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The Reasoning Skills and Thinking Dispositions of Problem Gamblers: A Dual-Process Taxonomy

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ABSTRACT

We present a taxonomy that categorizes the types of cognitive failure that might result in persistent gambling. The taxonomy subsumes most previous theories of gambling behavior, and it defines three categories of cognitive difficulties that might lead to gambling problems: The autonomous set of systems (TASS) override failure, missing TASS output, and mindware problems. TASS refers to the autonomous set of systems in the brain (which are executed rapidly and without volition, are not under conscious control, and are not dependent on analytic system output). Mindware consists of rules, procedures, and strategies available for explicit retrieval. Seven of the eight tasks administered to pathological gamblers, gamblers with subclinical symptoms, and control participants were associated with problem gambling, and five of the eight were significant predictors in analyses that statistically controlled for age and cognitive competence. In a commonality analysis, an indicator from each of the three categories of cognitive difficulties explained significant unique variance in problem gambling, indicating that each of the categories had some degree of predictive specificity. Copyright © 2006 John Wiley & Sons, Ltd.

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Pathological gambling is defined as "persistent and recurrent maladaptive gambling behavior that disrupts personal, family, and vocational pursuits" (DSM-IV-TR, American Psychiatric Association, 2000, p. 671). Despite substantial monetary losses and negative social consequences, pathological gamblers find it difficult to stop or reduce their gambling behavior (Blaszczynski & Nower, 2002). The lifetime prevalence rates of pathological gambling in North American adults have been estimated at roughly 0.5–4.0% of the population

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(National Research Council, 1999; Petry, 2005; Petry & Armentano, 1999; Petry & Mallya, 2004; Shaffer, Hall, & Vander Bilt, 1999). However, as the gaming industry expands in various jurisdictions in the United States and Canada, these prevalence rates might well increase (Govoni, Frisch, Rupcich, & Getty, 1998; Ledgerwood & Petry, 2005; Petry & Mallya, 2004).

Problem gambling thus remains a continuing and perhaps growing social problem. Social scientists have tried to understand the phenomenon by applying a wide range of frameworks and theories (methods of treatment are likewise quite varied, see Petry, 2005; Toneatto & Ladouceur, 2003). In addition to such classic frameworks as psychoanalytic theory and Skinnerian learning theory (see Griffiths, 1995, for a review), psychologists have explored gambling behavior through models such as arousal theories (Brown, 1986; Sharpe, Tarrier, Schotte, & Spence, 1995), impulse control theories (Bechara, 2005; Cavedini, Riboldi, Keller, D'Annucci, & Bellodi, 2002), personality trait theories (Allcock & Grace, 1988; Blaszczynski & Steel, 1998; Gibson & Sanbonmatsu, 2004; Langewisch & Frisch, 1998), addiction theories (Ainslie, 2001; Dickerson, 1989; Jacobs, 1986; Rachlin, 1990, 2000), and the heuristics and biases approach (Gibson, Sanbonmatsu, & Posavac, 1997; Griffiths, 1994, 1995; Keren, 1994; Rogers, 1998; Toneatto, 1999; Wagenaar, 1988). We do not lack theories of gambling behavior. The problem has been that these models and theories have developed in isolation. In the present study, we report one of the few investigations to examine variables from across a wide variety of perspectives and their association with problem gambling.

In summary, research has not settled on a single theoretical perspective from which to view pathological gambling behavior. The problem has not been a lack of demonstrated performance relationships—cognitive and/or motivational/affective differences between pathological gamblers and nongamblers have been found on a variety of tasks. The problem has been that from a methodological standpoint, many of the observed cognitive/behavioral differences are correlated with each other and with empirically established demographic variables associated with gambling, such as age, gender, cognitive ability, and education (Mok & Hraba, 1991; National Research Council, 1999; Petry, 2005; Petry & Mallya, 2004). It is often unknown which observed performance differences between pathological gamblers and nongamblers would remain after statistical control for well-known demographic correlates, or after statistical control of variables reflecting other well-known theories. In this investigation, we examined multiple domains of cognition and motivational/affective control in three groups: pathological gamblers, gamblers with subclinical problems, and individuals with no gambling problems. Importantly, we report one of the few investigations to examine multiple domains of cognitive and motivational/affective control. The multiple domains were chosen to fit within a broad theoretical model that we think will provide a useful taxonomy within which to conceptualize the cognitive and motivational processing differences that are associated with problem gambling. That broad theoretical framework takes as its foundation dual-process theories of cognitive functioning.

Evidence from cognitive neuroscience and cognitive psychology is converging on the conclusion that mental functioning can be characterized by two different types of cognition having somewhat different functions and different strengths and weaknesses (Barrett, Tugade, & Engle, 2004; Bechara, 2005; Evans, 2003, in press; Evans & Over, 1996; Fodor, 1983; Goel & Dolan, 2003; Kahneman, 2003; Kahneman & Frederick, 2002, 2005; Lieberman, 2003; McClure, Laibson, Loewenstein, & Cohen, 2004; Metcalfe & Mischel, 1999; Sloman, 1996, 2002; Stanovich, 1999). There are many such theories (22 dual-process theories are presented in a Table in Stanovich, 2004) and they have some subtle differences, but they are similar in that all distinguish autonomous from nonautonomous processing. The acronym TASS has been used to refer to The Autonomous Set of Systems (TASS) (see Evans, 2004; Stanovich, 2004). TASS is referred to as autonomous because: (1) their execution is rapid, (2) their execution is mandatory when the triggering stimuli are encountered, (3) they are not under conscious control, and (4) they are not dependent on input from the analytic system. Included in TASS are processes of implicit and instrumental learning, overlearned associations, processes of behavioral regulation by the emotions, and the encapsulated modules for solving specific adaptive problems that have been posited by evolutionary psychologists. Most TASS processes can operate in parallel with each other and with the analytic system. These processes conjoin the

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properties of automaticity, quasi-modularity, and heuristic processing as these constructs have been variously discussed in cognitive science.

In contrast, the analytic system conjoins the various characteristics that psychologists have viewed as typifying controlled processing. Analytic cognitive processes are serial (as opposed to parallel), often rule-based, often language-based, computationally expensive—and they are the focus of our awareness. The analytic system is responsible for the ability to create temporary models of the world and test the outcomes of imaginary actions (Currie & Ravenscroft, 2002; Evans & Over, 1999, 2004; Nichols & Stich, 2003; Sterelny, 2001). Most important for our discussion here, the analytic system carries out the critical process of overriding TASS outputs when they are not appropriate (particularly when inappropriate outputs from coarse-grained systems of emotional regulation are generated). By taking early representations triggered by TASS offline and substituting better responses that have survived the cognitive selection process of simulation, the analytic system carries out activities often labeled as executive or inhibitory control.

