Consciousness and Cognition 49 (2017) 227–236

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Future-oriented mental time travel in individuals with disordered gambling

Xavier Noël [a,*], Mélanie Saeremans [b], Charles Kornreich [a,b], Nematollah Jaafari [d,e], Arnaud D'Argembeau [c]

[a] Laboratoire de Psychologie Médicale et d'Addictologie, Université Libre de Bruxelles (ULB), Belgium
[b] Centre Hospitalier Universitaire Brugmann, Psychiatry Department, Clinic of Behavioural Addictions, Brussels, Belgium
[c] Unité de Recherche en Psychologie et Neuroscience Cognitives, Université de Liège, Belgium
[d] Unité de Recherche Clinique Intersectorielle en Psychiatrie à vocation régionale Pierre Deniker, Centre Hospitalier Henri Laborit, Poitiers, France
[e] Université de Poitiers - INSERM CIC-P 1402 du CHU de Poitiers - INSERM U 1084, Experimental and Clinical Neuroscience Laboratory - Groupement de Recherche CNRS 3557, Poitiers, France

ARTICLE INFO

Article history:
Received 6 October 2016
Revised 16 January 2017
Accepted 6 February 2017
Available online 20 February 2017

Keywords:
Gambling
Future-oriented mental travel
Autonoetic consciousness

ABSTRACT

This study investigated the ability of individuals with disordered gambling to imagine future events. Problem gamblers (n = 35) and control participants (n = 35) were asked to imagine positive and negative future events for three temporal distances (one week, one year, 5–10 years). Then, a variety of phenomenological aspects of their future thoughts (e.g., sensory and contextual details, autonoetic consciousness) were rated. Compared to control subjects, problem gamblers generated fewer positive and negative events across all temporal distances, an impairment that was correlated to verbal fluency scores. Furthermore, problem gamblers rated imagined events as containing fewer sensory and contextual details, and lacking autonoetic consciousness. These findings demonstrate that problem gambling is associated with a reduced future-oriented mental time travel ability and, in particular, with diminished autonoetic consciousness when imagining future events.

1. Introduction

Recently reclassified as a 'Substance-Related and Addictive Disorder' in the Diagnostic and Statistical Manual Version 5 (DSM-5) (American Psychiatric Association, 2013), gambling disorder offers a unique condition to examine nonchemical factors in addiction. Around 2% of the general worldwide population (Hodgins, Stea, & Grant, 2011) shows non-ambiguous signs of poor control of their behavior despite the presence of multiple negative consequences—a main characteristic of addiction (APA, 2013). Several lines of research (e.g., personality, genetic, cognitive neuroscience) give weight to the idea that impulsivity is an active ingredient of disordered gambling (Grant, Odlaug, & Chamberlain, 2016; Odlaug, Schreiber, & Grant, 2013). For instance, gambling addiction is associated with sub-optimal decision-making, such as a high delay discounting rate and a lack of consideration for delayed consequences (Brevers, Bechara, Cleeremans, & Noël, 2013; Petry, 2001).

* Corresponding author at: Psychological Medicine Laboratory, Université Libre de Bruxelles, CHU-Brugmann, CP403/21, place Van Gehuchten, 4, 1020 Brussels, Belgium.
E-mail address: xnoel@ulb.ac.be (X. Noël).

http://dx.doi.org/10.1016/j.concog.2017.02.006
1053-8100/

Considering these findings, deleterious gambling behavior could be conceived as a series of decisions undertaken with insufficient forethought, a phenomenon that characterizes an impulsive mode of decision-making. Surprisingly little is known, however, about the capacity of individuals with disordered gambling to mentally navigate the future. Yet future-oriented mental time travel is crucial for human decision making and provides, in particular, a motivational 'brake' that counters impulsive and short-sighted decisions (Boyer, 2008). Research has indeed shown that future-oriented thoughts are common in everyday life (D'Argembeau, Renaud, & Van der Linden, 2011) and may support adaptive behaviors and self-control (Bulley, Henry, & Suddendorf, 2016).

Interestingly, episodic stimulation of the future, and in particular its emotional component, relies on the ventromedial prefrontal cortex (Benoit, Szpunar, & Schacter, 2014; Bertossi & Ciaramelli, 2016; D'Argembeau, Xue, Lu, Van der Linden, & Bechara, 2008), a brain region involved in decision-making under uncertainty (Platt & Huettel, 2008), which is disturbed in problem gamblers, notably when playing the Iowa Gambling task (Brevers et al., 2013). In addition, a shortened time horizon has been evidenced in individuals with addictive behavior (e.g., Keough, Zimbardo, & Boyd, 1999; Sher, Trull, Bartholow, & Vieth, 1999), including pathological gambling (Hodgins & Engel, 2002; but see Mackillop, Anderson, Castelda, Mattson, & Donovick, 2006). These different lines of research raise the possibility that disordered gambling might in part be due to difficulties in episodic foresight. Better understanding these potential future-oriented thought disturbances may prove useful for inspiring novel cognitive interventions addressing problem gambling.

From this perspective, the current study sought to investigate both quantitative (number of imagined events; MacLeod & Byrne, 1996) and qualitative (phenomenological characteristics; D'Argembeau & Van der Linden, 2004) aspects of future-oriented thought in problem gambling. In particular, we were interested in assessing potential differences in fundamental dimensions of episodic foresight (Atance & O'Neill, 2001): the amount of sensory and contextual details experienced when imagining future events and associated subjective feeling of mental time travel (referred to as autonoetic consciousness; (D'Argembeau & Van der Linden, 2012). We also explored whether the effects of the emotional valence (positive versus negative) and temporal distance of imagined events on these different aspects of future thoughts (D'Argembeau & Van der Linden, 2004) are modified in individuals with problem gambling.

