AKADÉMIAI KIADÓ

Journal of Behavioral Addictions

9 (2020) 2, 347-362

DOI: 10.1556/2006.2020.00019

FULL-LENGTH REPORT

Inhibitory control in poker: Do experienced non-pathological poker gamblers exhibit better performance than healthy controls on motor, verbal and emotional expression inhibition?

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Received: September 10, 2019 • Revised manuscript received: January 15, 2020 • Accepted: April 22, 2020 • Published online: June 5, 2020

ABSTRACT

Background and aims: Strategic games, such as poker, require gamblers to develop several skills to perform better than others and to expect a potential gain. Players must remain as unpredictable and unreadable as possible by inhibiting the expression of their emotions in response to both good and bad poker events. The aim of the present study was to compare several aspects of the inhibition process in experienced poker gamblers and controls to better understand how inhibitory control is involved in poker performance. *Methods:* Thirty experienced non-pathological poker gamblers (EG) and thirty healthy controls with no or limited poker experience (HC) completed 3 cognitive tasks. Each task measured a specific type of inhibition: motor inhibition [Go/No-Go task], verbal inhibition [Hayling Sentence Completion Task] and expressive inhibition [expressive suppression task, which combines subjective, expressive (facial EMG) and physiological (skin conductance, heart interbeat interval, cardiovascular and respiratory activation) measures of emotional experience]. Linear mixed models with random effects were performed. *Results:* Inhibitory control skills were similar between the two groups, regardless of the form of inhibition tested. The only difference observed in EG was a higher ability to partially suppress the physiological expression of emotion. However, this difference was only present for negative and positive emotional induction and was not maintained for emotional induction related to poker situations. *Discussion and conclusions:* The development of specific inhibition skills in experienced poker gamblers was not supported and raises questions about the transferability of poker skills previously discussed in the literature.

KEYWORDS

inhibition, gambling, poker, skills, expressive suppression, cognition

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INTRODUCTION

Recent literature on gambling suggests a growing interest in distinguishing between two types of gambling games: strategic and non-strategic games (Bjerg, 2010; Boutin, 2010; Challet-Bouju, Hardouin, Lagadec et al., 2015; Challet-Bouju, Hardouin, Renard et al., 2015; Mouneyrac et al., 2018). Non-strategic games are games of pure chance for which the outcome of the game is totally independent of the gambler's actions. In contrast, strategic games are those in which the gambler can use skills to influence the outcome of the game. Beyond the distinction between strategic and non-strategic games, the expected value is also important (Bjerg, 2010; Boutin, 2010; Challet-Bouju et al., 2015). In bank games, gamblers play against the gambling provider (the 'bank'), and the gambler cannot expect any benefit in the long run. In social games, in contrast, players play against each other and are on statistically equal footing, even if a gambling provider such as a casino facilitates the game. As a consequence, the expected value can vary from negative to positive depending on the relative skill gap between players, and the gambler can expect a benefit from the game over the long term in case of skill superiority compared with his opponents. Poker, especially the Texas hold'em (TH) variant, is the most played game in the social strategic games category (Boutin, 2010). To expect a long-term benefit, a poker gambler must try, as much as possible, to maintain a skill gap between himself and his opponents, which would be to his advantage. Studies have demonstrated that between a third and a half of poker gamblers are convinced that skill is predominant, or even the only factor needed, in poker (Sévigny, Ladouceur, Dufour, & Lalande, 2008; Wood, Griffiths, & Parke, 2007). The skills used in poker, such as the ability to inhibit one's emotions, exhibit patience, adapt the game according to an opponents' skill level, and take risks if needed, are often considered a unique dimension: a general ability in poker (Croson, Fishman, & Pope, 2008; Dedonno & Detterman, 2008; Turner & Fritz, 2001). Nevertheless, this binary view of poker performance is considered by some authors to be largely insufficient, and they suggest exploring different cognitive, emotional and social skills implemented in poker (Bouju, Grall-Bronnec, Quistrebert-Davanne, Hardouin, & Vénisse, 2013; McCormack & Griffiths, 2011).

Numerous cognitive functions have been explored as potential factors related to both gambling and gambling problems. These include cognitive flexibility, planning, decision making, response inhibition, learning and working memory, intellectual functioning and the capacity to adapt a strategy within the gambling environment (Challet-Bouju, Bruneau, Ignace, Victorri Vigneau, & Grall Bronnec, 2017). Response inhibition, also referred to as inhibitory control, is the subject of the largest portion of cognitive studies on gambling (Challet-Bouju et al., 2017). Inhibitory control is defined as the capacity to stop or substitute all or some mental processes with or without intention (MacLeod, 2007). This system encourages the interruption of an ongoing behaviour when facing a potential menace (Billieux, Rochat, & Van der Linden, 2014). This system comprises the ability to inhibit a predominant response and the ability to inhibit distractors in the external environment. Inhibitory control in gambling is often explored in relation to motor inhibition. Motor inhibition includes both the suppression of the initiation of a motor response and the interruption of a previously conditioned on-going motor response (Billieux et al., 2014; Challet-Bouju et al., 2017; Verbruggen & Logan, 2008). Both suppression (Dubois, Slachevsky, Litvan, & Pillon, 2000; Kertzman et al., 2008) and interruption (Verbruggen & Logan, 2008) abilities have been found to be deficient in pathological gamblers, and a global deficit in motor inhibition was supported by a recent literature review by Chowdhury et al. (Chowdhury, Livesey, Blaszczynski, & Harris, 2017). In addition to motor inhibition, there are other forms of inhibitory control, such as verbal inhibition (inhibitory control applied to verbal expression) or emotional suppression (inhibitory control applied to emotional facial expression). These forms of inhibition are rarely, if ever, studied in the framework of gambling. Moreover, almost all studies on inhibition use problem or pathological gamblers as subjects, and studies on non-pathological gamblers are scarce. As a consequence, it remains unknown whether potential inhibitory control deficits are associated with gambling addiction or are more globally associated with gambling behaviour.

Some studies have investigated differences in neurocognitive functions (decision-making processes, delay discounting, reward/punishment sensitivity, motor impulsivity, cognitive flexibility, cognitive style, etc.) according to the preferred form of gambling, especially by comparing strategic and non-strategic problem gamblers (Goudriaan, Oosterlaan, De Beurs, & Van den Brink, 2005; Grant, Odlaug, Chamberlain, & Schreiber, 2012; Mouneyrac et al., 2018; Navas et al., 2017; Sharman et al., 2019). Among them, only few investigated specifically response inhibition with neurocognitive tasks, such as the Stop-Signal Task (Verbruggen & Logan, 2008), and failed to highlight any impairment in motor inhibition performances (Grant et al., 2012; Sharman et al., 2019). However, as for the whole gambling literature, studies have mainly focused on the exploration of motor inhibition and studies on the other forms of inhibitory control (verbal, emotional, etc.) are very scarce or even inexistent. Finally, none of them were exclusively focused on poker.

Performing a fine and thorough investigation of the inhibitory capacities of non-pathological poker gamblers, including the exploration of several aspects of the inhibition process, is therefore warranted. Such an investigation could be useful to better understand how inhibitory control could be involved in one's performance in poker. Indeed, taking the poker gamblers' point of view, a factor that could potentially determine the outcome of the game is the ability of poker gamblers to remain as unpredictable and unreadable as possible, by inhibiting the expression of their emotions in response to both good and bad poker events (Bouju et al., 2013). The expression of emotions is multimodal and can take various forms: bodily movements, gesture, facial muscle movements, vocal cues (Keltner, Sauter, Tracy, & Cowen, 2019). In the case of poker, players can betray their emotions in different ways, through gesture, facial movements or vocal clues to their opponents, which may interfere with the ability to remain unpredictable for opponents. The objective of this study was to investigate and compare the motor, verbal and expressive inhibition skills present in experienced non-pathological poker gamblers compared to healthy controls with no or limited poker experience. We were especially keen to test for inhibitory control superiority in experienced poker gamblers *versus* control participants. It was expected that experienced non-pathological poker gamblers would present higher inhibitory control abilities than controls, i.e. a higher performance on the cognitive tasks that explored motor, verbal and expressive inhibition. The originality of this study lies in the exploration of different forms of inhibition (motor, verbal and expressive) thought to be involved in experienced gamblers' superior performance in poker.