Within such a generic dual-process conceptualization, it is possible to describe three categories of cognitive failure that might result in persistent gambling behavior that disrupts other life pursuits—that is, pathological gambling. We have termed these three categories: TASS override failure; missing TASS output; and mindware problems. We will briefly describe each of the three categories in turn and indicate how they will be operationalized for the purposes of this study.

The analytic system and TASS often (because the latter can operate in parallel) provide outputs relevant to the same cognitive problem. When both systems provide outputs relevant to a decision situation, in some cases the outputs reinforce each other. For example, contrary to the folk wisdom that the emotions and the intellect are largely at war, many models in cognitive science view the emotions as useful signals for the gross reprioritizing of goals (Cacioppo & Berntson, 1999; Damasio, 1994; de Sousa, 1987; Frank, 1988; Johnson-Laird & Oatley, 1992, 2000; Matthews, Zeidner, & Roberts, 2002; Oatley, 1992, 2004; Pollock, 1995). Such behavioral regulation via the emotions is often a good first-pass strategy. More complicated are situations where the gross regulation by the emotions in TASS conflicts with the more fine-grained analysis performed by the analytic system. An inability to override TASS in such cases may be a cause of dysfunctional gambling behavior—calculations of the disutility of gambling by the explicit analytic system are ineffective against TASS-based systems that find gambling behavior reinforcing. This category of cognitive problem we term a TASS override failure. Perspectives on gambling behavior that have emphasized impulsivity (e.g., Blaszczynski, Steel, & McConaghy, 1997) would fall into this category.

In the present study, we measured the general tendency for TASS override failure with four different indicators—one a behavioral measure and the other three questionnaire measures. The behavioral measure was the Matching Familiar Figures Test (MFFT) developed by Kagan, Rosman, Day, Albert, and Philips (1964) to assess the dimension of reflectivity/impulsivity. Presumably, those more impulsive on this measure would be characterized by a higher probability of TASS override failure. We also included a questionnaire measure of impulsivity designed to capture self-reported tendencies towards impulsivity—a subscale of the I_7 Impulsivity Questionnaire developed by Eysenck, Pearson, Easting, and Allsopp (1985). Two other questionnaires designed to tap the tendency toward TASS override failure were administered: The Consideration of Future Consequences scale (CFC) developed by Strathman, Gleicher, Boninger, and Edwards (1994) to measure the extent to which individuals consider distant outcomes when choosing their present behavior and the Head Over Heart (HOH) scale devised by Epstein, Pacini, Heier, and Denes-Raj (1995; see also Epstein, Pacini, Denes-Raj, & Heier, 1996) to assess differences in intuitive versus analytical response tendencies.

The second category of cognitive failure hypothesized to be associated with pathological gambling is termed missing TASS output. Cognitive neuroscientists have uncovered cases of mental pathology that are characterized by inadequate behavioral regulation from the emotion modules in TASS. For example, the Damasio group (Damasio, 1994, 1996; Bechara, Damasio, Damasio, & Anderson, 1994; Eslinger & Damasio, 1985; Saver & Damasio, 1991) has studied a particular type of patient with damage in the

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ventromedial prefrontal cortex. These individuals have severe difficulties in real-life decision making but do not display the impairments in sustained attention and executive control that are characteristic of individuals with damage in dorsolateral frontal regions (e.g., Duncan, Emslie, Williams, Johnson, & Freer, 1996; McCarthy & Warrington, 1990; Pennington & Ozonoff, 1996). Damasio (1994)'s somatic marker hypothesis (and other related models, see Oatley, 1992) posit that emotions are efficacious because they serve to stop the combinatorial explosion of possibilities that would occur if an intelligent system tried to calculate the utility of all possible future outcomes. Emotions are thought to constrain the possibilities to a manageable number based on somatic markers stored from similar situations in the past. In short, emotions (computationally inexpensive regulatory systems) can get us in the ballpark of the right action and then expensive analytic processing can compute a more precisely optimal response from the vastly reduced set of possibilities that remain. Various neuropsychological problems might arise if this useful TASS output is missing. In this study, we examined the possibility that missing TASS output is associated with pathological gambling.

We examined the potential problem of missing TASS output in pathological gamblers by using the Iowa Gambling Task created by Bechara et al. (1994) (see also, Bechara, Damasio, Tranel, & Damasio, 1997, 2005; Bechara, Tranel, & Damasio, 2000). As a second index of problems with missing TASS output, we employed a questionnaire measure—the Alexithymia scale revised by Bagby, Parker, and Taylor (1994). It is designed to assess self-reported tendencies of difficulty identifying and describing feelings. A previous study has suggested that pathological gamblers may report such problems more than controls (Lumley & Roby, 1995).

The third category of potential cognitive failure—mindware problems—is interestingly related to the first that was discussed. TASS override is necessary when the automatic computations of TASS conflict with analytic-system computations indicating that another response is optimal for the situation. But unlike TASS processes, which do not strain cognitive capacity, analytic system processes are computationally expensive and difficult to sustain. What the analytic system gains from this expense is flexibility—the ability to run an almost inexhaustible set of mindware, a term used by Perkins (1995) to refer to the rules, procedures, and strategies that can be retrieved by the analytic system and used to transform decoupled representations (Clark, 2001 uses the term in a somewhat different way). Perkins uses the term to stress that the procedures implemented by the analytic system are more analogous to software than to hardware in the brain/computer analogy.

The mindware available to the analytic system for TASS override is in part the product of past learning experiences. This means that there will be individual differences in the mindware tools available for TASS override. Indeed, if one is going to trump a TASS-primed response with conflicting information or a learned rule, one must have previously learned the appropriate information or rule. If the appropriate information has not been learned (what might be termed a mindware gap) or, even worse, if an inappropriate strategy has been acquired (what might be termed contaminated mindware) then we have instances of the third category of our taxonomy: mindware problems.

Examples of mindware problems due to knowledge gaps are provided by the heuristics and biases framework on thinking and reasoning (e.g., Gilovich, Griffin, & Kahneman, 2002; Kahneman & Tversky, 1973, 1996, 2000; Tversky & Kahneman, 1983), and gambling research utilizing that framework (e.g., Toneatto, 1999). These research traditions suggest what the candidates for the knowledge gaps might be in the case of pathological gambling: knowledge and procedures for dealing with probability and probabilistic events. We constructed a composite measure of performance on a variety of heuristics and biases problems that are well-known demonstrations of probabilistic reasoning abilities that might be especially relevant to gambling. These included measures of knowledge of regression to the mean, outcome bias, covariation detection, the gambler's fallacy, probability matching, baserate neglect, Bayesian probabilistic updating, and covariation detection. Many of the tasks employed in our composite measure have become classics in the literature of probabilistic reasoning (Gilovich et al., 2002; LeBoeuf & Shafir, 2005; Nickerson, 2004; Nisbett & Ross, 1980; Shafir & LeBoeuf, 2002; Stanovich & West, 1999, 2000).

