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Impaired Metacognitive Capacities in Individuals with Problem Gambling

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Abstract Impaired insight into behavior may be one of the clinical characteristics of pathological gambling. In the present study, we tested whether the capacity to evaluate accurately the quality of one's own decisions during a non-gambling task was impaired in problem gamblers. Twenty-five problem gamblers and 25 matched healthy participants performed an artificial grammar-learning paradigm, in which the quality of choice remains uncertain throughout the task. After each trial of this task, participants had to indicate how confident they were in the grammaticality judgements using a scale ranging from 1 (low confidence) to 7 (high confidence). Results showed that (i), problem gamblers' performance on the grammaticality test was lower than controls'; (ii) there was a significant correlation between grammaticality judgments and confidence for control participants, which indicates metacognitive insight and the presence of conscious knowledge; (iii) this correlation was not significant in problem gamblers, which suggests a disconnection between performance and confidence in this group. These findings suggest that problem gamblers are impaired in their metacognitive abilities on a non-gambling task, which suggests that compulsive gambling is associated with poor insight as a general factor. Clinical interventions tailored to improve metacognition in gambling could be a fruitful avenue of research in order to prevent pathological gambling.

Keywords Insight · Metacognition · Decision-making · Uncertainty · Problem gambling

D. Brevers (✉) · M. Greisen · C. Kornreich · P. Verbanck · X. Noël
Medical psychology, alcohol and drug addiction, Université Libre de Bruxelles,
4, Place van Gehuchten, 1020 Brussels, Belgium
e-mail: dbrevers@ulb.ac.be

D. Brevers · A. Cleeremans
Consciousness, Cognition and Computation Group, Université Libre de Bruxelles,
4, Place van Gehuchten, 1020 Brussels, Belgium

A. Bechara
University of Southern California, Los Angeles, CA, USA

A. Bechara
Clinical Research Division, Douglas Mental Health University Institute, Montreal, QC, Canada

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Introduction

Impairment in recognition of severity of disorder (i.e., lack of insight) is one of the most common observations from the clinics of addiction. For instance, only 4.5 % of the 21.1 million persons classified as needing (but not receiving) substance use treatment reported a perceived need for therapy (SAMHSA 2007). Often considered by many clinicians as the expression of a psychological defense against suffering, this lack of insight can take the form of failure to recognize an illness. As suggested by Goldstein et al. (2009), addiction could be conceptualized, similarly to blind-sightedness where patients report they cannot see the visual cues that actually guide their behavior, as a compromised ability to recognize external (e.g., self-report judgment) and internal (e.g., behavior or brain behavior) drug-related cues. The underestimation of the addiction severity might drive these individuals' excessive drug use, where control of use becomes exceedingly deregulated.

Impaired insight ability could be estimated through the evaluation of metacognition capacity (Moeller et al. 2010). Metacognition refer to as our ability to introspect about self-performance. In other terms, metacognitive sensitivity refers to the ability to discriminate correct from incorrect performance (Cleeremans et al. 2007). The idea that metacognition is impaired in gambling addiction has received indirect support from previously identified dissociations between subjective evaluation of performance and actual performance. For instance, frequent gamblers tend to be overconfident and to exhibit more risk-taking behaviors prior to making what are considered as wrong choices (Goodie 2005; Lakey et al. 2007). Nevertheless, although these studies are suggestive of a deficit of metacognition, they have not tested this hypothesis directly.