METHODS

Participants

As part of the PERHAPS study (NCT02590211), two groups of participants were studied: experienced non-pathological poker gamblers (EG; n = 30) and healthy controls (HC; n = 30).

The participants were recruited between February 2017 and May 2018 through radio announcements and networking and from within the registry of volunteers for research that was created by our research team. Participants were adult men under the age of 60. To be considered as an experienced poker player (EG group), participants had to gamble in TH poker at least once a week for at least 3 months. Healthy controls were non-poker gamblers or had to gamble less than once a month (poker or other gambling activities). Non-inclusion criteria were a known gambling disorder as assessed by the NODS criteria (number of criteria ≥4); a gambling ban, guardianship or curatorship; a high level of depression (BDI-13 score ≥16) or anxiety trait (STAI Y–B score ≥56); cognitive impairment (MMSE score ≤24); currently unstabilised psychiatric disorder; any use of psychoactive substances known to alter cognition before the assessment (other than psychiatric medications for stabilised psychiatric disorders and nicotine); physical condition incompatible with the assessment (especially Parkinson's disease); history of seizure; colour blindness; uncorrected audition and vision problems; any heart problems or electrical implants; or participation in any medication trial during the previous month.

Procedure

Volunteers who were interested in participating in the study could contact the research team by phone or email. A quick phone assessment was first performed to screen for eligibility, and eligible participants came into the research unit for approximately 2 hours to confirm their inclusion and to perform the research visit. Participants were assessed individually in a quiet room in the research unit. They completed several measures to assess inclusion criteria and confounding factors and then cognitive tasks to investigate inhibitory control. Go/No-Go and expressive suppression tasks were computer-administered, and all tasks were administered in a random order. Participants were seated in a comfortable chair and positioned 60 cm from the screen. Stimulus presentation and timing of computer-administered tasks were performed using the experimental software SuperLab 5 (Cedrus Corporation, San Pedro, CA, USA). Participants' responses were collected using the 7-button response pad RB-730 (Cedrus Corporation). Breaks were proposed to avoid fatigue.

Measures used for inclusion and to measure confounding factors

NODS – DSM5 version (Gerstein et al., 1999). Participants were screened for current gambling disorders based on the National Opinion Research Center DSM-IV Screen for Gambling Problems (NODS). We used a revised version of the NODS that we created to take into account the changes in the gambling disorders section in the DSM-5 (American Psychiatric Association, 2013). If a gambling disorder was identified (number of criteria ≥4), the participant was not included.

Beck depression inventory (BDI-13) (Beck, Steer, & Carbin, 1988; Collet & Cottraux, 1986). The shortened version of the BDI (BDI-13) self-report questionnaire was used, and participants with severe depression (score ≥16) were not included.

State-trait anxiety inventory (STAI) (Spielberger, 1983). The Y–B version (anxiety trait) of the STAI self-report questionnaire was used, and participants with high to very high anxiety levels (score ≥56) were not included.

Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975). The MMSE interview was used, and participants with cognitive impairment (score ≤24) were not included.

Mini International Neuropsychiatric Interview (MINI) (Lecrubier et al., 1997). The MINI interview was used to screen participants for axis 1 psychiatric disorders, especially mood disorders, anxiety disorders, psychotic syndrome, and addictive disorders (combining both alcohol use disorders and substance use disorders).

Measures used to investigate inhibitory control

Three cognitive tasks were used to measure inhibitory control. Each task measured a specific type of inhibition: motor inhibition (Go/No-Go task: GNG), verbal inhibition (Hayling Sentence Completion Task: HSCT) and expressive inhibition (Expressive Suppression Task: EST).

Go/No-Go task (GNG) (Dubois et al., 2000; Kertzman et al., 2008). The design of Kertzman et al. was reproduced in this study (Kertzman et al., 2008). This allowed the investigation of pure response inhibition deficits with minimal working memory involvement and no emotional bias (Kertzman et al., 2008; Rebetez, Rochat, Billieux, Gay, & Van der Linden, 2015). We only used the GNG condition of the task. Red and black squares (80*80 pixels) were briefly presented (100 ms) in a random order at the centre of the screen against a white background. Participants were asked to respond to red squares (Go stimuli) by pressing a red button on the response box with their dominant hand and to withhold a response when black squares (No–go stimuli) were presented. The GNG task consisted of frequent Go trials (80%) and rare No–go trials (20%). Participants were instructed to respond as quickly as possible to Go trials within a maximum time frame of 2,000 ms. A constant interstimulus interval of 500 ms was used. They were instructed to keep their fingers over the keys to always be ready to respond. In addition to Kertzman's design, feedback was added when the response time was longer than 800 ms on Go trials, to stress the urge to respond. Three blocks of 50 trials were displayed, resulting in the presentation of 150 stimuli total. To ensure a good understanding of the task, participants performed a 15-trial practice. For Go trials, response times less than 250 ms were considered implausible responses (anticipative responses). Behavioural indices of performance were the number of commission errors (a response to a No-go trial) and the speed-accuracy trade-off index. A higher number of commission errors is characteristic of individuals with addiction and reflects defective inhibitory control (Brevers & Noel, 2013), i.e. a difficulty in delaying automatic responses (Kertzman et al., 2008). The speed-accuracy trade-off index is calculated as the sum of correct responses divided by the average go trial response time. A high score indicates good overall performance, either in terms of number of correct responses or the speed of responses (Bottesi, Ghisi, Ouimet, Tira, & Sanavio, 2015).

Hayling sentence completion task (HSCT) (Burgess & Shallice, 1997). We used the version created by the Neuropsychology Unit of the Cognitive Sciences Department of the University of Liège (Psychology and Education Sciences Faculty), with the kind permission of the authors (Meulemans, Andrès, Vincent, & Van der Linden, 1999). The HSCT consists of two series of fifteen incomplete sentences (the last word is missing). The interviewer reads the sentence aloud, and the participants have to give the last word as quickly as possible. Reaction times were recorded with a stopwatch and corresponded to the time between the last word pronounced by the interviewer and the beginning of the participant's first answer. In the first series, participants were asked to complete sentences with the expected word. The reaction times and error scores in this series provided a measure of the speed and quality of the initiation of a verbal automatic response (control condition). In the second series, participants were asked to complete sentences with a word that makes the sentences meaningless, i.e. without close links to the sentence or to the expected word. The reaction times and error scores in this series provided a measure of the verbal inhibition of a prepotent response (inhibition condition). A time limit of 30 s was given for responding. Moreover, penalties (0, 1 or 3 points) were given with respect to Burgess and Shallice's procedure (Burgess & Shallice, 1996). In the inhibition condition, if the participant gave the automatic word or did not respond during the 30 s period, he or she received a three-point penalty. When the response was not the automatic word, a one-point penalty was given when the spoken word was connected to the automatic word, i.e. a plausible word (one that provides an unusual sense to the sentence, or that is semantically or phonetically linked to the expected word); was a response that was grammatically incorrect or composed of several words; was a word that had already been given or a word that was to be inhibited in the previous sentences; or was a neologism, proper noun, or an obscenity. When the response was correct (unrelated response), the participant received zero points. For the automatic condition, the scoring rules were reversed: three points were given for an unrelated response, 1 point for a response somewhat connected to the expected word, and 0 points for the target word. To ensure the reliability of the scoring system, each item was rated twice by two independent staff members, and any discrepancy was discussed until a consensus was reached. To ensure that the participants understood the instructions properly, they were given 2 practice sentences before each series began. Indices of performance were calculated for each condition and comprised (i) the total response latency (in seconds), which is the summed response times, rounded to the next highest integer, across all fifteen sentences, including errors; and (ii) the total error score, which is the sum of penalties across all fifteen sentences.