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Mindware problems also arise because not all mindware is helpful—either to our goals in general or as an inoculation against pathological gambling. In fact, some acquired mindware can be the direct *cause* of irrational actions that thwart our goals or, again more specifically, can serve to maintain pathological gambling behavior. Although the idea of contaminated mindware is controversial (see Aunger, 2000) many theorists speculating on the properties of cultural replication would admit such a possibility (Aunger, 2002; Blackmore, 1999; Dawkins, 1993; Dennett, 1991, 2006; Distin, 2005; Laland & Brown, 2002; Richerson & Boyd, 2005; Stanovich, 2004). Based on some suggestive results indicating that pathological gamblers may be more prone to superstitious beliefs (Joukhador, Blaszczynski, & Maccallum, 2004; Toneatto, 1999), we developed a questionnaire that tapped belief in paranormal events, superstition, and luck.

Many of the previous perspectives used to understand gambling behavior can be subsumed within our taxonomy. Arousal theories, for instance, often implicate missing TASS output. Impulse control theories and addiction theories are examples of analyses that stress TASS override problems. For example, Bechara's (2005) theory of impulse control in drug addiction provides a fairly detailed neurocognitive perspective on how TASS override operates in the context of that type of addiction. In contrast, although there has been some work on gambling in the heuristics and biases tradition, the category of mindware problems has been relatively neglected in gambling research. This is an important omission, because the categories in our taxonomy may have differing implications for the remediation of gambling problems, as we will argue in the Discussion.

In summary, in this investigation we examined the performance of pathological gamblers, gamblers with subclinical symptoms, and nongamblers on tasks tapping three categories of cognitive failure that might result in persistent gambling behavior that disrupts other life pursuits: TASS override failure; missing TASS output; and mindware problems. Variables from these categories have rarely been investigated together. Thus, as predictors of gambling behavior, we will be able to examine the specificity and commonality among variables from a variety of theoretical perspectives. Our taxonomy will especially show its usefulness if specificity can be demonstrated–if the variables partitioned by this taxonomy are actually unique predictors. We assessed their uniqueness in two different ways. First, we examined whether the variables could account for variance in gambling behavior independent of demographic predictors such as age and cognitive competence. Second, we examined whether the predictors in our taxonomy were independent of each other in accounting for variance in gambling behavior. Our theoretically driven taxonomy of potential cognitive failures associated with pathological gambling should demonstrate such uniqueness for its predictors if in fact the taxonomy separates variables that are conceptually distinct.

METHOD

Participants

A total of 107 male participants (mean age = 31.8 years, $SD = 11.8$) took part in the study. We focused on male participants because the prevalence of pathological gambling is considerably greater in the male than in the female population (American Psychiatric Association, DSM-IV-TR, 2000; Petry, 2005). The participants were recruited through newspaper advertisements and flyers posted around a large university and in an addictions center of a metropolitan city, which were located close to one another. The flyers and newspaper advertisements requested interested gamblers and nongamblers to participate in a study about gambling. Potential participants were contacted and asked questions about their gambling activity in a telephone screening interview. Individuals currently undergoing treatment for problem gambling were excluded from the study.

Based upon the number of DSM-IV symptoms of problem gambling that they endorsed on a questionnaire, the participants were categorized into three groups: pathological gamblers, subclinical gamblers, and no-problem gamblers. The questionnaire consisted of 10 items (see Petry, 2005, p. 12) that asked participants to

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report the gambling problems they had experienced in the past 12 months. The questions covered social, financial, physical, and behavioral areas influenced by gambling. Sample items included: ''Are you preoccupied with gambling?'' and ''Do you find that you need to gamble with increasing amounts of money in order to achieve the level of excitement that you want?'' Each question was scored 1 for yes and 0 for no, for a possible total score of 10. Based on classification work by Stinchfield (2003) and Cox, Enns, and Michaud (2004), participants scoring four or more on the DSM-IV questionnaire were classified as pathological gamblers ($N = 24$), those with scores from one to three on the DSM-IV questionnaire were classified as subclinical gamblers ($N = 26$), and those with scores of zero were classified as individuals with no gambling problems ($N = 57$).

The DSM-IV classification was confirmed by administering the South Oaks Gambling Screen (SOGS; Lesieur & Blume, 1987)—a 20-item diagnostic questionnaire that assesses beliefs and attitudes towards gambling behavior and perceived problems. Most questions were answered yes (1) or no (0). Sample items include: ''Have you ever claimed to be winning when in fact you were losing?'' and ''Have you ever lost time from work or school because of gambling?'' Participants answered the questions based on the last 12 months and for their lifetimes (not including the last 12 months) and thus receive two separate scores (possible total score of 20 on both).

The means displayed in Table 1 indicate that the scores on the SOGS converged strongly with the classification based on the DSM-IV questionnaire. As indicated in Table 1, the groups did not differ significantly in educational level but they did differ in age—the pathological gamblers were significantly older than the no-problem group.

The pathological gamblers in our sample had a median annual income of $29 500 ($CDN) and gambled a median of $20 520 ($CDN) annually on gambling activities of all types. The subclinical gamblers in our sample had a median annual income of $29 500 and gambled a median of $3027 annually on gambling activities of all types. The individuals with no gambling problems had a median annual income of $10 000 and gambled a median of $80 annually on gambling activities of all types.

The participants were also administered the Vocabulary and Block Design subtests from the Wechsler Adult Intelligence Scale—Revised (WAIS-R; Wechsler, 1981). To arrive at a generic measure of cognitive competence, these two subtests were prorated to estimate Full-Scale IQ (Sattler, 1988). Such a measure was used because similar indices are often included as covariates in studies of gambling behavior. We do not assume that such an index has any of the properties sometimes associated with the concept of intelligence such as immutability. Most importantly, we do not assume that this measure should have causal priority—as

Table 1. Means (standard deviations) on demographic variables for the three groups

	No-problem group ($n = 57$)	Subclinical group ($n = 26$)	Pathological gamblers (n=24)	ANOVA F(2,104)
Diagnostic questionnaires				
Number of DSM-IV gambling symptoms	0.0_a (0.0)	1.85_b (0.78)	5.79_c (1.89)	302.81^{***}
South Oaks gambling screen-12 month score	0.51_a (1.00)	3.19_b (1.82)	11.42_c (3.99)	207.07^{***}
South Oaks gambling screen lifetime score	0.58_a (0.86)	3.00_b (1.93)	11.83_c (4.97)	158.94^{***}
Demographics				
Age (years)	28.7_a (11.0)	32.8 (10.9)	38.2_b (12.3)	6.09^{**}
Years of education	14.4 (1.7)	14.3 (1.8)	13.5 (2.2)	1.74
Cognitive ability measure				
WAIS-R score	118.0_a (13.1)	104.3_b (11.1)	99.0_b (13.8)	22.45^{***}

$^{**}p < 0.01$.
$^{***}p < 0.001$.
Note: Means in the same row that show different subscripts (a, b, c) are significantly different at $p < 0.05$ in a Scheffé post hoc test.