In a recent investigation (Brevers et al. 2012), we initially examined metacognition capacities in pathological gamblers during decision making under uncertainty, as measured by the Iowa Gambling Task (IGT; Bechara et al. 1994). Metacognition was assessed by asking participants to wager on their own decisions (i.e., post-decision wagering; see Persaud et al. 2007). Our main finding was that, unlike non-problematic gamblers, problem gamblers tend to wager high while performing poorly on the IGT. Overall these results suggested that pathological gamblers exhibited impairments not only in their ability to correctly assess risk in situations that involve ambiguity, but also in their ability to correctly express metacognitive judgments about their own performance. That is, pathological gamblers not only perform poorly, but they also erroneously estimate that their performance is much better than it actually is. However, there were several limitations to the interpretation of the results of this previous investigation. For instance, the idea that post-decision wagering constitutes an objective measure of awareness has been recently challenged. Indeed, several studies (Schurger and Sher 2008; Fleming and Dolan 2010) have reported that post-decision wagering could be significantly influenced by sensitivity to loss and reward (in particular loss aversion), for which problem gamblers are impaired (for a review see, van Holst et al. 2010). Moreover, the gambling-like context induced by the IGT could have further contributed to exacerbate abnormal post-wagering behavior in problem gamblers.

Here, in order to put forth the argument that metacognition is compromised in problem gamblers, we used a non-gambling task, that is, an artificial grammar-learning task (AGL; Reber 1967, 1989). This paradigm provides a more "neutral" situation of decision-making as compared with the IGT, while preserving a level of uncertainty, which makes it possible to explore metacognitive sensitivity (Fleming et al. 2010). A typical AGL paradigm consists of two phases. During the training phase, participants are first exposed to a succession of strings of letters. The strings are generated by a complex set of rules, typically a finite state grammar (see Fig. 1). During the second phase (i.e., the test session), participants are asked to classify new strings according to whether they obey the rules or not. Generally, depending on the grammar, participants exhibit better than chance classification accuracy in this second phase, yet remain unable to completely motivate their decisions, which is suggestive that learning in the first phase resulted in implicit knowledge (Reber 1967).

In the current study, participants were asked to indicate how confident they were in their grammaticality decisions using a scale ranging from 1 (low confidence) to 7 (high confidence) on each trial of the test phase of the AGL task. A positive correlation between judgment accuracy and the confidence rating reflects individual metacognitive judgment (Kunimoto et al. 2001; Galvin et al. 2003; Lau and Passingham 2006). In other words, metacognitive ability is expressed as the mapping between objective performance (in this case, the accuracy of grammatical judgment) and subjective confidence in the accuracy of such an objective judgment. In this context, we expected that, in contrast with controls, there would be no significant correlation between confidence rating and the quality of choice made by problem gamblers, i.e., we would observe a dissociation between self-perception of behavior and actual behavior. Finally, we also hypothesized that diminished performance for problem gamblers would remain after controlling for the effect of potential confounding factors such as anxiety, depression and IQ level.

Method

Participants

Two groups participated in the study: (1) a control group ($n = 25$) and (2) a problem gamblers group ($n = 25$). All subjects were adults (>18 years old) and provided informed consent that was approved by the appropriate human subject committee at the Brugmann University Hospital. The demographic data on the two groups are presented in Table 1.

Recruitment and Screening Methods

Gamblers were recruited through advertisement in the casino complex *VIAGE*, Brussels, Belgium. The ads asked for participants who "gambled frequently" to participate in a 1-day study to explore factors associated with gambling. In order to exclude occasional or non-frequent gamblers, a telephone-screening interview was conducted by means of a

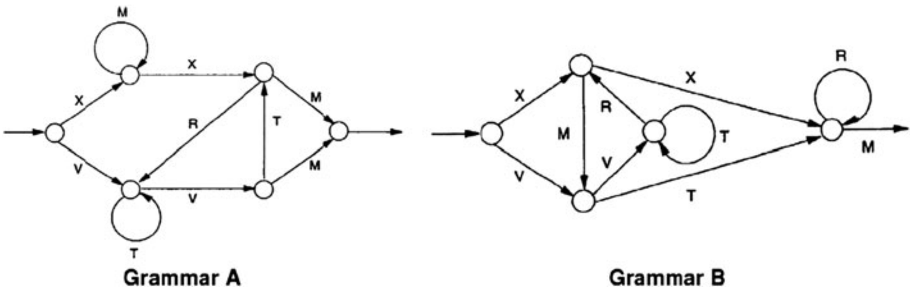

Fig. 1 The two finite state grammars used to generate the strings (taken from Reber 1967)

