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# Cortisol and Heart Rate Measures during Casino Gambling in Relation to Impulsivity

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**Key Words**

Pathological gambling · Casino · Impulsivity · Cortisol · Heart rate

**Abstract**

Problematic gambling behavior is thought to be influenced by neurobiological as well as environmental factors. In this study, we investigated the relationship among impulsivity, gambling behavior, the cardiovascular system and the hypothalamic-pituitary-adrenal axis activity in blackjack gamblers. Twenty-nine males were continuously monitored before, during and after a 90-min blackjack session in a casino wagering their own money and during a control condition where subjects played cards for accumulation of points. Heart rate and cortisol levels significantly increased with the onset of gambling and remained elevated throughout the test session compared to the control condition. After median split of impulsivity scores, high impulsivity subjects revealed significantly higher heart rate levels compared to the low impulsivity subgroup. Correlation analyses revealed a positive relationship between impulsivity scores and severity of pathological gambling. Impulsivity may be one important factor mediating gambling behavior and its accompanying autonomic response.



## Introduction

Subjective reports and empirical data suggest that impulsivity is one important factor which contributes to the pathogenesis of problem and pathological gambling [1–3]. In the current diagnostical manuals (ICD-10 and DSM-IV), pathological gambling has been classified as an impulse-control disorder. Pathological gamblers exhibit increased levels of impulsivity which are higher than in non-gamblers, recreational gamblers and even in those subjects that are addicted to alcohol or cocaine [2, 4, 5]. Furthermore, this impulsivity is related to gambling severity [4], and in early adolescence it predicts gambling behavior among males several years later [6].

Recent theoretical models of the development and maintenance of problematic and pathological gambling have underscored the significance of neurobiological mechanisms [7–9]. Specifically, it has been hypothesized that immaturity of frontal cortical and subcortical monoaminergic systems during neurodevelopment may contribute to elevated impulsivity in adolescents and to an increased vulnerability to addictive behaviors such as addictive gambling [3]. As impulsivity can be defined as acting with little forethought, self-control, or regard for consequences, trait impulsivity may be one promoting factor for problematic gambling behavior. Impulsive subjects may be highly responsive to positive reinforcement but rather insensitive to negative consequences. The con-

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tinuation of gambling despite harmful consequences comes from decision-making based on neural activity in the limbic system and orbitofrontal cortex. According to Bechara et al. [10], patients with lesions in the ventromedial prefrontal cortex failed to learn to make advantageous choices on the Iowa Gambling Task. Cavedini et al. [11] confirmed this diminished ability to evaluate future consequences in pathological gamblers. They continued choosing cards from the disadvantageous decks of cards, while the control subjects learned to choose more cards from the advantageous decks in consecutive stages of the task. In a game of dice task with explicit rules for gains and losses similar results could be found [12]. Pathological gamblers preferred in their decisions smaller immediate rewards to larger delayed rewards [13, 14]. Impulsivity as measured by the Eysenck Impulsivity Questionnaire was positively associated with delay discounting [15].

The aspect of rapidity or restlessness as one further element of impulsive behavior may also be reflected by the greater prevalence of attention-deficit hyperactivity disorders in problem gamblers as children [16, 17]. The question is whether the aspect of rapidity within impulsive behavior is also reflected by increased activity of the sympathetic nervous system and/or the hypothalamic-pituitary-adrenal (HPA) axis.

Nevertheless, experimental data regarding the relationship between neuroendocrine/physiological variables and psychological characteristics like impulsivity in casual, problem and pathological gamblers are rare. One study did not find any correlations between plasma testosterone and impulsivity measures on the Eysenck Personality Questionnaire in pathological gamblers [18]. Although not directly addressed to problem gambling, a meta-analysis of the psychophysiology of aggression, psychopathy, and conduct problems revealed low resting heart rate and high heart rate reactivity to be associated with aggression and conduct problems [19]. Similarly, a recent study demonstrated that exaggerated ethanol-induced cardiac reactivity – suggested as a marker of reward sensitivity – is associated with increased gambling behaviors in young men [20].

Despite the theoretical and empirical evidence for a direct association between personality characteristics and physiological measures, the relationship among the activity of the HPA axis, the sympathetic system, and impulsivity measures in a sample of casino gamblers has not yet been investigated. Therefore, this study analyzed the heart rate responses of blackjack players as an indicator of sympathetic nervous system activity during a gambling session in a casino in relation to impulsivity scores. Furthermore, we determined whether subjects with increased impulsivity traits show signs of a stress response in terms of increased HPA axis activation with elevated plasma cortisol during blackjack gambling in a casino.