Our second aim was to clarify the possible roles of future time perspective (i.e., individual differences in the general tendency to anticipate the future and plan for future goals; Zimbardo & Boyd, 1999) and episodic foresight (i.e., the ability to mentally simulate specific future events) in problem gambling. Previous studies have shown that future time perspective is significantly (although only moderately) related to measures of episodic foresight, such as the number of sensory descriptions provided when imagining future events (D'Argembeau, Ortoleva, Jumentier, & Van der Linden, 2010) or ratings of autonoetic consciousness (Arnold, McDermott, & Szpunar, 2011). In the present study, we investigated whether future time perspective and episodic foresight may each contribute to gambling problems. Given the contribution of working memory and executive resources in episodic foresight (Cole, Morrison, & Conway, 2013; D'Argembeau et al., 2010; Hill & Emery, 2013), and reported executive deficits in problem gamblers (Brevers et al., 2012), working memory and verbal fluency were also assessed.

Our main hypothesis was that individuals with disordered gambling would present future-oriented mental time travel deficits and especially a reduced episodic foresight (i.e., a lower experience of sensory and contextual details and autonoetic consciousness when imagining future events), considering the importance of this process in making (mal)adaptive decisions (Bulley et al., 2016). We also explored to what extent episodic foresight and future time perspective are associated constructs in problem gamblers.

2. Method

2.1. Participants

Thirty-five problem gamblers (with various gambling problem severity) and 35 control participants participated in the study. This sample size was determined in order to achieve a statistical power of 90%, considering an alpha error of 0.05 and a between-group effect size of $d = 0.80$ (using G*Power 3; Faul, Erdfelder, Lang, & Buchner, 2007). Problem gamblers were recruited through advertisement in different gambling areas (e.g., casino) across Belgium. Control participants were recruited mainly by word of mouth and through advertisement on social media (e.g. Facebook) and were not informed about the purpose of our research before the face-to-face interview. This procedure ruled out the possibility that control participants were particularly interested in gambling studies and practice. Participants who responded to the recruitment ads were screened over the telephone to ensure eligibility. All problem gamblers had a minimum of 3 on the Canadian Problem Gambling Index (CPGI) and fulfilled a minimum of 4 DSM-5 diagnostic criteria of gambling disorder. Thirty-four control participants had a score of 0 and 1 participant had a score of 2 of the CPGI. Suicidal intentions, acute psychotic symptoms, or current involvement in gambling treatment were exclusionary criteria. In addition, a minimum Mini-Mental State Examination (MMSE, Folstein, Folstein, & McHugh, 1975) score of 25 was required in order to exclude participants with severe cognitive impairment. Criteria were intentionally minimally restrictive to increase generalization. Participants were compensated 40 euros for their participation. The local ethical committee approved this study and all participants gave their informed written consent after the study had been fully described to them.

2.2. Materials

2.2.1. Cognitive and clinical measures

In order to evaluate whether potential cognitive deficits frequently reported in problem gamblers accounted for future thought characteristics, all participants received a validated French adaptation of phonemic and semantic fluency tasks (Cardebat, Doyon, Puel, Goulet, & Joanette, 1990), in which participants were allowed two minutes to generate as many words as possible beginning with the letter 'P', and to generate as many animal names as possible. Working memory was also assessed using the operation span task (Ospan; Turner & Engle, 1989), in which participants were requested to solve mathematical operations while simultaneously remembering a set of unrelated words. The Ospan score was calculated according to the partial credit unit (PCU) scoring procedure (Conway et al., 2005).

Given the high comorbidity between gambling problem and alcohol use disorders, the Alcohol Use Disorders Identification Task (AUDIT; Bohn, Babor, & Kranzler, 1995) was administrated. Positive and negative affect as well as depressive were investigated with the Positive and Negative Affect Schedule (Watson, Clark, & Tellegen, 1988) and the Beck Depression Inventory short version (Beck & Steer, 1993; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). The Fagerström Test of Nicotine Dependence (FTND) (Heatherton, Kozlowski, Frecker, & Fagerström, 1991) was also administered.

The Canadian Problem Gambling Index (CPGI) (Ferris & Wynne, 2001) was used to assess gambling severity scores. In this questionnaire, while thinking about the past 12 months participants have to fill a 9-item(s) questionnaire assessing problem gambling behavior (e.g. Loss of control; "How often have you bet more than you could really afford to lose?") and adverse consequences of gambling (e.g. Social consequences; "How often has your gambling caused any financial problems for you or your household?"). For each item, a score of 1 is given for "sometimes," 2 for "most of the time," and 3 for "almost always." The total score ranges between 0 and 27. The CPGI showed good validity (i.e., construct, criterion, content validity) in previous studies (Ferris & Wynne, 2001; Mcmillen & Wenzel, 2006). The internal consistency of this measure was good (alpha = 0.84) and higher than other measures such as DSM-IV and the often used South Oaks Gambling Screen (Ferris & Wynne, 2001). Test-retest reliability was judged as acceptable (0.78).

2.2.2. Fluency of future-oriented thoughts

Quantitative aspects of future-oriented mental time travel were assessed using a future event fluency task (MacLeod & Byrne, 1996). The participants were instructed to think about three time periods in the future (the next week, the next year, and the next 5–10 years) and two emotional valences (positive versus negative events). For each period and valence, they were asked to imagine as many events as possible that might happen in their personal future (e.g., "imagine as many positive events as possible that might happen to you during the next week"). It was specified that their productions could refer to trivial or important events, but should refer to things that might reasonably happen to them in the future. No mention was made of the specificity of events. For each condition, participants were given 60 s to generate as many events as possible. The total number of events for each category was computed.

2.2.3. Phenomenological characteristics of future-oriented thoughts

Qualitative aspects of future-oriented mental time travel were assessed by asking participants to rate their subjective experience while imagining six of the future events that had been generated in the fluency task (one event per category). Detailed written instructions explained that the events participants were to imagine had to be precise and specific (i.e., events that happen in a specific place at a specific time and that last a few minutes or hours but not more than an day); some examples were provided to illustrate what would or would not be considered as a specific event. The experimenter made sure that the participant clearly understood the notion of specificity before starting the task.