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might be implied when it is entered as a covariate or early in a hierarchical regression analysis. Indeed, we believe that the experimental indicators in this study have more direct relevance to gambling behavior.

As indicated in Table 1, the no-problem group had significantly higher prorated WAIS-R scores than the other two groups. Both age and WAIS-R were used as covariates in several of the analyses to be presented below.

Experimental tasks—TASS override failure

Matching familiar figures test (MFFT)

In the MFFT (Kagan et al., 1964) participants were presented with a target picture of an object, and their task was to find the correct match from an array of six other pictures. Participants' latency and number of errors were measured. When participants made an incorrect selection, they were asked to select again. This was repeated until the participant found the correct match (up to a maximum of six possible responses). The mean time to the first response for all items and the number of items on which the participant made at least one error were scored and standardized for each participant. Because the standardized reaction time did not correlate with any other variable in the study, the standardized number of errors ($\mathrm{MFFT}_{\mathrm{Total\ \#\ Errors}}$ *Z*-score) was the metric used in the subsequent analyses.

Impulsivity subscale

This 19-item subscale is part of the I_7 Impulsivity Questionnaire developed by Eysenck et al. (1985) and was used to capture self-reported tendencies towards impulsivity. The original subscale utilized a question format (for example, "Do you often buy things on impulse?"), and in the current study we changed the format into statements (for example, "I often buy things on impulse") so that these items could be administered as part of a thinking dispositions questionnaire which intermixed items from several other scales. Participants were asked to rate their agreement to each question using a six-point scale: Strongly Disagree (1), Disagree Moderately (2), Disagree Slightly (3), Agree Slightly (4), Agree Moderately (5), Strongly Agree (6). A composite score for this scale was created by summing responses to all items and then standardizing the summed score.

Consideration of future consequences (CFC) scale

This 12-item scale was developed by Strathman et al. (1994) to measure the extent to which individuals consider distant outcomes when choosing their present behavior. A sample item from the scale was: "I only act to satisfy immediate concerns, figuring the future will take care of itself" (reverse scored). The CFC items were administered as part of the thinking dispositions questionnaire, using the same six-point rating scale described previously. A composite score was created by summing responses to all items and then standardizing the summed score.

Head over heart (HOH) scale

This eight item scale was devised by Epstein et al. (1995; see also Epstein et al., 1996) to assess differences in intuitive versus an analytical style of reasoning. A sample item is: "My friends regard me as more of a 'thinking-type person' than a 'feeling type person'." The HOH items were administered as part of the thinking dispositions questionnaire, using the same six-point rating scale described previously. A composite score was created by summing responses to all items and then standardizing the summed score.

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Experimental tasks—Missing TASS output

Iowa gambling task

This task was modeled on the gambling task introduced into the literature by Bechara et al. (1994). Four decks of cards were placed in front of the participant, labeled as deck A, B, C, or D. On the back of each card, there was either a reward alone or a reward combined with a penalty. Each deck was created as either an advantageous deck (with positive expected value: decks C and D) or a disadvantageous deck (with negative expected value: decks A and B). The cards were organized in the same order for each participant. The order of cards was not random but instead arranged to adhere to certain expected value requirements in each deck (see below). There were 50 cards in each deck.

Participants were told that they would play a card game in which they had to select 100 cards, and that the purpose of the game was to maximize the amount of money they could win. They were told that on the back of each card there was either a reward alone or a reward combined with a penalty. They were to select cards from any of the four decks in any order they wished and the examiner would give them the reward and/or collect the penalty after each card selection based on what was on the back of the card. Participants were given $2000 of monopoly money at the beginning of the game. To increase motivation and the realism of the task, participants were told that they would receive $50.00 in gift certificates if they accumulated a net gain in the card task.

The logic of the reward and penalty arrangement in our study was analogous to that used in Bechara et al. (1994). Despite the larger rewards for the cards in decks A and B ($100 vs. $50 for decks C and D), these decks were disadvantageous because of large penalties. The expected value of decks A and B was negative—the participant would lose $250 for each 10 cards drawn. In contrast, despite the smaller rewards for the cards in decks C and D, these decks were advantageous. The expected value of decks C and D was positive–the participant would win $250 for each 10 cards drawn.

Participants were not told the number of cards in each deck (several blank cards were added to the bottom of each deck so that participants would not be concerned that a deck would be exhausted). Participants were not told anything about the pattern of rewards and penalties. The two key measures of performance in the task were: (1) The sum of cards selected from disadvantageous decks A and B during all 100 trials; and (2) The sum of cards selected from disadvantageous decks A and B during the last 50 trials (because participants need several draws from each of the decks in order to register the properties of the four decks).

Alexithymia scale—revised

This scale was comprised of 20 items from the revised scale published by Bagby et al. (1994) that is composed of questions related to difficulty identifying feelings, difficulty describing feelings, and externally oriented thinking. Examples of items were: "I have feelings that I can't quite identify" and "I find it hard to describe how I feel about people." The alexithymia items were administered as part of the thinking dispositions questionnaire, using the same six-point rating scale described previously. A composite score was created by summing responses to all items and then standardizing the summed score.

Experimental tasks—Mindware problems: probabilistic thinking composite

We constructed a Probabilistic Thinking Composite score based on 10 classic tasks from the heuristics and biases literature (e.g., Gilovich et al., 2002; Kahneman & Tversky, 1973, 1996; LeBoeuf & Shafir, 2005; Nickerson, 2004; Nisbett & Ross, 1980; Shafir & LeBoeuf, 2002; Stanovich, 1999). Each task was scored either 1 (correct) or 0 (incorrect) based on whether the participant gave the normatively appropriate response for the task. Scores across the 10 tasks were then summed. The tasks were:

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Gambler's fallacy 1

In the first gambler's fallacy problem, the participant read the following: Imagine that we are tossing a *fair* coin (a coin that has a 50/50 chance of coming up heads or tails) and it has just come up heads 5 times in a row. For the sixth toss, do you think that:

a. It is more likely that tails will come up than heads.
b. It is more likely that heads will come up than tails.
c. Heads and tails are equally probable on the sixth toss.