Expressive suppression task (EST) (Gross & Levenson, 1993, 1997)

Procedure. We adapted the expressive suppression task (EST) from (Gross & Levenson, 1993, 1997) from its original purpose to investigate the capacity of participants to hide, inhibit or reduce ongoing emotional expressive behavioural responses (Cutuli, 2014). Participants were instructed to watch several films carefully and to do their best not to let their feelings show. The participants' faces were filmed during the entire procedure to verify that the participant did not look away while watching the films. Before each film, a 1 min relaxing period was systematically given. Four types of films were presented to all participants: neutral, positive, negative and poker-related films. Each type of film was presented twice, via two different excerpts. Video clips lasted between 30 s and 3 min and 30 s. Neutral, positive and negative excerpts were from the FilmStim database created by Schaefer et al. (Schaefer, Nils, Sanchez, & Philippot, 2010). Four poker-related films were created specifically for this study and were previously validated on 15 volunteers recruited between September and December 2016. The two excerpts that elicited the highest increase in arousal between the relaxing period and the film viewing period were selected. The two excerpts showed poker end-of-tournament scenes with strong emotional valence. The presentation order of films was randomised.

Dependent variables. We isolated data in this task from two periods of interest: during the relaxing period (pre-film period; 60 s) and during the film viewing period (film period; 30 s to 3 min and 30 s). During the pre-film and film periods, emotional experience was measured and consisted of three components:

(i) *Measure of expressive behaviour.* We measured expressive behaviour with electromyography (EMG). The electrical activities (μV) of the *corrugator supercilii* and the *zygomaticus major* muscles were recorded from the left side of the face. *Corrugator supercilii*'s activity is highly activated during frowning and is associated with negative emotions, whereas *zygomaticus major*'s activity is highly activated during smiling and is associated with positive emotions (Ekman & Friesen, 1976). EMG raw signals were collected using the pre-amplified mini-Trigno EMG wireless system (Delsys, Natick, MA, USA) using miniature (25/12/7 mm) wireless surface EMG sensors (specifically designed for small and difficult-to-isolate muscles, such as facial muscles) and specific adhesive skin interfaces. The mini-Trigno EMG sensors comprise two fixed parallel bars with an interelectrode distance of 1 cm, which allows the signal to the muscle underneath the electrode to be amplified and isolated (Swanson, Holst, Infante, Poenitzsch, & Ortiz, 2016). The positioning of the EMG sensors was performed with respect to the guidelines proposed by Fridlund and Cacioppo (Fridlund & Cacioppo, 1986), after slight abrasion to the surface of the skin using alcohol wipes. Data collection was performed at a sampling rate of 1926 samples per second, with a signal bandwidth of 20 (±5) – 450 (±50) Hz, as recommended for facial EMG signals (van Boxtel, August 24–27, 2010).

(ii) *Measure of physiological arousal.* Following Gross and Levenson's procedure, we continuously recorded several indicators of the activity of the physiological systems modified by emotional responding (Gross & Levenson, 1997) with various transducers: [a] skin conductance (μS): GSR amplifier connected with two sensors positioned on the middle and index fingers of the non-dominant hand, [b] heart interbeat interval (ms): Trigno wireless EKG sensor connected with two disposable electrodes positioned in a bipolar configuration on the upper chest, [c] finger temperature (°C): skin temperature sensor positioned on the ring finger of the non-dominant hand, [d] finger pulse amplitude (mV): IR plethysmograph clip positioned on the ring finger of the non-dominant hand, [e] pulse transit time to the finger (ms): time between the R wave of the EKG signal and the upstroke of the finger pulse amplitude signal, [f] respiratory period (ms) and depth (mV): Piezo respiratory belt transducer positioned on the chest. Signals from the physiological measures were amplified and filtered using 16-channel data acquisition hardware (PowerLab 16/35P, AdInstruments, Oxford, UK).

(iii) *Measure of subjective experience.* We used the modified version of the Differential Emotions Scale (DES) to assess discrete emotional experiences (Schaefer et al., 2010). Each item of the DES consists of a list of 1–3 emotional adjectives, and participants have to rate the extent to which they felt each state during the pre-film and film periods, using a 7-point Likert scale from '*not at all*' to '*very intense*'. As described by Schaefer et al., we computed positive (DES+) and negative (DES-) composite scores (Schaefer et al., 2010). Moreover, after each film, participants rated the difficulty of suppressing facial expressions in response to viewing the film on a visual analogue scale from 1 ('*not difficult at all*') to 7 ('*extremely difficult*').

Synchronization between stimulus presentation and event markers (SuperLab 5), EMG/EKG recordings (Trigno System) and the physiological indicators (PowerLab 16/35P) was performed using a StimTracker ST-100 (Cedrus Corporation). Signals were recorded, displayed and analysed on a laboratory computer with the LabChart 8Pro software (AdInstruments).

For expressive and physiological measures, video recording and data were inspected to detect any artefacts, and altered signals were excluded from subsequent analysis.

Data reduction. Concerning the expressive behaviour, EMG raw data were subjected to a root-mean square (RMS) transformation (Larsen, Norris, & Cacioppo, 2003). To quantify the EMG affective responses, we standardised individual EMG data, following the recommendation of van Boxtel for using facial EMG signals as an index of affective states (van Boxtel, August 24–27, 2010). To achieve this, we expressed averaged RMS-transformed EMG response magnitudes during the film period as percentages of the baseline level of muscle activation. The baseline value for each film was the averaged value of the RMS-transformed EMG response during the pre-film period. A ratio score over 100% thus indicates an increase in muscle activation, whereas a ratio under 100% indicates a decrease.

To investigate physiological arousal, we used 4 final physiological indices: mean heart interbeat interval (IBI), mean skin conductance response (SCR) amplitude, cardiovascular activation score and respiratory activation score. As proposed by (Gross & Levenson, 1997), the cardiovascular and respiratory activation scores reflect, respectively, the sympathetic activation of the cardiovascular system (composite score combining unit-weighted standardised values of finger pulse amplitude, pulse transit time to the finger and finger temperature) and the respiratory activation (composite score combining unit-weighted standardised values of respiratory period and depth) in response to emotion elicitation. For skin conductance, as we used relatively complex and temporally extended stimuli (film excerpts), we observed a large number and unstructured sequences of SCRs. Following the recommendations of Green et al. in this type of emotional elicitation (Green, Kragel; Fecteau, & LaBar, 2014), we isolated the observed SCRs through a peak analysis and calculated the averaged amplitude of SCR during each period and each type of film. We applied a minimum peak height of 0.02 μS as a criterion to identify an SCR (Green et al., 2014), with the baseline defined as the minimum between peaks. The mean heart IBI represented the mean interval, in ms, between two R waves. For these four physiological indices (mean heart IBI, mean SCR amplitude, cardiovascular activation score and respiratory activation score), change scores were calculated as the raw difference between the averaged value during the film period and the averaged value during the pre-film period.

Regarding subjective experience, scores for difficulty suppressing emotion were used without adjustment. For DES scores, change scores were calculated as the raw difference between the post-film score and the pre-film score.

Statistical analyses. Descriptive statistics were performed to determine the means and standard deviations of all variables. Possible confounding factors that may have affected performance on the different cognitive tasks were tested based on Student's t-, Mann–Whitney or Fisher's exact tests, depending on the nature of the variable. The confounding factors tested were age; education level; MMSE score; BDI score; STAI score; concomitant treatment; and current mood, anxiety, psychotic and alcohol or substance use disorders. When the potential confounding factors differed significantly between the two groups at a 0.05 level of significance, they were entered as covariates in the statistical analyses.

For the GNG task, independent linear mixed models with random effects were performed, with Group (EG/HC) as a between-subjects factor, Block (1, 2 or 3) as a within-subject factor, and the number of commission errors and the speed-accuracy trade-off index as the dependent measures. The interaction between Group and Block was also included in the model.

For the HSCT, independent linear mixed models with random effects were performed, with Group (EG/HC) as a between-subjects factor, Condition (control or inhibition) as a within-subject factor, and the mean response time and mean error score as the dependent measures. The interaction between Group and Condition was also included in the model.