For each event category, participants were asked to select the first specific event that they had produced in the previous future event fluency task and they were instructed to imagine this event in as much detail as possible (i.e., "imagine the setting and course of the event, people and objects that would be present, your feelings, and so forth") in order to mentally 'pre-experience' the situation. Immediately after having imagined each event (i.e., a positive in one week, a negative in one week, a positive in one year, a negative event in one year, a positive event in 5–10 years, a negative event in 5–10 years), participants rated their subjective experience using 7-point rating scales adapted from the Memory Characteristics Questionnaire (Johnson, Foley, Suengas, & Raye, 1988) and modified appropriately for the future thinking task (see Table 1 in D'Argembeau & Van der Linden, 2006). Recent findings suggest that sensory-contextual qualities and autonoetic experience (the subjective sense of "pre-experiencing" imagined events) are fundamental, distinguishable aspects of episodic future thoughts (D'Argembeau & Van der Linden, 2012). In the present study, these two dimensions were investigated by computing two indices from participants' ratings: an index of sensory and contextual details, and an index of autonoetic experience. More specifically, the first index was computed by averaging responses to items related to sensory and contextual details: (1) 'My representation of this event involves visual details: 1 = none, 7 = a lot'; (2) 'My representation of this event involves other sensory details (sound, odours, taste): 1 = none, 7 = a lot'; (3) 'My representation of the location where the event takes place is: 1 = not at all clear, 7 = extremely clear'; (4) 'My representation of the people and objects involved is : 1 = not at all clear, 7 = extremely clear'. The index of Autonoetic consciousness was computed by averaging responses to the items: (1) 'While imagining the event, I feel as though I am experiencing it: 1 = not at all, 7 = completely'; (2) 'While imagining the event, I feel that I travel forward to the time when it would happen: 1 = not at all, 7 = completely'.

Table 1
Demographic and clinical data of the participants.

	Problem gamblers (PrG) (n = 35)	Healthy controls (HC) (n = 35)	Statistics
Age (in years)	33.17 (7.92)	34.00 (11.47)	t(68) = 0.35, p = 0.73
Education (in years)	14.11 (1.81)	14.94 (1.98)	t(68) = 1.82, p = 0.07
Gender (M)	32	34	Chi^2 = 1.07, p = 0.30
CPGI	9.49 (4.57)	0.06	t(68) = −12.17, p < 0.001
AUDIT	8.26 (5.93)	5.31 (4.54)	t(68) = −2.33, p = 0.02
FTND	0.94 (2.00)	2.37 (2.89)	t(68) = −2.40, p = 02
PAS	33.89 (5.78)	36.74 (6.30)	t(68) = 1.95, p = 0.05
NAS	23.06 (8.47)	19.31 (6.34)	t(68) = −2.09, p = 0.04
BDI	6.23 (4.58)	2.60 (2.96)	t(68) = −3.93, p < 0.001
Ospan	0.83 (0.08)	0.87 (0.07)	t(68) = −1.93, p = 0.06
Sem Fluency	27.14 (4.90)	30.09 (5.71)	t(68) = 2.31, p = 0.02
Phonetic Fluency	21.80 (4.14)	24.94 (4.00)	t(68) = 3.23, p = 0.002

Note. Values shown are the mean and standard deviation (between brackets) on each measure. CPGI = Canadian Problem Gambling Index, AUDIT = Alcohol Use Disorders Identification Test, FTND = Fagerstrom Test for Nicotine Dependence, PAS = Positive Affect Schedule, NAS = Negative Affect Schedule, BDI = Beck Depression Inventory, OSPAN = Operation Span Task, Sem Fluency = Semantic Fluency.

For exploratory purposes, participants also assessed the following additional items, although we did not have specific hypotheses as to how these dimensions of episodic foresight might be affected in problem gambling: emotional valence ('While imagining the event, I feel an emotion: −3 = very negative,+3 = very positive'), the personal importance of imagined events ('This event is important to me: 1 = not at all, 7 = very important'), the extent to which they had previously thought about these events ('I already thought about this particular event: 1 = never, 7 = very often'), the perceived likelihood that the events would really happen in the future ('The probability that this event will really happen in the future: 1 = very unlikely, 7 = very likely'), and their subjective sense of proximity to the events ('This events seems subjectively close to me: 1 = very close, 7 = very far'). All rating scales were reviewed with participants to unsure that they clearly understood all dimensions of episodic future thoughts that they were instructed to assess.

2.2.4. Zimbardo time perspective task (ZTPI)

Participants' temporal perspective was evaluated using the ZTPI. This self-report questionnaire assesses five different types of time perspectives: past-negative (a regretful perspective towards a past that is perceived as having included trauma, sadness, and pain), past-positive (a warm, sentimental view of an individual's past), present-fatalistic (a hopeless and helpless perspective on the present), present-hedonistic (a risk-taking and impulsive perspective) and future (an individual's general orientation towards the future; (Zimbardo & Boyd, 1999; French adaptation by Apostolidis & Fieulaine, 2004). The inventory features 56 statements such as "I make decisions on the spur of the moment" and "I get nostalgic about my childhood," to which respondents indicate their level of agreement using a 5-point Likert scale (1 = very uncharacteristic of me; 5 = very characteristic of me). The inventory's five-factor structure has been supported by confirmatory factor analysis and has been shown to have test–retest reliability ranging between 0.70 and 0.80 and significant convergent and discriminant validity (Andrade, Belo, Milfont, & Pessoa, 2008; Zimbardo & Boyd, 1999).

2.3. Procedure

All participants were tested individually in a quiet environment, in two sessions of approximately 1.5 h each that were separated by a 15-min break. They completed the task and questionnaires in the following order: verbal fluency tasks (semantic and phonetic), future-oriented mental time travel tasks (future event fluency and phenomenological characteristics), a delay-discounting task (the results of which will not be presented here), and finally the self-report questionnaires (CPGI, AUDIT, PAS, NAS, BDI and ZTPI). All responses provided during tasks assessing future-oriented mental time travel were audiorecorded and then transcribed for scoring.