Answer c is the normative response and was scored as 1, while the other two alternatives were scored as 0.

Gambler's fallacy 2

In the second gambler's fallacy problem, the participant read the following: When playing slot machines, people win something 1 out of every 10 times. Julie, however, just won her first three plays. What are her chances of winning the next time she plays? ___ out of ___.

An answer of 1 out of 10 is the normative response and was scored as 1, while any other response was scored as 0.

Regression to the mean

Taken from Lehman, Lempert, and Nisbett (1988), this problem was worded as follows: After the first 2 weeks of the major league baseball season, newspapers begin to print the top 10 batting averages. Typically, after 2 weeks, the leading batter often has an average of about 0.450. However, no batter in major league history has ever averaged 0.450 at the end of the season. Why do you think this is? Circle one:

a. When a batter is known to be hitting for a high average, pitchers bear down more when they pitch to him.
b. Pitchers tend to get better over the course of a season, as they get more in shape. As pitchers improve, they are more likely to strike out batters, so batters' averages go down.
c. A player's high average at the beginning of the season may be just luck. The longer season provides a more realistic test of a batter's skill.
d. A batter who has such a hot streak at the beginning of the season is under a lot of stress to maintain his performance record. Such stress adversely affects his playing.
e. When a batter is known to be hitting for a high average, he stops getting good pitches to hit. Instead, pitchers ‘‘play the corners’’ of the plate because they don't mind walking him.

The normative response—c—is the only response that shows some recognition of the possibility of regression effects, and was scored as 1 while the other options were scored as 0.

Covariation detection

Taken from Stanovich and West (1998b), the problem appeared as follows: A doctor has been working on a cure for a mysterious disease. Finally, he created a drug that he thinks will cure people of the disease. Before he can begin to use it regularly, he has to test the drug. He selected 300 people who had the disease and gave them the drug to see what happened. He selected 100 people who had the disease and did not give them the drug in order to see what happened. The table below indicates what the outcome of the experiment was

	Cure	
	Yes	No
Treatment present	200	100
Treatment absent	75	25

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Please judge whether this treatment is positively or negatively associated with the cure for this disease. Circle the number that best reflects your judgement.

−10 −9 −8 −7 −6 −5 −4 −3 −2 −1 0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +10

strong negative association — Neutral — Strong positive association

The normative response was any negative judgement and was scored as 1, while a non-normative response was a zero or positive judgement, and was scored as 0.

Probability matching versus maximizing 1

Taken from West and Stanovich (2003), the problem was stated as follows: A die with 4 red faces and 2 green faces will be rolled 60 times. Before each roll you will be asked to predict which color (red or green) will show up once the die is rolled. Pretend that you will be given 1 dollar for each correct prediction. Assume that you want to make as much money as possible. What strategy would you use in order to make *as much money as possible* by making the most correct predictions?

- Strategy A: Go by intuition, switching when there has been too many of one color or the other.
- Strategy B: Predict the more likely color (red) on most of the rolls but occasionally, after a long run of reds, predict a green.
- Strategy C: Make predictions according to the frequency of occurrence (four of six for red and two of six for green). That is, predict twice as many reds as greens.
- Strategy D: Predict the more likely color (red) on all of the 60 rolls.
- Strategy E: Predict more red than green, but switching back and forth depending upon ‘‘runs’’ of one color or the other.

Which Strategy is best?

Strategy D is the maximizing strategy and thus the normative response on the task. Participants answering ‘‘D’’ were given a score of 1, and all other options were scored as 0.

Probability matching versus maximizing 2

Taken from West and Stanovich (2003), the problem was as follows: A card deck has only 10 cards. Seven of the cards have the letter ‘‘a’’ on the down side. Three of the cards have the letter ‘‘b’’ on the down side. The 10 cards are randomly shuffled. Your task is to guess the letter on the down side of each card before it is turned over. Pretend that you will win $100 for each card’s down side letter you correctly predict. Indicate your predictions for each of the 10 cards:

- Card #1 will be a or b?
- Card #2 will be a or b?
- Card #3 will be a or b?
- Card #4 will be a or b?
- Card #5 will be a or b?
- Card #6 will be a or b?
- Card #7 will be a or b?
- Card #8 will be a or b?
- Card #9 will be a or b?
- Card #10 will be a or b?

The normative response is to choose ‘‘a’’ for all cards, and this response was scored as 1. Any other response was non-normative and scored as 0.

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Bayesian reasoning

Adapted from Beyth-Marom and Fischhoff (1983), this problem read as follows:

Imagine yourself meeting David Maxwell. Your task is to assess the *probability that he is a university professor* based on some information that you will be given. This will be done in two steps. At each step, you will get some information that you may or may not find useful in making your assessment. After each piece of information you will be asked to assess the probability that David Maxwell is a university professor. In doing so, consider all the information you have received to that point if you consider it to be relevant.

* Step 1. You are told that David Maxwell attended a party in which 25 male university professors and 75 male business executives took part, 100 people all together.

Question: What do you think the probability is that David Maxwell is a university professor? ___

* Step 2. You are told that David Maxwell is a member of the Bear's Club. 70% of the male university professors at the above mentioned party were members of the Bear's Club. 90% of the male business executives at the party were members of the Bear's Club.

Question: What do you think the probability is that David Maxwell is a university professor? ___

From Step 1, a reliance on the base rate would give an estimate of 0.25. For Step 2, if participants used the correct Bayesian adjustment $[(0.70 \times 0.25)/(0.70 \times 0.25+0.90 \times 0.75)]$ the correct estimate is 0.206. Therefore, if participants provided an estimate of 0.25 at Step 1 and an estimate lower than 0.25 for Step 2, this was normative and scored as 1. All other responses were scored as 0.