For the EST, independent linear mixed models with random effects were performed, with Group (EG/HC) as a between-subjects factor, Type of film (neutral, positive, negative or poker-related) as a within-subject factor, and the difficulty to suppress emotion score or the changes scores (DES change scores, EMG ratio scores, and the 4 physiological change scores) as the dependent measures. The interaction between Group and Type of film was also included in the model.

The significance level was fixed at $p < 0.05$ for all analyses.

Ethics

Participants were informed about the research and gave their written informed consent prior to their inclusion in the study. This study was approved by the French Research Ethics Committee (CPP) on September 12, 2016. Participants received a €30 gratification for their participation.

RESULTS

Sample description

Of the 545 who contacted the research team, 375 were screened for eligibility (the 170 others were unreachable), of

Table 1. Description of the socio-demographic characteristics and gambling-related data of healthy controls (HC) and experienced non-pathological poker gamblers (EG) (n = 60)

Sociodemographic characteristics	HC group (n = 30) Mean (sd)	EG group (n = 30) Mean (sd)	Whole sample (n = 60) Mean (sd)
Age (years)	29.1 (10.2)	33.2 (7.8)	31.2 (9.3)
Educational level (number of years)	14.7 (2.0)	13.3 (2.6)	14.0 (2.4)
Monthly income (euros)	1,247.0 (1,000.6)	1,498.0 (853.7)	1,373.0 (930.7)
	N (%)	N (%)	N (%)
Marital status			
Single	9 (30.0 %)	6 (20.0 %)	15 (25.0%)
In a relationship	12 (40.0 %)	16 (53.3 %)	28 (46.7 %)
With family/friends	9 (30.0 %)	8 (26.7 %)	17 (28.3 %)
Professional activity			
Working	19 (63.4 %)	24 (80.0 %)	43 (72.7 %)
Student	10 (33.3 %)	2 (6.7%)	12 (20.0 %)
Not working	1 (3.3 %)	4 (13.3 %)	5 (8.3 %)
Gambling-related data	**Mean (sd)**	**Mean (sd)**	**Mean (sd)**
Age of gambling onset (years)	14.4 (4.6)	14.9 (3.9)	14.7 (4.2)
Duration of gambling history	12.1 (11.5)	18.3 (8.0)	15.2 (10.3)
	N (%)	N (%)	N (%)
Current gambling participation (last 12 months) (n = 53)			
Lotteries and scratch cards	9 (39.1 %)	18 (60.0 %)	27 (50.9%)
Electronic gambling machines	2 (8.7 %)	8 (26.7 %)	10 (18.9 %)
Black Jack	0	5 (16.7 %)	5 (9.4 %)
Horse race betting	1 (4.3 %)	7 (23.3 %)	8 (15.1 %)
Sports betting	4 (17.4 %)	21 (70.0 %)	25 (47.2 %)
Poker	2 (8.7 %)	30 (100.0 %)	32 (60.4 %)
Current gambling frequency (last 12 months) (n = 60)			
Once a week or more	0 (0.0%)	30 (100.0%)	30 (50.0%)
Less than once a week	13 (43.3%)	0 (0.0%)	13 (21.7%)
No gambling in the last 12 months	17 (56.7%)	0 (0.0%)	17 (28.3%)

Table 2. Descriptive results from the cognitive tasks in experienced non-pathological poker gamblers (EG) and healthy controls (HC) (n = 60)

Cognitive tasks	Variables of interest		EG group (n = 30) Mean (sd)	HC group (n = 30) Mean (sd)
Go/No-Go task	Number of commission errors (n = 59)	Block 1	0.72 (0.65)	0.67 (0.88)
		Block 2	0.93 (0.96)	0.93 (0.94)
		Block 3	0.79 (0.77)	1.30 (1.21)
	Speed accuracy trade-off index (n = 59)	Block 1	0.15 (0.01)	0.14 (0.02)
		Block 2	0.14 (0.01)	0.14 (0.02)
		Block 3	0.15 (0.01)	0.14 (0.03)
Hayling sentence completion task	Response latency (sec)	Control condition	15.20 (0.41)	15.23 (0.57)
		Inhibition condition	53.47 (26.56)	52.27 (29.33)
	Total error score	Control condition	0.20 (0.41)	0.20 (0.48)
		Inhibition condition	6.07 (2.86)	5.60 (2.47)
Expressive suppression task	EMG *Corrugator Supercilii* ratio score (% of baseline)	Neutral films (n = 57)	112.39 (24.81)	108.15 (35.21)
		Positive films	110.49 (26.73)	110.52 (36.67)
		Negative films (n = 59)	117.69 (40.60)	109.05 (15.14)
		Poker-related films	104.09 (16.43)	105.50 (12.63)
	EMG *Zygomaticus Major* ratio score (% of baseline)	Neutral films (n = 57)	97.01 (9.89)	95.77 (7.44)
		Positive films	122.39 (75.05)	154.78 (170.81)
		Negative films (n = 59)	96.64 (16.18)	100.24 (15.77)
		Poker-related films	106.13 (27.37)	94.44 (10.37)
	IBI change score (ms)	Neutral films (n = 54)	−15.24 (38.78)	−15.69 (31.04)
		Positive films (n = 57)	13.66 (81.76)	14.23 (42.44)
		Negative films (n = 56)	−2.66 (66.68)	18.01 (34.02)
		Poker-related films (n = 57)	1.79 (65.64)	5.94 (30.38)
	SCR amplitude change score (μS)	Neutral films (n = 56)	0.32 (1.12)	0.23 (0.60)
		Positive films (n = 59)	0.28 (0.62)	0.50 (0.76)
		Negative films (n = 57)	0.19 (0.46)	0.50 (0.86)
		Poker-related films (n = 59)	0.47 (0.67)	0.43 (0.84)
	Cardiovascular activation change score	Neutral films (n = 55)	0.21 (1.19)	0.27 (1.42)
		Positive films (n = 56)	0.33 (1.59)	−0.31 (2.14)
		Negative films (n = 56)	0.23 (1.42)	0.20 (1.51)
		Poker-related films (n = 57)	−0.64 (1.45)	−0.17 (2.12)
	Respiratory activation change score	Neutral films (n = 51)	0.18 (2.44)	−0.04 (1.49)
		Positive films (n = 54)	0.07 (1.67)	−0.10 (1.41)
		Negative films (n = 54)	−0.11 (1.30)	−0.05 (1.31)
		Poker-related films (n = 55)	−0.04 (1.34)	0.08 (1.42)
	Difficulty to suppress emotion score	Neutral films	1.18 (0.39)	1.33 (1.42)
		Positive films	3.72 (2.12)	4.03 (2.14)
		Negative films	2.95 (1.44)	3.28 (1.51)
		Poker-related films	2.82 (1.70)	1.90 (2.12)
	DES+ change score	Neutral films	−0.56 (1.07)	−0.82 (1.19)
		Positive films	0.14 (1.06)	0.69 (1.35)
		Negative films	−1.95 (1.39)	−1.23 (1.17)
		Poker-related films	0.07 (1.19)	−0.62 (1.02)
	DES- change score	Neutral films	−0.12 (0.27)	0.00 (0.22)
		Positive films	0.21 (0.66)	0.24 (0.68)
		Negative films	1.48 (1.22)	1.61 (1.38)
		Poker-related films	−0.04 (0.22)	0.06 (0.28)

Table 3. Results from linear mixed models applied to Go/No-Go task outcomes, comparing experienced non-pathological poker gamblers (EG) and healthy controls (HC) (n = 60)

	Estimate	Standard deviation	Confidence interval	p-value
Number of commission errors				
Group (HC group = ref)	0.15	6.32	[−4.36; 4.19]	0.886
Block (block 1 = ref)				
Block 2	2.20	6.13	[−1.58; 7.08]	0.216
Block 3	4.40	7.29	[0.22; 10.34]	**0.014**
Interaction group x block				
Group x Block 2	−0.71	8.83	[−7.11; 4.54]	0.760
Group x Block 3	−3.91	9.36	[−11.35; 1.07]	0.116
Speed accuracy trade-off index				
Group (HC group = ref)	0.01	0.06	[−0.00; 0.01]	0.279
Block (block 1 = ref)				
Block 2	0.00	0.00	[−0.01; 0.01]	0.690
Block 3	−0.00	0.00	[−0.01; 0.01]	0.780
Interaction group x block				
Group x Block 2	−0.01	0.00	[−0.02; 0.00]	0.246
Group x Block 3	0.00	0.00	[−0.01; 0.01]	0.961

Significant p values ($p < 0.05$) are indicated in bold.
Significant confounding factors (educational level, MMSE score) were entered as covariates.