2.4. Analysis

All statistical tests were two-tailed. An alpha level of 0.05 was used, and effect sizes were estimated using partial eta-squared (η_p^2). SPSS (The Statistical Package for the Social Sciences version) 23.0 was used. Initial data analyses assessed differences between groups on demographic variables (e.g., gender, age) and current clinical status (depression, anxiety, positive mood). To test differences between groups on future-oriented mental time travel, we ran ANOVAS with event valence (positive vs. negative), and time (one-week, one-year and 5–10 year) as within-subject factors and group (problem gamblers, controls) as between-subjects factor. Post hoc analyses were pairwise comparisons and t-tests, when appropriate. Between-group differences on the mental time perspective (evaluated by the ZTPI scales) were tested with independent sample t-tests. Pearson's product-moment correlations were carried out to investigate the relationship between variables of interest (i.e., low mood,

future event fluency, autonoetic consciousness, sensory and contextual details of imagined events, future time perspective, and verbal fluency).

3. Results

3.1. Clinical data

Table 1 displays demographic and clinical data for the two groups. The two groups were similar in terms of age, gender, education, working memory (OSPAN) and positive affect intensity (PAS). Problem gamblers (PrG) showed more severe problem gambling severity (CPGI), nicotine dependence (Fagerstrom), negative affect intensity (NAS), alcohol use disorders (AUDIT) and depressive symptoms (BDI) than control participants (CONT). Scores and statistics are reported in Table 1.

3.2. Temporal perspective

On the ZTPI, PrG scored higher than CONT on Past Negative, Present Fatalistic and Present Hedonistic dimensions. No significant difference emerged for Future and Past Positive dimensions. Scores and statistics are reported in Table 2.

3.3. Future event fluency

We ran an ANOVA with event valence (positive vs. negative), and time (one-week, one-year and 5-year) as within-subject factors and group (PrG, CONT) as between-subjects factor on the number of events generated in the future fluency task (see Table 3 for *M*s. and *SD*s). A main effect of valence emerged, $F(1,68) = 4.81$, $p = 0.03$, $\eta_p^2 = 0.07$, showing that participants generated a greater number of positive than negative events. We also found a main effect of group, $F(1,68) = 6.92$, $p = 0.001$, $\eta_p^2 = 0.09$, with CONT generating more future events than PG ($p = 0.001$). No other main effect or interaction was significant ($ps > 0.13$). When looking at the relationship between future event fluency and measures of verbal fluency in problem gamblers, we found that the total number of future events generated across time and valence conditions was correlated to both semantic and phonemic fluency, $r = 0.41$, $p = 0.02$ and $r = 0.70$, $p < 0.001$, respectively.

3.4. Phenomenological characteristics of future-oriented thoughts

3.4.1. Sensory and contextual details

We ran an ANOVA with event valence (positive vs. negative), and time (one-week, one-year and 5–10 year) as within-subject factors and group (PrG, CONT) as between-subjects factor on the index of sensory and contextual details (see Table 4 for *M*s. and *SD*s). Main effects of valence $F(1,68) = 35.87$, $p < 0.001$, $\eta_p^2 = 0.35$ and time $F(2,68) = 15.28$, $p < 0.001$, $\eta_p^2 = 0.18$ were found. Follow-up comparisons revealed that participants reported more detailed representations for positive compared to negative future events, and for events that were imagined to happen in one week compared to the other two conditions (1 year and 5–10 years). We also observed a main effect of group $F(1,68) = 9.93$, $p = 0.002$, $\eta_p^2 = 0.13$, and a significant group x time interaction, $F(2,136) = 5.67$, $p = 0.004$, $\eta_p^2 = 0.08$, showing that CONT reported more detailed future event representations than PrG for events imagined in one-week and one-year, but not for events imagined in 5–10 years. The overall index of sensory and contextual details (i.e., averaged across times and valences) did not correlate with either semantic or phonemic fluency in problem gamblers, $r = -0.23$, $p = 0.18$ and $r = -0.009$, $p = 0.96$, respectively.

3.4.2. Autonoetic consciousness

An ANOVA on the index of autonoetic consciousness (see Table 4 for *M*s. and *SD*s) showed a main effect of valence $F(1,68) = 26.79$, $p < 0.001$, $\eta_p^2 = 0.28$, with positive events being associated with higher autonoetic experience scores than negative events. We also found a main effect of group $F(1,68) = 5.42$, $p = 0.02$, $\eta_p^2 = 0.07$, with CONT reporting a higher feeling of pre-experiencing imagined future events than PrG. The interactions between group and valence and between group $\times$ time were not significant ($ps > 0.40$). The overall index of autonoetic consciousness (i.e., averaged across times and valences) did not correlate with either semantic or phonemic fluency in problem gamblers, $r = -0.02$, $p = 0.90$ and $r = -0.10$, $p = 0.55$, respectively.

Table 2
Mean Scores for the Zimbardo Time Perspective Inventory (ZTPI) in problem gamblers (PrG) and Healthy Controls (HC).

	PrG (n = 35)	HC (n = 35)	Statistics
Past negative	22.46 (6.33)	26.87 (7.59)	t(68) = −2.65, p = 0.01
Past positive	24.69 (4.90)	24.49 (5.42)	t(68) = 0.16, p = 0.88
Present Hedonistic	60.89 (10.95)	55.74 (10.29)	t(68) = −2.03, p = 0.04
Present Fatalistic	20.86 (4.75)	15.37 (5.06)	t(68) = −4.28, p < 0.001
Future	39.54 (7.71)	41.57 (5.36)	t(68) = 1.28, p = 0.21

Note. Standard deviations are shown in parentheses.

Table 3
Mean events fluency scores for positive and negative events across temporal distance in problem gamblers (PrG) and Healthy Controls (HC).

	PrG	HC
Positive events		
1-week	4.77 (1.37)	5.40 (1.44)
1-year	4.80 (1.53)	5.66 (1.37)
5/10-year	4.51 (1.50)	5.54 (1.60)
Negative events		
1-week	4.80 (1.53)	5.66 (1.37)
1-year	4.54 (1.50)	5.37 (1.88)
5/10-year	4.60 (1.38)	5.11 (1.71)

Table 4
Mean subjective experience ratings for positive and negative events across temporal distance in problem gamblers (PrG) and Healthy Controls (HC).