Statistical reasoning

Taken from Fong, Krantz, and Nisbett (1986), this problem presented two types of conflicting information: one statistical in favor of one decision and the other based on personal experience, favoring the other decision. The problem was as follows:

The Caldwells had long ago decided that when it was time to replace their car they would get what they called "one of those solid, safety-conscious, built-to-last Swedish" cars—either a Volvo or a Saab. When the time to buy came, the Caldwells found that both Volvos and Saabs were expensive, but they decided to stick with their decision and to do some research on whether to buy a Volvo or a Saab. They got a copy of Consumer Reports and there they found that the consensus of the experts was that both cars were very sound mechanically, although the Volvo was felt to be slightly superior on some dimensions. They also found that the readers of Consumer Reports who owned a Volvo reported having somewhat fewer mechanical problems than owners of Saabs. They were about to go and strike a bargain with the Volvo dealer when Mr. Caldwell remembered that they had two friends who owned a Saab and one who owned a Volvo. Mr. Caldwell called up the friends. Both Saab owners reported having had a few mechanical problems but nothing major. The Volvo owner exploded when asked how he liked his car. "First that fancy fuel injection computer thing went out: $400 bucks. Next I started having trouble with the rear end. Had to replace it. Then the transmission and the clutch. I finally sold it after 3 years at a big loss." What do you think the Caldwells should do?

The problem was followed by the choices: (1) They should definitely buy the Saab, (2) They should probably buy the Saab, (3) They should probably buy the Volvo, (4) They should definitely buy the Volvo. A preference for the Volvo indicates a tendency to rely on the large-sample information in spite of the salient personal testimony and was the normative response and scored as 1. Choosing the Saab was scored as 0.

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Outcome bias

Our measure of outcome bias derived from a problem investigated by Baron and Hershey (1988):

> A 55-year-old man had a heart condition. He had to stop working because of chest pain. He enjoyed his work and did not want to stop. His pain also interfered with other things, such as travel and recreation. A successful bypass operation would relieve his pain and increase his life expectancy from age 65 to 70. However, 8% of the people who have this operation die as a result of the operation itself. His physician decided to go ahead with the operation. The operation succeeded. Evaluate the physician's decision to go ahead with the operation.

Participants responded on a 7-point scale ranging from 1 (incorrect, a very bad decision) to 7 (clearly correct, an excellent decision). This question appeared earlier in the battery of reasoning questions. Later in the battery, participants evaluated a different decision to perform surgery that was designed to be objectively better than the first (2% chance of death rather than 8%; 10-year increase in life expectancy versus 5-year, etc.) even though it had an unfortunate negative outcome (death of the patient). If people rate the decision on the positive outcome case as better than the negative outcome decision, then they have displayed outcome bias. The absence of outcome bias was scored as the normative response for this problem, and was scored as 1, while outcome-biased responses were scored as 0.

Probabilistic reasoning

The probabilistic reasoning task was a marble game that was modeled on a task introduced by Kirkpatrick and Epstein (1992) (see also Denes-Raj & Epstein, 1994). The task read as follows: Assume that you are presented with two trays of black and white marbles, a large tray that contains 100 marbles and a small tray that contains 10 marbles. The marbles are spread in a single layer in each tray. You must draw out one marble (without peeking, of course) from either tray. If you draw a black marble you win $2. Consider a condition in which the small tray contains 1 black marble and 9 white marbles, and the large tray contains 8 black marbles and 92 white marbles [A visual of each tray was presented to participants]. From which tray would you prefer to select a marble in a real situation? (Check one): ____ the small tray ____ the large tray.

The normative response was to select the small tray, and was scored as 1, while picking the large tray was scored as 0.

Experimental tasks—Mindware problems: superstitious thinking composite

Superstitious thinking composite

This scale was composed of two items from a paranormal scale used by Jones, Russell, and Nickel (1977), four items from a luck scale used by Stanovich and West (1998a), four items from an ESP scale used by Stanovich (1989), and three items from a superstitious thinking scale published by Epstein and Meier (1989). Examples of items include: ‘‘Astrology can be useful in making personality judgments,’’ ‘‘The number 13 is unlucky,’’ and ‘‘I do not believe in any superstitions’’ (reverse scored). The superstitious thinking items were administered as part of the thinking dispositions questionnaire, using the same six-point rating scale described previously. A composite score was created by summing responses to all items and then standardizing the summed score.

Procedure

Participants were tested individually by a single experimenter (EL), and the tasks were completed in the following order: demographic questionnaire, WAIS subtests (Block Design and Vocabulary), Probabilistic

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Thinking (Part 1), thinking dispositions questionnaire, Iowa Gambling Task, diagnostic scales (SOGS and DSM-IV gambling scale), Probabilistic Thinking (Part 2), Matching Familiar Figures Test, and Probabilistic Thinking (Part 3). The entire battery took about 3 hours to complete.

RESULTS

Table 2 displays the means for the three groups on each of the variables in the study. The next to last column presents the results of a one-way ANOVA conducted on each of the variables in turn. There was a significant difference between the groups on each of the tasks in the study with the exception of the Iowa Gambling Task. On that task, the trends were in the expected direction (more choices of disadvantageous decks A and B by the subclinical and pathological gamblers) but they did not reach statistical significance. Post-hoc tests indicated that the pathological gamblers differed significantly from the no-problem gamblers on all of the other tasks.

The final column of Table 2 presents the results of an ANCOVA run on each of the tasks in which both age and WAIS-R scores were used as covariates because the pathological and subclinical gamblers tended to be older and to have lower WAIS-R scores than the no-problem gamblers. Only one of the variables that was significant in the analysis without covariates failed to reach significance in the ANCOVA analysis—the MFFT *Z*-score. However, the ANCOVA did also markedly reduce the differences between the groups on the Probabilistic Thinking Composite score. The ANCOVA reduced the effect size (eta-squared) of this variable from 0.250 to 0.065 and the difference between the groups was significant only at the 0.05 level ($p = 0.032$).

In order to further examine which of the variables were independent predictors of gambling behavior (after the effects of age and WAIS-R were accounted for), a converging analysis was run treating gambling behavior as a continuous variable. Table 3 presents the results of a series of hierarchical regression analyses in which

Table 2. Means (and SDs) of the three groups on the experimental tasks

	No-problem group ($n = 57$)	Subclinical group ($n = 26$)	Pathological gamblers ($n = 24$)	ANOVA $F(2,104)^1$	ANCOVA $F(2, 104)^2$
TASS override					
MFFT $_{\text{Total \# Errors}}$ *Z*-score	-0.32_a (0.84)	0.19 (1.02)	0.55_b (1.07)	8.04^{***}	0.88
Impulsivity subscale *Z*-score	-0.37_a (0.92)	0.19_b (1.05)	0.68_b (0.67)	12.16^{***}	10.27^{***}
Consideration of future consequences *Z*-score	0.37_a (0.97)	−0.15 (0.80)	-0.73_b (0.84)	12.95^{***}	5.51^{**}
Head Over Heart *Z*-score	0.29_a (1.04)	−0.16 (0.97)	-0.51_b (0.69)	6.38^{**}	7.04^{***}
Missing TASS output					
Iowa gambling task AB 100 draws	39.32 (15.63)	45.42 (13.78)	47.42 (15.40)	3.00	0.46
Iowa gambling task AB last 50 draws	17.51 (12.71)	21.50 (10.50)	22.17 (11.79)	1.74	0.10
Alexithymia *Z*-score	-0.35_a (0.98)	0.14 (0.80)	0.68_b (0.87)	11.03^{***}	7.61^{***}
Mindware problems					
Probabilistic thinking composite	6.79_a (2.02)	4.23_b (2.47)	4.42_b (2.15)	17.36^{***}	3.57^{*}
Superstitious thinking composite *Z*-score	-0.29_a (0.93)	0.07 (1.01)	0.61_b (0.91)	7.83^{***}	4.08^{*}