Table 4. Results from linear mixed models applied to Hayling Sentence Completion Task outcomes, comparing experienced non-pathological poker gamblers (EG) and healthy controls (HC) (n = 60)

	Estimate	Standard deviation	Confidence interval	p-value
Response time				
Group (HC group = ref)	0.09	0.28	[−0.46; 0.63]	0.753
Condition (control = ref)	2.53	0.15	[2.23; 2.82]	<0.001
Interaction group x condition	0.02	0.21	[−0.39; 0.44]	0.907
Error score				
Group (HC group = ref)	−0.02	0.03	[−0.08; 0.04]	0.523
Condition (control = ref)	0.36	0.03	[0.31; 0.41]	<0.001
Interaction group x condition	0.03	0.04	[−0.04; 0.10]	0.437

Significant confounding factors (educational level, MMSE score) were entered as covariates.

which 289 were non-eligible and 26 refused to participate. At the end, 60 participants were included, 30 in each group, as expected.

Socio-demographic characteristics and gambling-related data are presented in Table 1. Regarding the confounding factors tested, the two groups were similar on all the variables except education level (HC group: 14.7 (2.0) years vs EG group: 13.3 (2.6) years; p-value 0.025) and MMSE score (HC group: 29.4 (0.9) vs EG group: 28.9 (1.1); p-value 0.031). As a consequence, these variables were entered as covariates in all the statistical analyses.

Table 2 displays the descriptive results from the cognitive tasks (GNG, HCST and EST) for the two groups.

Results of the Go/No-Go task

As presented in Table 3, GNG performances did not differ between groups, either concerning commission errors or the speed accuracy trade-off index. Only an effect of Block was found, with the number of commission errors increasing in block 3.

Results of the Hayling sentence completion task

As presented in Table 4, HSCT performances did not differ between groups concerning total response latency or total error score. Independent of the group, an effect of Condition was observed for both total response latency and total error score, with the inhibition condition being more difficult (higher response latencies and higher error scores), as expected.

Results of the expressive suppression task

EST performance is presented in Table 5.

Expressive behaviour. Figure 1 illustrates the comparison of *corrugator supercilii* and *zygomaticus major* EMG ratio scores between the two groups according to film emotional valence. Regarding the *corrugator supercilii*, we failed to reveal any significant effect, even for the Type of film. It was expected that negative films would induce higher activation of the *corrugator supercilii* than the other films. However, the instructions given to refrain from expressing any facial expression may explain the absence of activation in this

Table 5. Results from linear mixed models applied to Suppressive Expression Task outcomes, comparing experienced non-pathological poker gamblers (EG) and healthy controls (HC) (n = 60)

	Estimate	Standard deviation	Confidence interval	p-value
EMG Corrugator ratio score				
Group (HC group = ref)	2.75	5.90	[−9.07; 14.56]	0.643
Film type (neutral = ref)				
Poker-related	−0.76	4.85	[−10.30; 8.78]	0.876
Negative	1.68	4.85	[−7.86; 11.23]	0.729
Positive	3.79	4.86	[−5.77; 13.35]	0.436
Interaction group x film type				
Group x Poker-related	−7.21	6.73	[−20.45; 6.03]	0.285
Group x Negative	3.58	6.73	[−9.65; 16.82]	0.595
Group x Positive	−8.52	6.77	[−21.84; 4.79]	0.209
EMG Zygomaticus ratio score				
Group (HC group = ref)	−1.04	13.25	[−27.59; 25.51]	0.938
Film type (neutral = ref)				
Poker-related	−0.84	12.87	[−26.15; 24.48]	0.948
Negative	2.54	12.88	[−22.78; 27.86]	0.844
Positive	60.35	12.87	[35.05; 85.66]	<0.001
Interaction group x film type				
Group x Poker-related	9.66	17.96	[−25.66; 44.98]	0.591
Group x Negative	−3.24	17.96	[−38.56; 32.08]	0.857
Group x Positive	−35.44	18.08	[−70.99; 0.11]	0.051
IBI change score				
Group (HC group = ref)	2.03	5.52	[−18.95; 23.00]	0.847
Film type (neutral = ref)				
Poker-related	21.72	7.19	[1.17; 42.28]	0.038
Negative	32.11	7.19	[11.55; 52.67]	0.002
Positive	27.22	7.24	[6.66; 47.77]	0.010
Interaction group x film type				
Group x Poker-related	−4.69	14.41	[−33.02; 23.64]	0.745
Group x Negative	−19.51	14.41	[−47.85; 8.83]	0.177
Group x Positive	1.75	14.50	[−26.77; 30.28]	0.904
SCR amplitude change score				
Group (HC group = ref)	0.14	0.16	[−0.19; 0.46]	0.410
Film type (neutral = ref)				
Poker-related	0.23	0.14	[−0.04; 0.50]	0.094
Negative	0.30	0.14	[0.03; 0.57]	0.030
Positive	0.30	0.14	[0.03; 0.56]	0.031
Interaction group x film type				
Group x Poker-related	−0.08	0.03	[−0.46; 0.29]	0.673
Group x Negative	−0.42	0.06	[−0.80; −0.05]	0.027
Group x Positive	−0.35	0.19	[−0.72; 0.03]	0.070
Cardiovascular activation change score				
Group (HC group = ref)	0.42	0.35	[−0.29; 1.12]	0.242
Film type (neutral = ref)				
Poker-related	−0.18	0.29	[−0.74; 0.39]	0.544
Negative	0.34	0.29	[−0.24; 0.91]	0.250
Positive	−0.11	0.29	[−0.67; 0.45]	0.689
Interaction group x film type				
Group x Poker-related	−0.31	0.41	[−1.13; 0.50]	0.452
Group x Negative	−0.34	0.41	[−1.16; 0.48]	0.413
Group x Positive	0.02	0.41	[−0.79; 0.84]	0.953
Respiratory activation change score				
Group (HC group = ref)	0.13	0.40	[−0.68; 0.93]	0.751
Film type (neutral = ref)				
Poker-related	0.10	0.25	[−0.40; 0.59]	0.704
Negative	−0.19	0.17	[−0.56; 0.45]	0.840
Positive	−0.07	0.17	[−0.57; 0.27]	0.768

(continued)

Table 5. Continued

	Estimate	Standard deviation	Confidence interval	p-value
Interaction group x film type				
Group x Poker-related	−0.35	0.34	[−1.02; 0.32]	0.307
Group x Negative	−0.25	0.34	[−0.92; 0.43]	0.470
Group x Positive	0.01	0.34	[−0.66; 0.69]	0.970
Difficulty to suppress emotions				
Group (HC group = ref)	−0.07	0.32	[−0.71; 0.58]	0.838
Film type (neutral = ref)				
Poker-related	0.52	0.27	[−0.00; 1.03]	0.052
Negative	1.95	0.27	[1.43; 2.47]	<0.001
Positive	2.64	0.27	[2.12; 3.16]	<0.001
Interaction group x film type				
Group x Poker-related	1.12	0.37	[0.38; 1.85]	0.003
Group x Negative	−0.18	0.37	[−0.91; 0.55]	0.626
Group x Positive	−0.10	0.37	[−0.84; 0.63]	0.779
DES+ change score				
Group (HC group = ref)	0.85	0.29	[0.27; 1.42]	0.005
Film type (neutral = ref)				
Poker-related	0.08	0.15	[−0.23; 0.38]	0.621
Negative	−0.57	0.15	[−0.87; −0.27]	<0.001
Positive	1.16	0.15	[0.86; 1.46]	<0.001
Interaction group x film type				
Group x Poker-related	0.57	0.22	[0.15; 0.99]	0.008
Group x Negative	−0.69	0.22	[−1.11; −0.27]	0.001
Group x Positive	−0.46	0.22	[−0.88; −0.04]	0.034
DES- change score				
Group (HC group = ref)	−0.11	0.15	[−0.41; 0.19]	0.471
Film type (neutral = ref)				
Poker-related	0.05	0.12	[−0.19; 0.29]	0.671
Negative	1.57	0.12	[1.33; 1.81]	<0.001
Positive	0.27	0.12	[0.03; 0.50]	0.030
Interaction group x film type				
Group x Poker-related	−0.01	0.17	[−0.34; 0.32]	0.963
Group x Negative	−0.04	0.17	[−0.37; 0.30]	0.835
Group x Positive	−0.02	0.17	[−0.35; 0.32]	0.920