	Sensory details and contextual information		Autonoetic consciousness	
	PrG	HC	PrG	HC
Positive events				
1-week	4.19 (1.01)	5.22 (1.17)	3.97 (1.66)	4.61 (1.25)
1-year	3.89 (0.97)	4.52 (1.30)	4.06 (1.64)	4.63 (1.35)
5/10-year	3.79 (1.23)	3.99 (1.15)	3.96 (1.66)	4.53 (1.32)
Negative events				
1-week	3.75 (1.44)	4.42 (1.28)	3.73 (1.51)	4.47 (1.36)
1-year	3.13 (1.16)	4.08 (1.24)	3.34 (1.39)	3.86 (1.17)
5/10-year	3.41 (1.28)	3.12 (1.21)	3.23 (1.43)	3.21 (1.43)

Note. Standard deviations are shown in parentheses.

3.4.3. Supplementary exploratory analyses

Similar ANOVAs were conducted for the additional dimensions of episodic future thoughts that were assessed by participants (see Table 5 for *M*s and *SD*s).

3.4.3.1. Personal importance. A main effect of time was found $F(2,136) = 4.49$, $p = 0.01$, $\eta_p^2 = 0.06$, showing that events imagined in one-week were judged less important than events imagined in the more distant future. The effect of group was not significant $F(1,68) = 2.23$, $p = 0.14$, $\eta_p^2 = 0.03$, and the interactions group x time and group x valence were not significant (*p*s > 0.28).

3.4.3.2. Emotional valence. Unsurprisingly, there was a main effect of the valence of imagined events, $F(1,68) = 274.81$, $p < 0.001$, $\eta_p^2 = 0.0.81$, with positive events being rated as more positive negative events. A main effect of time also emerged, $F(2,136) = 4.23$, $p = 0.02$, $\eta_p^2 = 0.06$, indicating that the valence of events was more pronounced for distant events. Finally, there was a significant group × valence interaction $F(1,68) = 7.36$, $p = 0.008$, $\eta_p^2 = 0.10$, positive events were rated as more positive in HC than PrG ($p = 0.006$), whereas the group difference was not significant for negative event ($p = 0.10$).

Table 5
Mean subjective experience ratings for positive and negative events across temporal distance in problem gamblers (PrG) and Healthy Controls (HC).

	Importance		Emotion		Previously thought		Probability		Proximity	
	PrG	HC	PrG	HC	PrG	HC	PrG	HC	PrG	HC
Positive events										
1-week	5.51 (1.48)	5.54 (1.27)	1.77 (1.26)	2.26 (0.98)	5.43 (1.65)	4.51 (1.63)	5.00 (1.28)	5.66 (1.64)	3.63 (1.48)	3.11 (1.57)
1-year	5.80 (1.45)	6.17 (1.04)	1.77 (1.52)	2.57 (0.98)	5.63 (1.50)	5.20 (1.45)	4.51 (1.36)	5.34 (0.99)	4.29 (1.43)	4.17 (1.52)
5/10-year	5.71 (1.47)	5.89 (1.11)	1.83 (1.18)	2.40 (0.65)	5.09 (1.58)	4.83 (1.64)	4.37 (1.33)	4.74 (1.07)	5.49 (1.36)	4.71 (1.38)
Negative events										
1-week	4.77 (1.82)	5.46 (1.48)	−0.69 (1.89)	−1.31 (1.69)	4.89 (1.64)	3.97 (1.54)	4.26 (1.48)	3.83 (1.60)	3.77 (1.66)	3.57 (1.56)
1-year	5.26 (1.90)	5.46 (1.58)	−1.49 (1.65)	−1.77 (1.40)	4.69 (1.55)	3.57 (1.46)	3.37 (1.54)	3.57 (1.67)	5.23 (1.65)	4.71 (1.27)
5/10-year	5.29(1.98)	5.91 (1.50)	−1.14 (1.80)	−1.77 (1.66)	5.43 (1.65)	3.11 (1.45)	3.40 (1.44)	3.86 (1.67)	4.83 (1.74)	5.51 (1.52)

Note. Standard deviations are shown in parentheses.

3.4.3.3. Previous thoughts about the imagined events. There was a main effect of valence, $F(2,136) = 50.21$, $p < 0.001$, $\eta_p^2 = 0.43$, showing that participants had previously thought about positive events more often than negative events. We also found a main effect of group, $F(1,68) = 13.05$, $p = 0.001$, $\eta_p^2 = 0.16$, with PrG having previously thought about the imagined events more often than CONT. Interestingly, a valence x group interaction emerged, $F(1,68) = 4.38$, $p = 0.04$, $\eta_p^2 = 0.06$, showing that the higher frequency of previous thought in PrG was more pronounced for negative events ($p < 0.001$) than for positive events ($p = 0.06$).

3.4.3.4. Judgments of the likelihood of imagined events. There was a main effect of time, $F(2,136) = 7.39$, $p = 0.02$, $\eta_p^2 = 0.10$, with participants considering that events imagined in one week were more likely to happen than events imagined in more distant futures (one-year, $p = 0.001$; 5–10 years, $p = 0.001$). A main effect of valence was also observed, $F(1,68) = 65.94$, $p < 0.001$, $\eta_p^2 = 0.49$, with participants judging positive events as more likely than negative events ($p < 0.001$). A main effect of group showed that PrG reported imagined events as less likely than controls ($F(1,69) = 4.25$, $p = 0.04$)). There was no significant interaction between group and other factors (time or valence).

3.4.3.5. Sense of proximity. Unsurprisingly, the subjective sense of proximity was stronger for events that were imagined to happen sooner than latter (one week versus one year versus 5–10 years; all p-values < 0.01) as revealed by a main effect of time $F(2,136) = 41.53$, $p < 0.001$, $\eta_p^2 = 0.38$. In addition, there was a significant group x time interaction $F(1,68) = 7.10$, $p = 0.01$, $\eta_p^2 = 0.10$, indicating that PrG had a reduced sense of temporal distance for events imagined in the distant future. Indeed, unlike HC, PrG did not feel events imagined in 5–10 years as more distant than events imagined in one year ($p = 0.01$).