Table 1 Demographical data and current clinical status for problem gamblers and normal control groups

	Controls	Gamblers	*p* value
n	25	25	
Years of study	≤12: 83.3 %	≤12: 75 %	.47[a]
	>12: 16.6 %	>12: 25 %	
Males/females	18/7	19/6	.75[a]
Age	30.50 (7.54)	32.09 (9.10)	.56[b]
Gambling frequency (day/month)	0.52 (0.34)	15.56 (8.79)	.001[b]
SOGS	0.00 (0.00)	8.56 (4.79)	.24[b]
Cig/day	3.00 (5.74)	5.85 (8.07)	
Alcohol use (day/month)	5.16 (3.76)	6.04 (3.49)	.33[b]
STAI-E	29.84 (9.41)	37.88 (11.26)	.005[b]
STAI-T	35.79 (11.31)	45.19 (11.22)	.002[b]
BDI	2.50 (4.03)	6.95 (6.16)	.003[b]
ASRS	3.72 (2.74)	4.88 (2.80)	.14[b]
ASC	50.45 (11.56)	44.13 (15.59)	.18[b]
WAIS VOC	44.68 (6.27)	44.76 (6.74)	.93[b]
WAIS BLOC REP	15.36 (1.84)	14.40 (2.66)	.25[b]
WAIS BLOC TR	19.64 (5.56)	21.52 (6.91)	.30[b]

Values shown are the mean and standard deviations on each measure

SOGS South Oaks Gambling Screen, *STAI-E* state version of the state-trait anxiety inventory, *STAI-T* trait version of the state-trait anxiety inventory, *BDI* beck depression inventory, *ASRS* adult ADHD self-report scale, *ASC* attentional control scale, *WAIS VOC* WAIS vocabulary, *WAIS BLOC REP* WAIS block design correct responses, *WAIS BLOC TR* WAIS bloc design reaction time

[a] Chi Square test

[b] Wilcoxon-Mann–Whitney rank-sum test (two-sided)

locally developed screening tool including an examination of frequency of gambling behavior and comorbid psychiatric disorders.

Participants from the control group were recruited by word of mouth from the community (e.g., hospital employees). To avoid biases, resulting from inside knowledge of how these tasks operate, psychiatrists, psychologists and other personnel with psychological training were excluded from participation.

We excluded any subject who was (a) over 65 years, or (b) experienced either a substance use disorder during the year before enrollment into the study. Participants were judged to be medically healthy on the basis of their medical history. The presence of problems related to substance use and medical history were examined with items taken from the Addiction Severity Index short form (ASI; Mclellan et al. 1992; the selection of items was undertaken by S.M. and P.V.; CHU-Brugmann board-certified psychotherapists). More specifically, items selected from the ASI - short form investigated the frequency of a specific behavior (e.g., In the past 30 days, how many days have you used alcohol) and the presence of a specific disorder (e.g., Experienced serious depression?).

All problem gamblers ($n = 25$) scored ≥ 3 on the South Oaks gambling screen (SOGS; Lesieur and Blume 1987), indicative of problem gambling. In addition, pathological gambling was assessed by using the DSM-IV-TR. We observed that 15 (60.0 %) of the 25 problem gamblers met the DSM-IV criteria for pathological gambling. On the SOGS, only 7 controls (28.0 %) reported playing the numbers or betting on lotteries occasionally (i.e., less than once a week) over the past 12 months preceding testing. None of the other controls gambled. All control scored 0 on the SOGS (see Table 1).