Significant confounding factors (educational level, MMSE score) were entered as covariates.

muscle during negative films. In contrast, concerning the *zygomaticus major*, there was a significant effect for the Type of film, with positive films eliciting higher activation of the *zygomaticus major*, as expected. This may indicate that the inhibition of facial expressions during positive films seems to be more difficult than inhibiting expressions during negative films in both groups. Neither an effect of Group nor a Type of film x Group interaction was observed, although a trend ($p = 0.051$) was observed for the interaction between Group and positive films. This trend indicates that the EG group tends to display lower activation of the *zygomaticus major* in response to films that elicit positive emotions.

Physiological arousal. Figure 2 illustrates the comparison of heart IBI change score variations between groups and types of film. Linear mixed models did not highlight any effect of Group or a Group x Type of film interaction. The only significant effect observed was for the Type of film, with an increase in the IBI (i.e. slower heart rate) during the three types of emotional films compared to that during neutral films. Gross and Levenson (Gross & Levenson, 1997) highlighted that this type of response is typical of attempts to suppress responses to emotional films, especially negative ones.

Figure 3 illustrates the comparison of SCR amplitude change score variations between groups and types of film. The results from linear mixed models indicated no effect of Group, a significant effect of Type of film for negative and positive films (with a trend towards significance for poker-related films; $p = 0.094$) and a significant Group x Type of film interaction ($p = 0.027$) for negative films only (a trend – $p = 0.070$ – was observed for positive films). The SCR amplitude increased significantly more for both negative and positive films (and to a lesser extent (trend) for poker-related films) compared to neutral films, but participants from the EG group showed a lower change score than participants from the HC group for negative films and, to a lesser extent (trend), for positive films. This means that the SCR amplitude of those in the EG group increased less during the negative (and positive) films.

Finally, for cardiovascular and respiratory activation scores, we failed to highlight any significant effect of Type of film or Group or a Group x Type of film interaction.

Subjective experience. Figure 4 illustrates the comparison of the subjective rating of difficulty to suppress emotions during the films between groups and types of film. The results from linear mixed models highlighted no effect of Group, a significant effect of Type of film (for positive and negative films and a trend very close to significance for poker-related films; $p = 0.052$) and a significant Group x Type of film interaction (for poker-related films only). As expected, it was more difficult to suppress emotion during emotional films than during neutral films in both groups, but participants from the EG group rated the difficulty to suppress emotions higher than the HC group in the case of poker-related films only.

Finally, Fig. 5 illustrates the comparison of DES+ and DES– scores between groups and types of film. Concerning DES+ scores, the results from linear mixed models indicated a significant effect of Group, a significant effect of Type of film (for negative and positive films only) and a significant

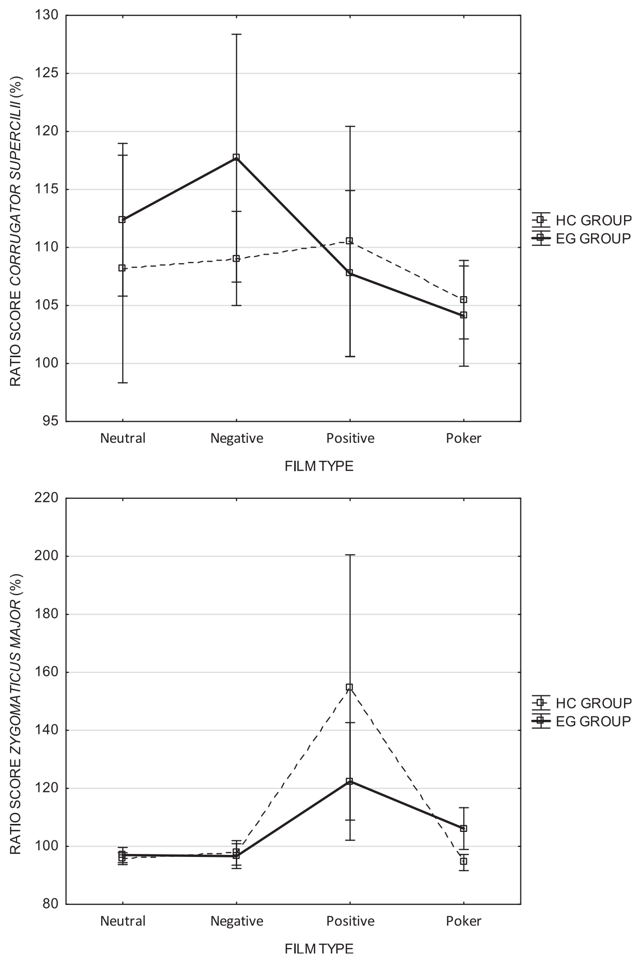

Figure 1. Comparison of the *corrugator supercilii* and *zygomaticus major* EMG activities (ratio scores) for different film emotional valences in experienced non-pathological poker gamblers (EG) and healthy controls (HC) ($n = 60$)

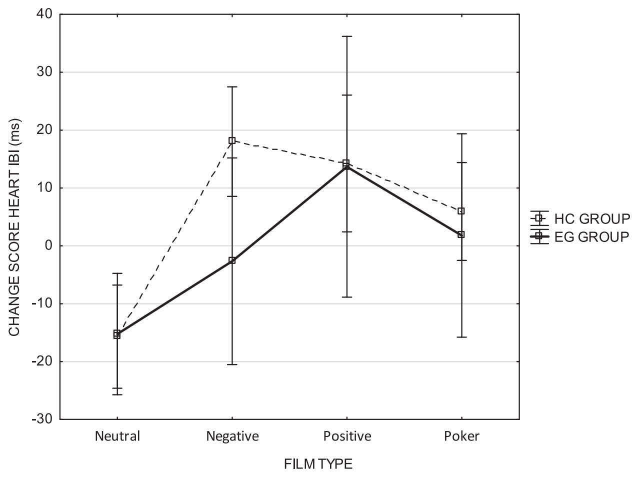

Figure 2. Comparison of heart IBI (change scores) for different film emotional valences in experienced non-pathological poker gamblers (EG) and healthy controls (HC) ($n = 60$)

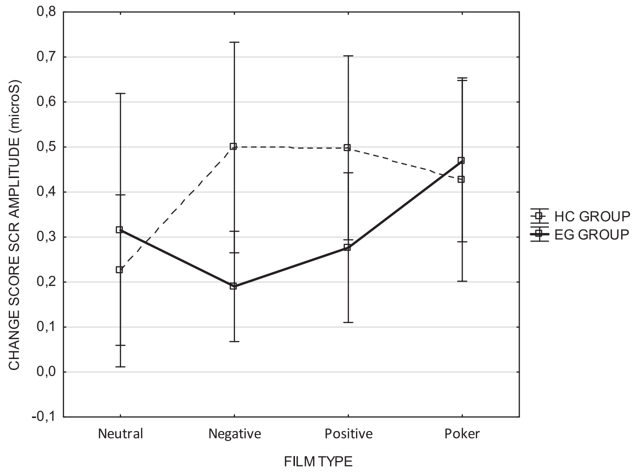

Figure 3. Comparison of skin conductance levels (change scores) for different film emotional valences in experienced non-pathological poker gamblers (EG) and healthy controls (HC) ($n = 60$)