3.5. Relationship between future time perspective and episodic foresight in problem gamblers

Finally, we investigated whether future time perspective (one's general orientation towards the future) was related to episodic foresight in problem gamblers. The correlations between future time perspective and sensory/contextual details and autonoetic consciousness were small and not statistically significant, $r = 0.25$, $p = 0.15$ and $r = 0.19$, $p = 0.27$, respectively.

4. Discussion

The present study sought to investigate whether individuals with disordered gambling (problem gamblers, PrG) have a compromised ability to mentally navigate the future. A first important finding is that, although problem gamblers displayed an equivalent consideration for the future as control participants (as evaluated by the ZTPI), they displayed reduced future-oriented thinking abilities. Specifically, they imagined fewer future events in a future event fluency task and showed reduced episodic foresight—their future thoughts lacked episodic details and richness (sensory details and contextual information) and were associated with a reduced autonoetic consciousness. To our knowledge, these results are the first to demonstrate that individuals with problem gambling exhibit future-oriented mental time travel impairments.

In terms of quantitative aspects of future-oriented mental time travel, we found that the number of imagined future events in the fluency tasks was reduced in PrG. In terms of qualitative aspects of future-oriented thought, we found that PrG constructed less detailed representations of possible future events, and that they showed reduced autonoetic consciousness when imagining events. This latter result is particularly compelling considering the fact that PrG reported to have previously thought about imagined events more often than CONT, which is typically associated with higher autonoetic consciousness (D'Argembeau & Van der Linden, 2012). A closer inspection of our data also revealed that unlike normal controls who reported more sensory details for close than distant future events, PrG judged those phenomenological aspects as less differentiated across time distances. Relatedly, the subjective sense of temporal proximity of imagined events was more similar across temporal distances in PrG. These findings suggest mental representations of future events are less differentiated as a function of temporal distance in problem gamblers.

Taken together, these results provide important information that further our understanding of the cognitive processes that may underlie gambling behaviors. Previous studies have shown that disordered gambling is characterized by an automatic cognitive processing mode leading to habitual decisions and action routines driven by internal and external cues (Noël, Brevers, & Bechara, 2013a, 2013b). The capacity to mentally construct alternative futures may be crucial to counter this habitual processing and engage in more adaptive behavior. Deficits in mental time travel may thus lead to reduced behavioural flexibility (Suddendorf & Corballis, 2007), thereby maintaining damaging behavioural patterns such as problem gambling. In particular, to the extent that autonoetic consciousness may contribute to successful goal pursuit (e.g., by increasing motivation and effort to attain imagined future states), the alteration of the subjective experience of problem gamblers when they imagine future events could have important implications in terms of readiness to change and craving management. Indeed, although people who express stronger commitment to change their gambling behavior show better gambling outcomes over 12 months (Hodgins, Ching, & McEwen, 2009), a low level of autonoetic consciousness for imagined future events may weaken their motivation to achieve such future goals.

The impairment of mental time travel into the future in problem gamblers also raises the question of whether therapeutic interventions that improve episodic foresight might contribute to reduce disordered gambling. Techniques aiming at

increasing the subjective 'sense of self' when envisioning future events might be particularly useful. For example, in the context of relapse prevention, clinical interventions using guided mental imagery (Hackmann, Bennett-Levy, & Holmes, 2011) could promote the sense of pre-experiencing future events unrelated to gambling (e.g., enjoying watching a movie at the cinema). Such imagined future situations could act as counter-rewards that help resist immediate temptations (Boyer, 2008). Indeed, problem gamblers often experience an intense desire to gamble, which involves affectively charged sensory images that simulate the gambling experience (May, Andrade, Panabokke, & Kavanagh, 2004; May et al., 2014). The vividness of these gambling-related images sharply contrasts with the relatively poor mental images that problem gamblers form of their personal future. Therefore, it would be interesting in future work to investigate whether training future-oriented mental time travel helps counter gambling-related images and whether this moderates the relationship between craving intensity and the risk of relapse.

Recent research on episodic future thinking has shown that the ability to imagine future events depends on multiple component processes, including executive functions, visuo-spatial imagery, and self-consciousness (D'Argembeau et al., 2010). Although the present study did not aim at identifying the mechanisms at stake in the diminished capacity of mental time travel in problem gamblers, it is interesting to note that the number of imagined future events was related to executive functioning (i.e., verbal fluency tasks) in PrG. This finding suggests that executive deficits in pathological gamblers contribute to their diminished ability to imagine future episodes, a process that is largely preserved in non-pathological gamblers. However, alterations in the phenomenological experience of problem gamblers when they imagined future events were unrelated to verbal fluency performance (for a similar finding in long-term opiate users, see Mercuri et al., 2015). An important avenue for future research would be to investigate the possible contribution of other executive functions than those evaluated here (e.g., response inhibition) and of non-executive processes (e.g., visuo-spatial imagery) to the future thinking abnormalities observed in problem gamblers.

In terms of the valence of imagined events, we replicated the typical finding that people produce a greater number of positive events and that these are associated with more details and a higher sense of pre-experiencing than negative events (for review, see MacLeod, 2016). These valence effects were similar in the two groups, suggesting that disordered gambling is associated with a general reduction in mental time travel. Interestingly, however, exploratory analyses indicated that problem gamblers had previously thought about the imagined negative events more frequently than control participants and that the positive events they imagined were less positive. This suggests that problem gambling may be associated with a more negative/less positive view of one's personal future.

When examining time perspectives (as assessed by the ZTPI), we found that problem gamblers showed greater past negativism, present hedonism and present fatalism than control participants. Importantly, however, no difference was found on the future time perspective scale (for similar results, see Hodgins & Engel, 2002). These results indicate that future-oriented mental time travel and future time perspective are not reducible to each other, and that problem gambling are specifically associated with the former. Indeed, PrG showed a reduced capacity to envision future events but did not differ from controls in terms of their general future orientation. Besides, the correlation between future time perspective and our indices of episodic foresight were low and non significant.