Current Clinical Status

Current clinical status of depression, anxiety and ADHD were rated with French versions of the Beck Depression Inventory (Beck et al. 1961), the Spielberger State–Trait Anxiety Inventory (STAI; Spielberger 1983) and the Adult ADHD Self-Report Scale (ASRS-v 1.1, part A; Kessler et al. 2005), respectively. Information related to alcohol use (day/month) and alcohol intoxication has been collected by means of the ASI—short form interview. The number of cigarettes per day was also included on the basis of previous studies (e.g., Heishman 1998) that highlighted an effect of nicotine dependence on cognitive processing (e.g., sustained attention).

Intelligence and attentional control were also examined. We assessed intelligence with two subtests of the WAIS, block design and vocabulary (Wechsler 2000). This short form of the WAIS correlates with the full scale WAIS IQ in the 0.90 range (Groth-Marnat 1997). Attentional control was estimated with the Attentional Control Scale (ACS; Derryberry and Reed 2002).

Materials

Two finite state grammars were used to generate the letter strings. Both grammars were taken from (Reber 1967) and are shown in Fig. 1. Both grammars use the same letter set (M, T, V, R and X) and contain the same set of valid starting bigrams and final letters. Forty-five grammatical strings between five and nine characters in length were selected from each grammar. The training sets comprised 15 strings (of the 45 strings from the appropriate grammar) repeated three times in random orders. The test set comprised a combination of 30 strings from each grammar that had not been seen during training, combined in random order. The selection of strings was made such that there was the same number of strings of each length in both training sets and that the proportion of strings of each length was the same for training and test sets. The grammar strings used are listed in the Appendix.

Strings were presented in black on a white background at the center of a 13-in computer screen with a letter height of 11 mm. The viewing distance was approximately 55 cm and the letter size selected to achieve an average visual angle for the string widths of 2.8°. This visual angle was chosen to match the average for strings of the same length in Buchner (1994).

Procedure

An intake interview was first undertaken, which included screening (in the gambler group: DSM-IV criteria for pathological gambling; in the control group: substance use and medical history on the basis of items taken from the ASI—short form) and self reports measures (SOGS score, current clinical status and demographics for all participants).

AGL Training Stage Participants were made aware that complex set of rules dictated which letters could follow which other letters within the strings, and instructed that they should attempt to identify the rules. Strings were presented one at a time for 5 s each with a 2 s blank screen between strings. Participants were no permitted to write or make notes during training.

AGL Test Stage AGL task is notable for the controversial claim that subjects acquire knowledge which allows them to distinguish strings which follow the same rules as a set of previously memorized strings, from those which do not, but that they are not consciously aware of this knowledge (Reber 1967, 1989). Nevertheless, it has been reported (e.g., Chan 1992) that, compared with subjects given no-searching instructions before training, there was an association between confidence and performance in participants who were aware of the rule-governed nature of the strings. Hence, in order to promote the occurrence of metacognitive processes, participants were informed that exactly half of the strings they were about to see would obey the same complex set of rules as those in the training stage.

Test strings were presented on the computer display one at a time, with participants allowed to advance through them at their own pace. After each string presentation, participants had to indicate the following in the answer booklet provided: whether or not they believed the string obeyed the same rules as those in the learning phase (yes or no, hereafter referred to as their grammatically judgment) and their confidence in their judgment (from 1 to 7 on a likert scale; 1 = not at all, 7 = totally).

Data Analyses

Judgment Accuracy Judgment accuracy was the percentage of strings correctly classified as grammatical or non-grammatical during the test phase of the AGL task. Firstly, we performed a one sample Wilcoxon signed rank test, for each group, with percentage of grammaticality judgments correct and level of chance (.50) as median test value. Secondly, a Wilcoxon-Mann–Whitney test was performed with percentage of grammaticality judgments correct as test variable and group as grouping variable.

Level of Confidence Level of confidence was the mean of confidence ratings for each judgment of the test phase. Firstly, we performed one sample Wilcoxon signed rank test, for each group, with level of confidence and 4 (contrast between lower and higher confidence level) as median test value. Secondly, Wilcoxon-Mann–Whitney test was performed with confidence level as test variable and group as grouping variable.