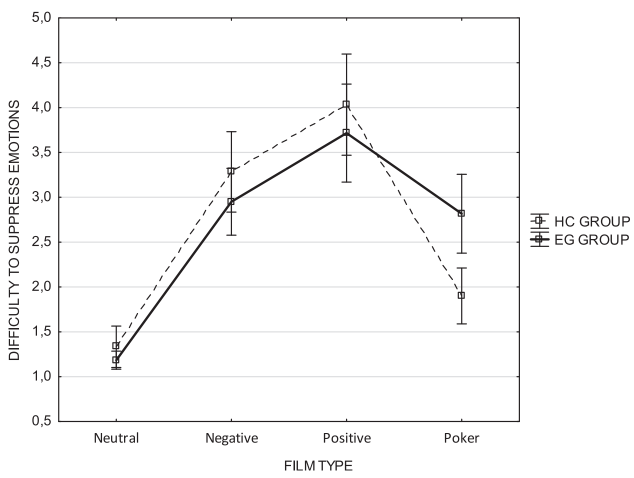

Figure 4. Comparison of the subjective rating of difficulty suppressing emotions during films with different emotional valences in experienced non-pathological poker gamblers (EG) and healthy controls (HC) ($n = 60$)

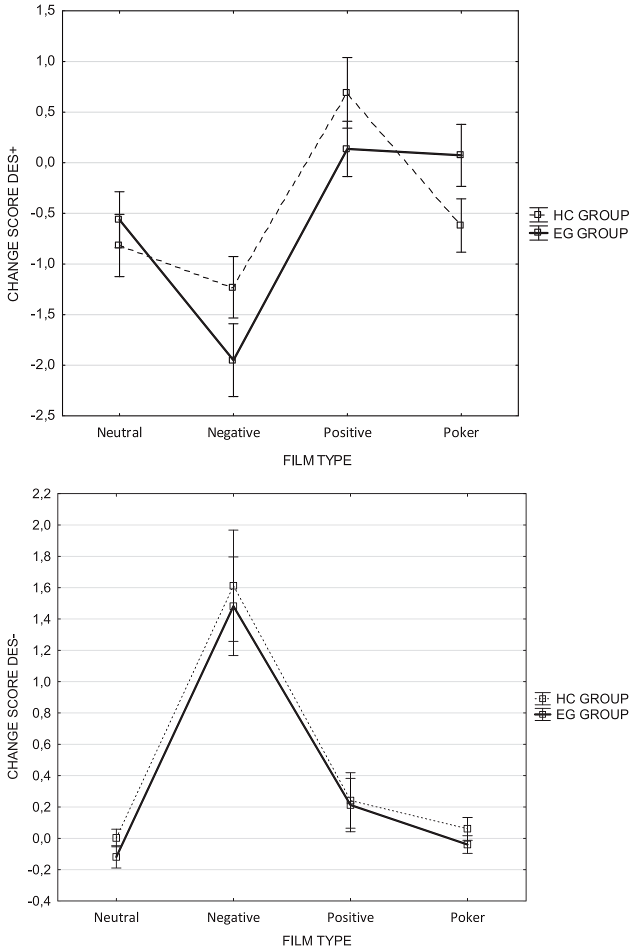

Figure 5. Comparison of DES+ and DES– scores (change scores) for different film emotional valences in experienced non-pathological poker gamblers (EG) and healthy controls (HC) (n = 60)

Group x Type of film interaction (for the three types of films). As expected, DES+ scores were higher for positive films and lower for negative films. Moreover, participants from the EG group scored lower than those from the HC group for both positive and negative films, which seems to indicate that their self-reported positive experience was less positive for those films. In contrast, they had higher scores for poker-related films, which indicates that their subjective positive experience was stronger than that of HC participants for poker situations, in the same range as that for positive films. Regarding DES– scores, the results from linear mixed models indicated no effect of Group, a significant effect of Type of film (for negative and positive films only) and no significant Group x Type of film interaction. As expected, DES– scores increased for negative films in both groups. However, these scores also increased, but to a lesser extent, for positive films.

DISCUSSION AND CONCLUSIONS

In this study, we investigated three modalities of inhibition skills (motor, verbal and expressive) in experienced non-pathological poker gamblers compared to healthy controls with no or little poker experience. Our main hypothesis was that experienced poker gamblers had better inhibitory control skills than control participants.

The first important result from this study concerns the absence of higher inhibition skills than those of controls in experienced poker gamblers.

Unexpectedly, both motor and verbal inhibition performance was comparable between experienced poker gamblers and healthy controls. To our knowledge, verbal inhibition has never been studied in the framework of gambling. In contrast, motor inhibition has been extensively studied in the field of gambling (Challet-Bouju et al., 2017; Chowdhury et al., 2017). Considering our results, it seems that experienced poker gamblers do not exhibit better inhibitory control skills than non-gamblers controls regarding verbal or motor inhibition.

In contrast, expressive inhibition performance differed between experienced poker gamblers and controls. The EST has primarily been used to assess emotion regulation strategies (Gross & Levenson, 1993, 1997), especially in social interactions (Butler et al., 2003; Cutuli, 2014). A point of originality in the present study was the adaptation of this task to explore participants' capacity to inhibit emotional expressive behavioural responses, especially in the context of poker situations. The observed differences concerned physiological arousal and subjective experience but not expressive behaviour (EMG), which was comparable between the two groups. Because expressive suppression is a response-focused emotional regulation strategy (Cutuli, 2014), we can conclude that experienced poker gamblers did not perform better than controls in refraining from displaying emotional expressions consciously. The only physiological arousal parameter that differed between the two groups was the change in the mean SCR amplitude due to film viewing. Experienced poker gamblers seem to be able to suppress partially the physiological impact of viewing negative and positive (trend) films but not poker-related films. There was, therefore, emotional induction produced by gambling activity that resulted in a failure to suppress expression. As a consequence, we hypothesise that experienced poker gamblers have higher physiological emotional inhibition skills than controls (significantly for negative films, and as a trend for positive films), but only to a point, i.e. the emotion elicited by poker-related situations may be too intense to be suppressed by poker gamblers.

Finally, subjective experiences were very different depending on the type of film and the group. First, as expected, difficulty in inhibiting emotions seemed to increase with the emotional valence of the film in both groups (i.e. difficulty in suppressing emotions was higher when viewing positive, negative and poker-related films than neutral films). Nevertheless, healthy controls did not seem to experience difficulty suppressing their emotions during poker-related films, expressing similar difficulty ratings as those for neutral films, compared to experienced poker gamblers for whom the difficulty of suppressing their emotions during poker-related films was very similar to that experienced during positive and negative films. Second, emotional experiences conformed to our expectations for positive and negative films, i.e. DES+ scores increased for positive films, and DES- scores increased for negative films. However, experienced poker gamblers rated their positive emotional experiences lower than controls rated positive emotional experiences for both positive and negative films. Regarding poker-related films, both negative and positive emotional experiences were quite similar to those for neutral films. However, while negative emotional experiences were comparable between the two groups, positive emotional experience differed between poker gamblers and controls. Indeed, experienced poker gamblers had an inverted subjective experience for poker-related films compared to those for positive and negative films, i.e. they rated their positive emotional experience higher than controls for poker-related films. This result indicates that poker gamblers have a stronger positive emotional experience when they are in a poker-related situation, even with suppression instructions, which contrasts with their weaker emotional experience for other emotional situations. It can be imagined that expressive suppression is not the emotion-regulation strategy used by poker gamblers in real-life poker situations. Indeed, expressive suppression is one emotion regulation strategy among others, such as cognitive reappraisal, distraction, and rumination (Brans, Koval, Verduyn, Lim, & Kuppens, 2013; Cutuli, 2014; Hayes et al., 2010). However, as good poker performance is highly influenced by self-control and the gambler's capacity to be unreadable to their opponents (Bouju, Grall-Bronnec, Quistrebert-Davanne, Hardouin, & Vénisse, 2013; Boutin, 2010), response-oriented strategies, such as expressive suppression, may be more effective in a poker situation than antecedent-focused strategies such as cognitive reappraisal (Cutuli, 2014).