Several limitations of the present study should be mentioned. First, a limitation of the cross-sectional nature of the present study that calls for more work is that it remains unknown whether the observed deficits in future-oriented mental time travel in problem gamblers represent a thinking style that emerges as a result of problem gambling symptomatology or whether it constitutes a more stable cognitive style that predisposes an individual to developing problem gambling. Whatever it may be, promising data from several recent studies indicate that episodic future thinking results in better control of impulsive behavior (e.g., food reduction in overweighted females, Daniel, Stanton, & Epstein, 2013; alcohol in heavy drinker, Snider, LaConte, & Bickel, 2016). Therefore, it would be interesting to further investigate whether training future-oriented time travel is also beneficial for individuals with problem gambling. A second limitation is related to the potential contribution of depressive symptoms in our main findings. Problem gamblers had indeed higher BDI scores than control participants and this difference could in part account for the observed reduction in episodic foresight ability (note that introducing BDI scores in the analyses to "control for" depressive symptoms would not be appropriate here as the two groups were determined nonrandomly; see Miller & Chapman, 2001). However, we believe that depressive symptoms are unlikely to entirely explain our results considering that, even if BDI scores were statistically higher in gamblers, they remained relatively low (Beck & Steer, 1993). Furthermore, measures of low mood as assessed by the Beck Depression Inventory and the Negative Affect Schedule were not correlated with measures of future thinking (future event fluency, sensory-perceptual details, autonoetic consciousness) in problem gamblers (all $rs < 0.22$, $ps > 0.20$).

In conclusion, this study shows that disordered gambling is associated with a reduced capacity for future-oriented thought and in particular a reduction in fundamental aspects of episodic foresight. These findings call for further exploration of the component processes underlying future thinking in problem gamblers, which has the potential to stimulate innovative forms of treatment.

Acknowledgements

X. Noël and A. D'Argembeau are supported by the Fonds de la Recherche Scientifique (F.R.S.-FNRS), Belgium.

References

American Psychiatric Association (2013). American Psychiatric Association., & DSM-5 Task Force. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5*.

Andrade, P. R., Belo, R. P., Milfont, T. L., & Pessoa, V. S. (2008). Testing Zimbardo time perspective inventory in a Brazilian sample. *Revista Interamericana de psicologia/Interamerican Journal of Psychology, 42*(1).

Apostolidis, T., & Fieulaine, N. (2004). Validation française de l'échelle de temporalité. *Revue Européenne de Psychologie Appliquée/European Review of Applied Psychology, 54*(3), 207–217.

Arnold, K. M., McDermott, K. B., & Szpunar, K. K. (2011). Individual differences in time perspective predict autonoetic experience. *Consciousness and Cognition, 20*(3), 712–719.

Atance, C. M., & O'Neill, D. K. (2001). Episodic future thinking. *Trends in Cognitive Sciences, 5*(12), 533–539.

Beck, A. T., & Steer, R. A. (1993). *Beck depression inventaory manual*. San Antonio: Psychological Corporation.

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry, 4*, 561–571.

Benoit, R. G., Szpunar, K. K., & Schacter, D. L. (2014). Ventromedial prefrontal cortex supports affective future simulation by integrating distributed knowledge. *Proceedings of the National Academy of Sciences of the United States of America, 111*(46), 16550–16555.

Bertossi, E., & Ciaramelli, E. (2016). Ventromedial prefrontal damage reduces mind-wandering and biases its temporal focus. *Social Cognitive and Affective Neuroscience*.

Bohn, M. J., Babor, T. F., & Kranzler, H. R. (1995). The Alcohol Use Disorders Identification Test (AUDIT): Validation of a screening instrument for use in medical settings. *Journal of Studies on Alcohol, 56*(4), 423–432.

Boyer, P. (2008). Evolutionary economics of mental time travel? *Trends in Cognitive Sciences, 12*(6), 219–224.

Brevers, D., Bechara, A., Cleeremans, A., & Noël, X. (2013). Iowa Gambling Task (IGT): Twenty years after – Gambling disorder and IGT. *Frontiers in Psychology, 4*, 665.

Brevers, D., Cleeremans, A., Verbruggen, F., Bechara, A., Kornreich, C., Verbanck, P., & Noël, X. (2012). Impulsive action but not impulsive choice determines problem gambling severity. *PloS One, 7*(11), e50647.

Bulley, A., Henry, J., & Suddendorf, T. (2016). Prospection and the present moment: The role of episodic foresight in intertemporal choices between immediate and delayed rewards.

Cardebat, D., Doyon, B., Puel, M., Goulet, P., & Joanette, Y. (1990). Formal and semantic lexical evocation in normal subjects. Performance and dynamics of production as a function of sex, age and educational level. *Acta Neurologica Belgica, 4*, 207–217.

Cole, S. N., Morrison, C. M., & Conway, M. A. (2013). Episodic future thinking: Linking neuropsychological performance with episodic detail in young and old adults. *Quarterly Journal of Experimental Psychology (2006), 66*(9), 1687–1706.

Conway, A. R. A., Kane, M. J., Bunting, M. F., Hambrick, D. Z., Wilhelm, O., & Engle, R. W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic Bulletin & Review, 12*(5), 769–786.

D'Argembeau, A., Ortoleva, C., Jumentier, S., & Van der Linden, M. (2010). Component processes underlying future thinking. *Memory & Cognition, 38*(6), 809–819.

D'Argembeau, A., Renaud, O., & Van der Linden, M. (2011). Frequency, characteristics and functions of future-oriented thoughts in daily life. *Applied Cognitive Psychology, 25*(1), 96–103. http://dx.doi.org/10.1002/acp.1647.

D'Argembeau, A., & Van der Linden, M. (2004). Phenomenal characteristics associated with projecting oneself back into the past and forward into the future: Influence of valence and temporal distance. *Consciousness and Cognition, 13*(4), 844–858.

D'Argembeau, A., & Van der Linden, M. (2006). Individual differences in the phenomenology of mental time travel: The effect of vivid visual imagery and emotion regulation strategies. *Consciousness and Cognition, 15*(2), 342–350.

D'Argembeau, A., & Van der Linden, M. (2012). Predicting the phenomenology of episodic future thoughts. *Consciousness and Cognition, 21*(3), 1198–1206.