Metacognition Metacognition was assessed according to the extent to which confidence was correlated with accuracy (i.e., the zero-correlation criterion; Chan 1992). In order to determine the relationship between judgment accuracy and confidence, Spearman correlation coefficient analyses were conducted between proportion of grammatically judgment correct and mean of confidence ratings. This analysis was undertaken separately for controls ($n = 25$) and problem gamblers ($n = 25$).

Non-parametric statistical tests have been chosen due to the small size of the present sample. Wilcoxon signed rank tests were performed using SigmaXL V6 for Mac OS X. Wilcoxon-Mann–Whitney test and Spearman correlation coefficient analyses were performed using SPSS 19 for Mac OS X.

Results

Demographics and Current Clinical Status

A description of demographic variables, scores on the South Oaks Gambling Screen (SOGS), Beck Depression Inventory (BDI), the Trait and State version of the State-Trait

Anxiety Inventory (STAI), Adult ADHD Self-Report Scale (ASRS-v 1.1), Attentional Control Scale, alcohol use (day/month), average number of cigarettes smoked per day and estimated IQ are presented in Table 1. Chi square analyses revealed no differences in the number of male and female participants. Depression was higher in problem gamblers than in controls (see Table 1). Trait and state anxiety were higher in the problem gamblers in comparison with the control group (see Table 1). No other group difference was present.

Judgment Accuracy

The mean percentage of judgments as grammatically correct in controls was 72.2 % ($SD = 14.9$). Wilcoxon one sample signed rank test indicated that the median percentage of judgments as grammatically correct was significantly greater than chance (50.0 %) (median = 73, Wilcoxon Statistic = 294.50, $p < .0001$), indicating that learning had taken place.

With regards to problem gamblers, the mean percentage of judgments as grammatically correct was 63.8 % ($SD = 14.2$). Wilcoxon one sample signed rank test indicated that the median percentage of judgments as grammatically correct was significantly greater than chance (median = 61, Wilcoxon Statistic = 240.00, $p = .002$), which reveals that learning had taken place, as in control participants.

However, the mean percentage of judgments as grammatically correct was higher in controls than in problem gamblers, (Mann–Whitney U statistic = 210.00, Z = −1.99, $p = .046$), indicating that learning was better in controls than in problem gamblers.

Level of Confidence

The mean percentage of confidence ratings for each judgment of the test phase was 4.41 ($SD = .91$) in controls, and was 4.43 ($SD = .81$) problem gamblers. In both gamblers and controls groups, Wilcoxon one sample signed rank test indicated that the median percentage of confidence ratings was significantly greater than 4, which is indicative of a high confidence level [controls: median = 4.17, Wilcoxon Statistic = 248.00, $p = .022$; gamblers: median = 4.36, Wilcoxon Statistic = 249.50, $p = .019$]. There was no significant difference between controls and problem gamblers on mean scores of confidence level [Mann–Whitney U statistic = 301.00, Z = -.22, $p = .82$].

Metacognition

In controls (n = 25), analyses revealed that the proportion of correct grammatical judgments was significantly correlated with mean scores of confidence level [Spearman rho = .54, $p < .006$]. In problem gamblers (n = 25), analyses revealed that the percentage of judgments as grammatically correct was not significantly correlated with mean scores of confidence level (Spearman rho = −.20, $p = .26$). Results for correlation analyses are depicted in Fig. 2.