Our main hypothesis that experienced poker gamblers would show better inhibitory control than control participants is not supported by our findings, as the performances of EG participants were globally similar to those of HC participants, regardless of the form of inhibition tested. The only difference observed in experienced poker gamblers was a better ability to partially suppress the physiological expression of emotion. However, this difference was only present during negative and positive emotional induction but was absent during emotional induction related to poker situations. This result suggests that experienced poker gamblers may not develop different inhibition skills than controls, especially when they are faced with poker-related situations. This result questions the transferability of poker skills to real-life situations, as proposed by Parke et al. (Parke, Griffiths, & Parke, 2005). However, poker situations may elicit low emotional response in non-poker players, i.e. no need for significant inhibition skills to refrain emotional expressions in these situations. This may also explain why experienced poker gamblers, who already have trained themselves not to respond emotionally, and non-poker players with a weak response have displayed similar performance scores of emotional inhibition in poker films.

A second lesson that can be taken from this study is that while experienced poker gamblers did not present higher inhibition skills than controls, they did not exhibit poorer performance, especially regarding motor inhibition. A recent review by Chowdhury et al. suggested that motor disinhibition may explain why pathological gamblers exhibit impaired ability to control their gambling behaviour (Chowdhury et al., 2017). As highlighted by Odlaug et al., deficits regarding motor inhibition observed in pathological gamblers may either be due to the repetitive gambling behaviour itself or may already exist in people 'at-risk' for pathological gambling (Odlaug, Chamberlain, Kim, Schreiber, & Grant, 2011). Their results indicated that contrary to their expectations, people 'at-risk' for pathological gambling did not display worse inhibition skills than healthy controls, which may invalidate the idea of the pre-existence of inhibition deficits in people at elevated risk for pathological gambling. Considering our results, the fact that experienced poker gamblers do not have worse motor inhibition skills than non-gamblers controls, despite a longer gambling history duration and a higher frequency of gambling, may indicate that motor disinhibition observed in pathological gamblers may not occur during non-pathological gambling practice and may not be due to repetitive gambling.

This study has some limitations. First, the fact that participants were exclusively male does not allow our results to be generalised to the whole poker gamblers population. Second, the sample size was quite small, with 30 subjects in each group. Third, the threshold for identifying experienced poker gamblers (gambling in TH poker at least once a week for at least 3 months) is debatable. Fourth, it is not impossible that certain participants were already familiar with the film excerpts presented in the EST, especially the poker-related films for experienced poker gamblers (famous end-of-tournament scenes). However, if such a bias was present, it should have been in favour of poker gamblers exhibiting higher expressive inhibition capacity, which was not the case here. Several strengths in our study compensated for these limitations, including its originality (study conducted with non-problematic gamblers, original use of the EST), its multimodal examination of the phenomenon of inhibition and its rigorous methodology considering several confounding factors.

Moreover, we have to highlight that the poker gamblers group was composed only of participants free from pathological gambling. One may question whether certain people have innately worse inhibition skills than others, independent of the presence of pathological gambling. Given the central role of inhibition in the aetiology of addictive disorders (Billieux et al., 2014; Inserm, 2008), such inhibition deficits may play a role in the potential future development of at-risk or even pathological gambling behaviours. For this reason, we intend to extend this study by recruiting a sample of clinically pathological experienced poker gamblers (recruitment in progress). The objective of this future work will be to compare their inhibitory skills with those of both healthy controls and non-pathological experienced poker gamblers to distinguish deficits related to gambling pathology from those related to repetitive gambling. Despite not being performed on a clinical sample, this study can provide some interesting insights for clinical interventions.

Indeed, the only recommended treatment that has demonstrated efficacy for the management of gambling disorders is cognitive-behavioural therapy (CBT) (Korn & Shaffer, 2004; Stea & Hodgins, 2011). In addictions in general, CBT is focused on the role of emotions and thoughts related to the addictive disorder, discerning risk situations, learning alternative strategies, etc. For the particular case of gambling, a specific programme has been developed by Ladouceur et al. (Ladouceur, Sylvain, Boutin, & Doucet, 2002; Ladouceur et al., 2001). It consists of a classical CBT programme, with the addition of education on gambling-related cognitive distorsions, and especially erroneous beliefs about chance. However, the population of individuals with gambling disorders is very heterogeneous, which might explain the wide-range of success rates for psychological interventions such as CBT (from 39 to 89% at the completion of treatment and from 30 to 71% at 12-month follow-up (Merkouris, Thomas, Browning, & Dowling, 2016)). Among other factors, one explanation for the various success rates of treatment may be that CBT programmes include a focus on the importance of chance in gambling. Given the particularity of poker, which is almost the only game in which skill can (theoretically) lead to a long-term potential benefit (Bjerg, 2010; Boutin, 2010), poker gamblers are often very critical towards such programmes, feeling unaffected by strategies to deconstruct erroneous beliefs about chance. The present findings indicate that increased inhibition skills do not seem to be present in experienced poker gamblers, which may serve as an argument for the deconstruction of erroneous beliefs about supposed skill in poker. Moreover, we showed that the only observed difference between experienced non-pathological poker gamblers and controls was a higher capacity to reduce the physiological impact of emotional elicitation, which was no longer maintained when poker gamblers were faced with poker-related situations. We assume that this result could be confirmed and perhaps even more pronounced in experienced pathological poker gamblers. If this is true, biofeedback management could be specifically indicated because it allows the patient to visualise his physiological response to certain stimuli. This strategy could assist gamblers in developing voluntary control over their body's responses and gambling desires, similar to successful interventions for other psychiatric pathologies such as mood and anxiety disorders (Canadian Agency for Drugs and Technologies in Health, 2014). Finally, if the presence of an inhibitory control deficit is verified, it might be useful to set up cognitive remediation programmes dedicated to inhibition training to improve gambling addiction care in addition to the usual tools of care. Such programmes are indeed a promising therapeutic option for the treatment of several mental health disorders, even if they are still understudied in gambling disorders (Challet-Bouju et al., 2017).

Funding sources: The PERHAPS study was funded by a grant from the University Hospital of Nantes (Internal call for tenders; RC14_0036). The present work was performed in the framework of a traineeship (A.L. Quibel) for which a research subvention from the GIS 'Jeu et Sociétés' was obtained. The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Authors' contribution: GCB: study concept and design; analysis and interpretation of data; obtained funding; study supervision; wrote first draft of the manuscript. EH, ET, JL and ALQ: collected data; inspected artefacts in the physiological records (EST) and detected of any cause for invalid responses in all cognitive tasks. ML: performed statistical analysis. MGB: obtained funding; study supervision; inclusion of participants. All authors had full access to all data and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors gave feedback on the first draft of the manuscript and approved the final manuscript.

Conflict of interests: GCB, ET, JL and MGB declare that the University Hospital of Nantes received funding from the gambling industry (FDJ and PMU) in the form of a philanthropic sponsorship (donations that do not assign purpose of use). Scientific independence with respect to these gambling industries is guaranteed, and this funding has never had any influence on the present work. There were no constraints on publishing. EH, LM and ALQ have no conflicts of interest to declare.

Acknowledgements: This research was conducted on the initiative of and coordinated by the Addictology and Psychiatry Department of the University Hospital of Nantes, which sponsored this study. We want to warmly thank Pr Thierry Meulemans from the Neuropsychology Unit of the Cognitive Sciences Department at the University of Liège (Psychology and Education Sciences Faculty) for his kind permission to use its French version of the Hayling Sentence Completion Task. We also want to warmly thank Pr Alexandre Schaefer from the Faculty of Business and Economics of the Monash University for his kind permission to use excerpts from the FilmStim database and for his related advice.

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