D'Argembeau, A., Xue, G., Lu, Z.-L., Van der Linden, M., & Bechara, A. (2008). Neural correlates of envisioning emotional events in the near and far future. *NeuroImage, 40*(1), 398–407.

Daniel, T. O., Stanton, C. M., & Epstein, L. H. (2013). The future is now: Comparing the effect of episodic future thinking on impulsivity in lean and obese individuals. *Appetite, 71*, 120–125.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175–191.

Ferris, J., & Wynne, H. (2001). *The Canadian problem gambling index* Final report. Canadian Centre on Substance Abuse.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). «Mini-mental state». A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12*(3), 189–198.

Grant, J. E., Odlaug, B. L., & Chamberlain, S. R. (2016). Neural and psychological underpinnings of gambling disorder: A review. *Progress in Neuro-Psychopharmacology & Biological Psychiatry, 65*, 188–193.

Hackmann, A., Bennett-Levy, J., & Holmes, E. (2011). *Oxford guide to imagery in cognitive therapy*. Oxford University Press.

Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., & Fagerström, K. O. (1991). The Fagerström Test for Nicotine Dependence: A revision of the Fagerström Tolerance Questionnaire. *British Journal of Addiction, 86*(9), 1119–1127.

Hill, P. F., & Emery, L. J. (2013). Episodic future thought: Contributions from working memory. *Consciousness and Cognition, 22*(3), 677–683.

Hodgins, D. C., Ching, L. E., & McEwen, J. (2009). Strength of commitment language in motivational interviewing and gambling outcomes. *Psychology of Addictive Behaviors: Journal of the Society of Psychologists in Addictive Behaviors, 23*(1), 122–130.

Hodgins, D. C., & Engel, A. (2002). Future time perspective in pathological gamblers. *The Journal of Nervous and Mental Disease, 190*(11), 775–780. http://dx.doi.org/10.1097/01.NMD.0000038173.64197.93.

Hodgins, D. C., Stea, J. N., & Grant, J. E. (2011). Gambling disorders. *The Lancet, 378*(9806), 1874–1884.

Johnson, M. K., Foley, M. A., Suengas, A. G., & Raye, C. L. (1988). Phenomenal characteristics of memories for perceived and imagined autobiographical events. *Journal of Experimental Psychology. General, 117*(4), 371–376.

Keough, K. A., Zimbardo, P. G., & Boyd, J. N. (1999). Who's smoking, drinking, and using drugs? Time perspective as a predictor of substance use. *Basic & Applied Social Psychology, 21*(2), 149–164.

Mackillop, J., Anderson, E. J., Castelda, B. A., Mattson, R. E., & Donovick, P. J. (2006). Convergent validity of measures of cognitive distortions, impulsivity, and time perspective with pathological gambling. *Psychology of Addictive Behaviors: Journal of the Society of Psychologists in Addictive Behaviors, 20*(1), 75–79.

MacLeod, A. K. (2016). Prospection, well-being and memory. *Memory Studies, 9*(3), 266–274.

MacLeod, A. K., & Byrne, A. (1996). Anxiety, depression, and the anticipation of future positive and negative experiences. *Journal of Abnormal Psychology, 105*(2), 286–289.

May, J., Andrade, J., Kavanagh, D. J., Feeney, G. F. X., Gullo, M. J., Statham, D. J., ... Ellipsis Connor, J. P. (2014). The craving experience questionnaire: A brief, theory-based measure of consummatory desire and craving. *Addiction (Abingdon, England), 109*(5), 728–735.

May, J., Andrade, J., Panabokke, N., & Kavanagh, D. (2004). Images of desire: Cognitive models of craving. *Memory (Hove, England), 12*(4), 447–461.

Mcmillen, J., & Wenzel, M. (2006). Measuring problem gambling: Assessment of three prevalence screens. *International Gambling Studies, 6*(2), 147–174.

Mercuri, K., Terrett, G., Henry, J. D., Bailey, P. E., Curran, H. V., & Rendell, P. G. (2015). Episodic foresight deficits in long-term opiate users. *Psychopharmacology, 232*(7), 1337–1345.

Miller, G. A., & Chapman, J. P. (2001). Misunderstanding analysis of covariance. *Journal of Abnormal Psychology, 110*(1), 40–48.

Noël, X., Brevers, D., & Bechara, A. (2013a). A neurocognitive approach to understanding the neurobiology of addiction. *Current Opinion in Neurobiology, 23*(4), 632–638.

Noël, X., Brevers, D., & Bechara, A. (2013b). A triadic neurocognitive approach to addiction for clinical interventions. *Frontiers in Psychiatry, 4*, 179.
Odlaug, B. L., Schreiber, L. R. N., & Grant, J. E. (2013). Personality dimensions and disorders in pathological gambling. *Current Opinion in Psychiatry, 26*(1), 107–112.
Petry, N. M. (2001). Pathological gamblers, with and without substance use disorders, discount delayed rewards at high rates. *Journal of Abnormal Psychology, 110*(3), 482–487.
Platt, M. L., & Huettel, S. A. (2008). Risky business: The neuroeconomics of decision making under uncertainty. *Nature Neuroscience, 11*(4), 398–403.
Sher, K. J., Trull, T. J., Bartholow, B. D., & Vieth, A. (1999). Personality and alcoholism: Issues, methods, and etiological processes. In K. E. Leonard & H. T. Blane (Eds.), *Psychological theories of drinking and alcoholism* (2nd ed., pp. 54–105). New York, NY, US: Guilford Press.
Snider, S. E., LaConte, S. M., & Bickel, W. K. (2016). Episodic future thinking: Expansion of the temporal window in individuals with alcohol dependence. *Alcoholism, Clinical and Experimental Research, 40*(7), 1558–1566.
Suddendorf, T., & Corballis, M. C. (2007). The evolution of foresight: What is mental time travel, and is it unique to humans? *The Behavioral and Brain Sciences, 30*(3). 299-313-351.
Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language, 28*(2), 127–154.
Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*(6), 1063–1070.
Zimbardo, P. G., & Boyd, J. N. (1999). Putting time in perspective: A valid, reliable individual-differences metric. *Journal of Personality and Social Psychology, 77*(6), 1271–1288.