[1] *F*-statistic comparing groups.
[2] *F*-statistic with age and WAIS-R score covaried.
$^{*}p < 0.05$.
$^{**}p < 0.01$.
$^{***}p < 0.001$.
Notes: Means in the same row that show different subscripts (a, b, c) are significantly different at $p < 0.05$ in a Scheffé post hoc test in the analyses without covariates. MFFT refers to the Matching Familiar Figures Test; TASS refers to the autonomous set of systems; AB refers to decks A and B.

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Table 3. Hierarchical regression analyses with age and cognitive ability entered first as predictors of DSM gambling scale score

Step	Variable	Multiple R	R^2 Change	F Change
1	Age	0.253	0.064	7.20**
2	WAIS-R score	0.452	0.141	18.37***
TASS override				
3	MFFT $_{\text{Total \# Errors}}$ Z-Score	0.458	0.005	0.68
3	Impulsivity subscale Z-score	0.555	0.104	15.43***
3	Consideration of future consequences Z-score	0.508	0.053	7.37**
3	Head Over Heart Z-score	0.544	0.091	13.31***
Missing TASS output				
3	Iowa gambling task AB 100 draws	0.462	0.008	1.10
3	Iowa gambling task AB last 50 draws	0.454	0.002	0.21
3	Alexithymia Z-score	0.556	0.104	15.53***
Mindware problems				
3	Probabilistic thinking composite	0.456	0.003	0.37
3	Superstitious thinking composite Z-score	0.514	0.060	8.34**

$^{**}p < 0.01$.
$^{***}p < 0.001$.
Notes: Results for each of the experimental variables when entered as the third step. MFFT refers to the Matching Familiar Figures Test; TASS refers to the autonomous set of systems; AB refers to decks A and B.

the criterion variable was the DSM-IV gambling scale score. Age was entered first into the analysis and accounted for 6.4% of the variance. The WAIS-R variable was entered next and accounted for an additional 14.1% of the variance in DSM scores. The remaining variables in the study were then each entered individually as third steps in a series of separate regression analyses. The results of each of those nine separate analyses are presented in Table 3.

Four of the nine variables failed to reach significance and, as expected, these outcomes converged with trends displayed in Table 2. First, it is not surprising that the two variables from the Iowa Gambling Task were not independent predictors because neither variable was significant in a univariate ANOVA. The MFFT, while significant in the univariate ANOVA, was not significant in the ANCOVA. Thus, it is not surprising that it did not survive as a unique predictor in a hierarchical regression analysis. Perhaps a little surprising is that the Probabilistic Thinking composite was not a significant predictor in the regression analysis. However, as noted above, it did attain significance in the ANCOVA only at the 0.05 level, and it was the variable whose effect size was most reduced by the ANCOVA. Most of the variance in DSM-IV gambling scores accounted for by the Probabilistic Thinking Composite score was already accounted for when WAIS-R scores entered at the second step because the WAIS-R and the Probabilistic Thinking Composite were highly correlated ($r = 0.69$).

Five variables that were significant in the ANCOVA were also significant unique predictors when entered as the third step in the hierarchical regressions. Three of those variables—Impulsivity subscale Z-score, Head-Over-Heart Z-score, and Alexithymia Z-score—each accounted for roughly 10% unique variance. Two others—Consideration of Future Consequences Z-score and Superstitious Thinking composite Z-score—each accounted for roughly 5–6% of the variance in DSM gambling scores after age and WAIS-R had been partialled out. Variables from all three categories explained unique variance: three from the TASS override category, one from the missing TASS output category, and one from the mindware problems category.

Our last analysis examined another aspect of the specificity of the predictors by asking if, among themselves, they predict independent or redundant variance. Our theoretical taxonomy would be supported if indicators of each of the categories explained unique variance when all of the indicators were serving as predictors. We conducted a commonality analysis (see Pedhazur, 1997) in which the variance explained by

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Table 4. Results of a commonality analysis involving an indicator of each category in the taxonomy

	TASS override indicator	Missing TASS output indicator	Mindware problems indicator
Unique variance	0.028	0.032	0.083
Common 1&2	0.065	0.065	
Common 1&3	0.026		0.026
Common 2&3		0.014	0.014
Common 1&2&3	0.066	0.066	0.066

Notes: Unique variance, explained variance in DSM scores that is unique to that indicator; Common 1&2, explained variance in DSM scores that is common to indicators 1 and 2; Common 1&3, explained variance in DSM scores that is common to indicators 1 and 3; Common 2&3, explained variance in DSM scores that is common to indicators 2 and 3. Common 1&2&3, explained variance in DSM scores that is common to all three indicators 3. The criterion variable was DSM gambling scale score.

each variable is partitioned into a portion unique to that variable and portions shared with every possible combination of variables. As indicators for each of the theoretical categories we utilized those variables that had survived the covariance analyses presented so far—either in the ANCOVAs or in the hierarchical regression analyses. Three variables from the TASS override failure category were unique predictors in at least one of the covariance analyses: Impulsivity subscale *Z*-score, Consideration of Future Consequences *Z*-score, and Head-Over-Heart *Z*-score. These *Z*-scores were summed into a composite score (after the latter two variables had been reflected) that served as our indicator of TASS override failure. The Alexithymia *Z*-score served as the indicator of missing TASS output because it was the only variable from this category to survive as a predictor in either the ANCOVA or hierarchical regression analyses. Both the Superstitious Thinking composite and Probabilistic Thinking composites survived as predictors in the ANCOVA analyses, so they were combined into an indicator of mindware problems. The Probabilistic Thinking composite was turned into a *Z*-score and reflected before being added to the Superstitious Thinking composite *Z*-score.

The results of the commonality analysis are presented in Table 4. The first row indicates the unique variance in DSM scores explained by each of the indicators. The next row displays the explained variance in DSM scores that is common to indicators 1 and 2 (0.065). The third row displays the explained variance in DSM scores that is common to indicators 1 and 3 (0.026). The fourth row displays the explained variance in DSM scores that is common to indicators 2 and 3 (0.014). The last row indicates that the explained variance in DSM scores that is common to all three indicators is 0.066. All of the variance components added together $(0.028 + 0.032 + 0.083 + 0.065 + 0.026 + 0.014 + 0.066)$ sum to the total variance explained in DSM gambling scores by the three indicators (0.314).