Correlation Between AGL Performances, Current Clinical Status and Gambling Problem Severity

Among participants with gambling-related problems, we found no significant correlation (Spearman Rho) between judgment accuracy or level of confidence during the AGL, and

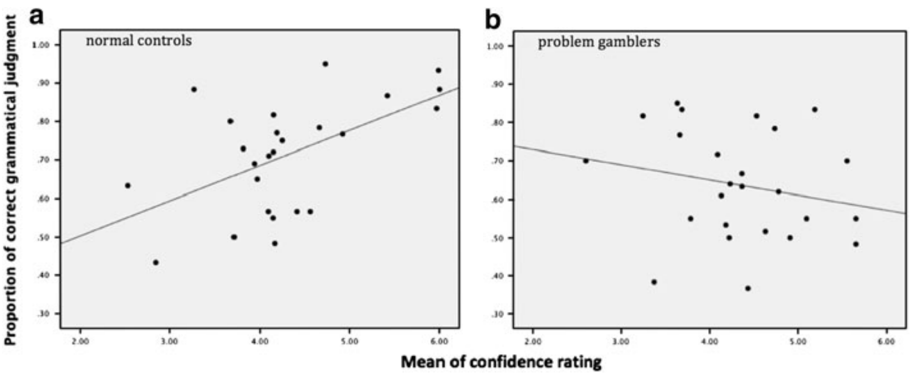

Fig. 2 Correlation between proportion of correct grammatical judgment and mean of confidence rating in **a** normal controls and **b** problem gamblers

their scores on depression, anxiety trait, anxiety state, attention capacity or gambling problem severity.

Discussion

The aim of this paper was to examine metacognitive capacities of problem gamblers, which is thought to play a key role in the failure to recognize having a problem or to minimize the extent of a problem. Metacognitive ability was estimated by using an AGL paradigm and throughout an examination of the relationship between proportion of correct grammatical judgment and participants' confidence in their judgment.

We observed that the confidence level in controls participants tends to vary according to their performance, whereas that of problem gamblers does not. These results persisted after controlling for other possible confounds (age, sex, cigarette smoking, IQ, anxiety, ADHD, depression), which is consistent with the idea that metacognition may represent cognitive dimension that could underlie symptomatology of gambling addiction. In addition, we observed a diminished accuracy of judgements as grammatically correct in problem gamblers, which suggests that diminished ability to estimate the quality of one's own decision is associated with choice adjustments.

Results of the present study complement our previous study investigating metacognitive capacity in gambling addiction (Brevers et al. 2012), by means of which we highlighted that pathological gamblers not only perform poorly on the IGT, but they also erroneously think that they are performing much better than they actually are (i.e., they tend to wager high while performing poorly). The present study rules out the alternate explanations related to reward and loss sensitivities and confirm the presence of metacognitive impairment in problem gamblers. Taken together, the results of our previous and current studies suggest that problem gamblers exhibit impaired metacognition in both gambling-like (e.g., IGT with post-decision wagering; Brevers et al. 2012) and more "neutral" situations of decision-making (e.g., the AGL task). In other words, problem gamblers exhibit a fundamental impairment in their capacities to discriminate correct from incorrect among various situation of decision-making.

Similar as the IGT, poor judgment of problem gamblers on the AGL task could be a result of impairment in a range of cognitive (e.g., working memory; Waldron and Ashby

2001) and emotional (e.g., pre-choice emotional activation; Bierman, Destrebecqz, & Cleeremans, 2005) factors (for a review see Goudriaan et al. 2004; Van Holst et al. 2010). Therefore, further studies are needed to disentangle these processes and also to assess their relationship to metacognitive processes. Another possibility would be to examine metacognitive ability using less complex or multi-determinate task, such as simple perceptual decisions paradigms (Fleming et al. 2010; Song et al. 2011).

A limitation of this study is that we only recruit casino gamblers. Therefore, our conclusions may not apply to all types of problem gamblers (e.g., poker gamblers, sports betters). The use of the SOGS in order to distinguish low problem gambler from non-problem gambling is also limitation of the present study. Indeed, although the SOGS has been the most commonly used measure of problem gambling, several problems with its use have been identified. Most notably, evidence suggests that the SOGS over-estimates the rate of problem gambling (Stinchfield 2002). Another limitation of the present study is that performance on the AGL varies across participants. Hence, participants' metacognitive judgments were not estimated on a same level of uncertainty. In order to obtain a more consistent evaluation, future studies should investigate metacognition on a per-participants basis. For instance, Fleming et al. (2010) determined metacognitive ability at an individual level by keeping participant's performance at a constant level. As a last limitation, due to small sample size, present results must be interpreted with caution. Therefore, it is certainly important to extend this research to a larger sample and to various types of gamblers, which has both extreme ends of the spectrum of gambling dependence well represented.

