)	2.045t	75	0.044	0.48d
Gambling Symptom Assessment Scale, total score	30.1 (7.1)	31.9 (6.8)	0.735t	58	0.465	
Sheehan Disability Scale	15.9 (6.2)	14.2 (8.4)	-0.527t	75	0.602	
Hamilton Depression Scale	8.8 (7.2)	7.2 (4.6)	-1.025t	64	0.309	
Hamilton Anxiety Scale	6.8 (3.3)	6.7 (4.2)	-0.022t	58	0.982	
Any lifetime psychiatric disorder, n (%)	21 (95.5)	39 (70.9)	f	n/a	0.030	
Any lifetime alcohol/substance use disorder, n (%)	10 (45.5)	15 (27.3)	2.37c	1	0.124	

All scores are Mean ($\pm$ SD) unless otherwise indicated

Effect size: d = Cohen

p-value = two-tailed t-test

Strategic gambling = poker, sports, cards, dice, blackjack, track (horses, dogs)

Non-strategic gambling = slots, lottery, pull tabs, bingo, keno, video poker

Abbreviations: PG-YBOCS=Yale Brown Obsessive Compulsive Scale Modified for Pathological Gambling

^aStatistic: c = Chi-square; t = t-test; f = Fisher's exact;

Table 4

Motor Inhibition and Cognitive Flexibility in Strategic and Non-Strategic Gamblers

Cognitive Task	Strategic (n=22)	Non-Strategic (n=55)	Statistic ^a	df	p-value
Intra-dimensional Extra-dimensional Set Shift Task					
IDED Stages completed	8.59 (0.8)	8.35 (0.9)	1.129t	75	0.263
IDED total errors	24.3 (15.3)	22.7 (12.9)	0.455t	75	0.65
IDED total errors (adjusted)	28.8 (23.6)	29.1 (20.5)	0.047t	75	0.963
Total Reversal Errors	8.55 (6.3)	8.15 (8.4)	0.201t	75	0.841
Intradimensional Shift	0.81 (1.5)	0.56 (0.63)	1.054t	75	0.295
Extradimensional Shift	11.59 (9.3)	11.98 (10.3)	0.155t	75	0.877
Stop-Signal Task					
SST SSRT	209.6 (103.1)	184.8 (54.4)	1.381t	75	0.171
SST median go reaction time	478.4 (166.2)	523.8 (131.1)	1.268t	75	0.209
SST p(inhibition)	0.47 (0.15)	0.52 (0.13)	1.549t	75	0.125

All scores are Mean ($\pm$ SD)

p-value = two-tailed t-test

Strategic gambling = poker, sports, cards, dice, blackjack, track (horses, dogs)

Non-strategic gambling = slots, lottery, pull tabs, bingo, keno, video poker

Abbreviations: IDEED = Intradimensional Extradimensional; SST = Stop Signal Task; SSRT = Stop-Signal Reaction Time

^aStatistic: t = t-test: two sample assuming equal variances

Table 5
Motor Inhibition and Cognitive Flexibility in Strategic and Non-Strategic Gamblers vs Age- and Gender-matched Healthy Controls

	Performance (mean $\pm$ SD)			ANOVA		Post-Hoc LSD Tests	
	Strategic (n=22)	Non-Strategic (n=23)	Healthy Controls (n=28)	F	p-value	Strategic vs. Controls p-value	Strategic vs. Non-Strategic p-value
IDED total errors (adjusted)	24.3 (15.3)	24.9 (11.9)	11.86 (8.08)	10.036	<0.001	<0.001	0.568
Intradimensional Shift	0.81 (1.5)	0.57 (0.73)	0.32 (0.48)	1.598	0.210		
Extradimensional Shift	11.59 (9.3)	13.13 (10.4)	4.64 (5.03)	7.604	0.007	0.002	0.604
SST SSRT	209.6 (103.1)	182.6 (61.7)	146.5 (35.8)	5.138	0.008	0.004	0.288
SST median go reaction time	478.4 (166.2)	524.1 (128.6)	486.1 (127.4)	0.702	0.499		
SST p(inhibition)	0.47 (0.15)	0.52 (0.14)	0.54 (0.07)	1.234	0.298		

All scores are Mean ($\pm$ SD)

p-value = two-tailed t-test

Strategic gambling = poker, sports, cards, dice, blackjack, track (horses, dogs)

Non-strategic gambling = slots, lottery, pull tabs, bingo, keno, video poker

Abbreviations: IDED = Intradimensional Extradimensional; SST = Stop Signal Task; SSRT = Stop-Signal Reaction Time