There are two findings of note in this analysis. First, all three variables accounted for significant unique variance: TASS override (unique $R^2 = 0.028$; $F(1,103) = 4.26$, $p < 0.05$); missing TASS output (unique $R^2 = 0.032$; $F(1,103) = 4.76$, $p < 0.05$); mindware problems (unique $R^2 = 0.083$; $F(1,103) = 12.43$, $p < 0.001$). This finding provides some validation for the conjecture that the three categories partition separate predictors of gambling behavior. The second important finding revealed by this analysis, however, was that the category of mindware problems was very separable from other predictors. The proportion of unique variance that it accounted for was 2–3 times as large as that of the other two indicators, and it was the only indicator where the amount of unique variance explained in DSM gambling scores (0.083) was larger than the explained variance held in common by all three indicators (0.066).

DISCUSSION

Our results indicate that in order to explain gambling behavior, all of the categories of variables in our taxonomy are needed. Two different types of specificity were demonstrated. Variables from each of the

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three categories survived as predictors of DSM scores after two types of analyses (ANCOVA and hierarchical regression) were used to control for common covariates in gambling studies—age and cognitive competence.

A second type of specificity for the predictors across the categories of the taxonomy was demonstrated in the commonality analysis. Using single indicators of each of the categories, it was found that each type of cognitive failure predicted significant unique variance when the variance accounted for by the other indicators was partialled out. It was important to observe, though, that the category of mindware problems was the most separable category. It displayed the largest unique variance and the smallest bivariate commonalities with the other two indicators (see Table 4). This finding is important for two reasons. First, mindware problems have received less emphasis in theories of gambling than have some other perspectives. For example, perspectives similar to TASS override failure—impulse control theories for instance (e.g., Blaszczynski et al., 1997)—are fairly well represented in the gambling literature, but this is less true of perspectives falling into the category that we would call mindware problems.

The second reason that the findings regarding the mindware problem category are notable is that the categories in our taxonomy may have differing implications for the remediation of gambling problems. For example, the developmental literature indicating that we know how to foster the type of inhibitory control that would help TASS override problems is still very sparse (Barkley, 1998a, 1998b; Castellanos, Sonuga-Barke, Milham, & Tannock, 2006). Likewise, it is very much an open question whether ‘‘workarounds’’ can be found for the types of regulatory problems of the emotions exemplified in problems of missing TASS output (Matthews et al., 2002; Salovey & Grewal, 2005). However, regardless of how these two issues are resolved, there is no doubt that mindware problems in the very domains most relevant to gambling behavior (e.g., probabilistic reasoning and causal thinking) are very remediable, and that we know much about what the relevant mindware is and how it can be taught (Nickerson, 2004; Nisbett, 1993; Perkins, 1995; Ritchhart & Perkins, 2005; Toneatto & Sobell, 1990).

Perhaps the most puzzling outcome in the study concerned the Iowa Gambling Task. Performance on this task displayed a very weak relation with gambling behavior. It did not reach significance in the three-group ANOVA. In more continuous analyses, the zero-order correlation between the DSM gambling scale and the total number of disadvantageous choices from all 100 trials with decks A and B was 0.22 ($p < 0.05$; the correlation with A and B choices over the last 50 trials was nonsignificant, $r = 0.16$). This association was not significant in the regression analysis where age and WAIS-R were partialled out. Because the weakness of this association was surprising, we explored an alternative way to examine associations with gambling task performance on this task. Bechara et al., (2001) statistically compared the proportion of individuals in each group who are considered impaired on the task. Based on the index used to evaluate card selections on the gambling task [(C+D)−(A+B)], a net score of less than 10 was considered impaired performance in their study. Thus, in a manner similar to other studies (Bechara & Damasio, 2002; Bechara, Dolan, & Hindes, 2002), we compared the number of individuals in each group using this impairment criterion. A higher proportion of our clinical groups displayed impaired performance on this task: 35.1% of our control group, 50% of our subclinical group, and 54.2% of our pathological gamblers. However, these differences did not attain statistical significance, χ^2 ($df = 2$, $N = 107$) $= 3.20$, *ns*.

These results are surprising because previous research (e.g., Cavedini et al., 2002; Petry, 2001) had suggested that pathological gambling would be related to performance on this task. However, the differences between the results in our study and previous research may be more apparent than real—in part a function of evaluating replication by the inappropriately discrete criterion of statistical significance. First, as is apparent from Table 2, our findings were in the expected direction: pathological gamblers made more disadvantageous choices than did subclinical gamblers, who in turn made more disadvantageous choices than the no-problem gamblers. A perusal of the magnitude of the trends across the studies reinforces the impression of similarity. In the Petry study, the pathological gamblers made an average of 9.0 more disadvantageous choices across the 100 trials than did the control participants. In the Cavedini et al. study, the average was 11.4 more

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disadvantageous choices. As can be seen in Table 2, the average of 8.1 more disadvantageous choices is lower than that observed in the other two investigations, but not at all out of line with them.

Despite the results from the Iowa Gambling Task, there were indications that each of the categories of cognitive difficulty displayed some degree of predictive specificity, including the category of missing TASS output. The other task in this category (in addition to the Iowa Gambling measure) was the Alexithymia scale, and here the results were much more clear cut. The three groups were significantly different not only in the ANOVA, but also in the ANCOVA with age and cognitive ability used as covariates. Furthermore, in the hierarchical regression analysis, the Alexithymia scale was the variable that accounted for the most unique variance (10.4%) in DSM scores after age and cognitive ability were partialed.

Problems in the domain of TASS override were even more definitively indicated by our data. The three groups were significantly different on all four indicators in this category, and three of the four tasks (Impulsivity, Consideration of Future Consequences, HOH) remained significant in the ANCOVA and hierarchical regression analyses that controlled for age and cognitive ability. The Impulsivity subscale and HOH scale were particularly strong independent predictors of gambling behavior in the regression analyses (roughly 9–10% unique variance explained in both cases). Explicit thoughts about the disutility of gambling may be ineffective against TASS-based systems that find the behavior reinforcing.

Finally, mindware problems might be a particularly strong factor underlying gambling behavior. As has been discussed, in the commonality analysis this class of variable proved to be the most potent predictor. The mindware problem category had the highest unique variance, yet it is the category least often represented in theories of gambling, including theories with roots in dual process theory.

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