Future studies are also needed in order to specify the nature of metacognitive impairment in problem gambling. For instance, functional neuroimaging studies could probe the neural basis of these deficits (see Fleming for a brain approach of metacognition in healthy participants). Indeed, recent investigation showed that the prefrontal cortex (brain area for which pathological gamblers exhibit diminished neural activity during decision-making; Tanabe et al. 2007), and especially the dorsolateral part of the prefrontal cortex, play a key role in the development of metacognition. For instance, Del Cul et al. (2009) showed that prefrontal lesions could affect subjective reports of visual experience more than visual task performance. Moreover, Slachevsky et al. (2001, 2003) have shown that lesion affecting the prefrontal cortex also affects awareness as well as the monitoring of actions or sensory-motor readjustments. Other studies showed that bilaterally depressed activity in the dorsolateral prefrontal cortex using transcranial magnetic stimulation, can affect metacognition but not task performance during a visual discrimination task (Rounis et al. 2010; Turatto et al. 2004). In this cross-sectional study, we cannot determine whether poor metacognition is a consequence or/and a cause of gambling behaviors. Interestingly, children in kindergarten (mean age, 5.5 years) with ADHD symptoms are both at risk to exhibit gambling-related problems at 11.5 years (Pagani et al. 2009) and show poor metacognition (e.g., they overestimate their scholastic competence, Hoza et al. 2002). Thus, poor metacognitive judgment could be a critical factor in the onset of a gambling-related disorder. In this context, a better understanding of metacognition and interoception processes in addiction could improve therapeutic strategies for treating addictive disorders. For instance, a higher awareness of alcohol dependence severity predicted actual abstinence for up to 1 year after treatment in alcoholics (Kim et al. 2007). Hence, targeting addicted individuals who have reduced self-awareness for tailored treatments might potentially improving currently available inter-vention approaches and could bridge the gap between the onset of addictive state and motivation for treatment in both substance and non-substance addiction.

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Appendix

Training-strings and test strings used in all experiments

Length	Training		Testing	
	Grammar A	Grammar B	Grammar A	Grammar B
7	XMXRTVM	VVTRMTM	XMMXRVM	VTRRRRM
7	VVTRVTM	VVTTRXM	XXRTVTM	VVRXRRM
7	VTVTRVM	VVRMTRM	XXRTTVM	XMVRXRM
7	VTTTTVM	XMTRRRM	XMMMMXM	XXRRRRM
8	VTTVTRVM	XMVTTRXM	VVTRTTVM	XMVTRXRM
8	VVTRTVTM	VVTTRXRM	XMMXRTVM	VVTTRMTM
8	VTTTTVTM	VVTRXRRM	VTTTTTVM	VVRMTRRM
8	XXRVTRVM	VVRMVRXM	XMXRTVTM	XMVTRMTM
8	VTVTRTVM	XMVRXRRM	XMXRTTVM	XMVRMTRM
8	XMMMMMXM	VTRRRRRM	XXRTTTVM	VVTTTRXM
9	XXRTVTRVM	XMVRXRRRM	XXRVTRVTM	VVRMTRRRM
9	VTVTRTTVM	VVRMVTRXM	XMXRTTTVM	VVRMVRMTM
9	XMMMXRVTM	VVTTTRMTM	VVTRTTVTM	XMVRMVRXM
9	XMMMMXRVM	XMVTRXRRM	VTTVTRTVM	VVTTRXRRM
9	XXRVTRTVM	XXRRRRRRM	XMXRVTRVM	VVTTTRXRM
9	XMMMXRTVM	VVTTRMTRM	VVTRTTTVM	XMVTTRXRM

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