## Methods and Material

### *Subjects*

Thirty-one male blackjack players were recruited in casinos through direct approach (n = 27) or through newspaper advertisements (n = 4). In the casinos, potential subjects were addressed and informed about the research project during gambling breaks and asked for participation (n = 21). Furthermore, during the research process other gamblers inquired about the research project and declared their interest for participation (n = 6). Of these, 29 subjects completed the whole procedure (mean age 43.0 ± 10.4 years). After complete description of the study to the participants, written informed consent was obtained. Each person was paid EUR 150.– for participation and traveling expenses. The protocol of the current study was approved by the local ethics committee of the Medical Faculty of the University of Essen for investigations using human subjects. Participants were screened via a general medical examination and a semistructured clinical interview (for assessment of addictive behaviors) by a medical doctor and clinical psychologist. Individuals on medication, abusing drugs/alcohol (except nicotine consumption), or exhibiting endocrinological, psychological, or physical disorder, were excluded from the study because of potential effects on the endocrine secretion pattern during the experiments (n = 2). Eighteen subjects were regular smokers and also smoked during the investigations. Apart from problematic gambling in certain subjects, there was no evidence for other addictive behaviors. Any alcohol consumption during the play was prohibited due to pronounced effects on various physiological measures.

### *Design and Procedure*

Specific testing dates were arranged with each participant in accordance with a counterbalanced cross-over design, so as to control habituation effects. Each subject participated in an experimental session in the casinos of Hannover or Bad Zwischenahn, Germany and a control session in the Medical School Hannover, Germany. In the experimental session, the heart rate recorder was fitted in a separate room once the participant arrived at the casino. Baseline data were collected 20 min before gambling by recording each subject's heart rate in a resting position. Heart rate recording took place during the entire session.

Thirty minutes before gambling, an intravenous cannula (Versify Granule, 18G) was inserted by a M.D. into a forearm vein for repeated blood sampling. Fifteen minutes before gambling, a baseline blood sample was drawn.

In the experimental session the subject was seated at the blackjack table and played the game using his own money. The minimum and maximum stake was EUR 10 and 500, respectively. All participants were able to complete the whole experimental session without running out of money. The second, third and fourth blood sample was collected following 30, 60 and 90 min of play, respectively. A follow-up blood sample and heart rate measurement was taken 20 min after the end of the play, and then the participants completed the final questionnaire (general emotional involvement while gambling, as explained below). The control session was conducted similar to the experimental session. However, participants played a game of cards without monetary stakes in a university environment. The degree of movement exhibited by the participants was the same between control and experimental sessions, and between measurement of baseline, play and after the play (e.g. the same distance between the gambling table/card playing and the separate room for blood sampling). Both the experimental and the control sessions occurred between 7 and 11 p.m., with the length of play lasting 1.5 h. Alcohol consumption during the experiments was prohibited.

*Measures*

Heart Rate Measurement

Heart rate was measured continuously during the entire session using a portable heart rate monitor (Accurex Plus, Polar, Büttelborn, Germany). The ECG was transmitted from a chest patch to a receiver worn around the wrist in the mode of a watch. Heart rate was recorded and saved by the receiver in 5-second intervals. Data were transferred from receiver to computer using 'Polar Interface Plus' software. For further analysis only data of the last 5 min of the baseline, the three game periods and the follow-up period were taken. Thus, for each interval/period, heart rate measures of 60 time points were averaged

Endocrine Measures

For repeated blood sampling an intravenous cannula was inserted into a forearm vein of the non-dominant arm. Blood was drawn before, during and after gambling and collected into EDTA tubes (Sarstedt, Nümbrecht, Germany). Blood samples were immediately centrifuged at 4°C and plasma stored on dry ice during the experiment and later stored at –70°C until endocrine analysis could be done.

All samples were assayed in duplicate within the same assay. Cortisol levels were detected by the Automated Chemiluminescence Immunoassay System 180 (ACS Centaur; Chiron Diagnostics, Germany). The intra- and interassay coefficients of variance were 4.5 and 6.4%.

Behavioral Measurement

Personality characteristics were measured using the German version of the adult Eysenck Impulsivity Questionnaire I7 [21, 22], a 54-item true/false questionnaire which consists of three subscales: impulsivity, venturesomeness, and empathy (reliability coefficient: $\alpha = 0.77$). This questionnaire has been standardized in Germany and has proven suitability. As this study primarily focused on impulsiveness, only the 17 items that relate to the impulsiveness scale were used.

For assessment of problem or pathological gambling the German version of the South Oaks Gambling Screen (SOGS) [23] was used, which examines gambling behavior over the previous 12 months. The SOGS is a widely used screening instrument based on DSM-III diagnostic criteria for pathological gambling (reliability coefficient: $\alpha = 0.97$). The majority of the 20 items are in a forced choice yes/no format. In accordance with established criteria, subjects who score 3 or 4 points on the SOGS are classified as 'problem gamblers' while those who score 5 or more points are classified as 'probable pathological gamblers' [24]. Fourteen subjects (mean age 42.1 ± 11.6 years) scored ≥ 3 on the SOGS (4 subjects scored 3 or 4; 9 scored ≥ 5) fulfilling the criteria to be at least problem gamblers. Fifteen participants (mean age 43.9 ± 9.5 years) scored ≤ 1 on the SOGS.

*Statistical Analyses*

Following statistical confirmation of normal distribution and variance homogeneity, data were analyzed using two-factor (condition × time) ANOVA with repeated measures, and with Greenhouse-Geisser corrections. Post-hoc analyses were conducted using Scheffé tests. Statistical significance was set at a probability level of $p < 0.05$. Ranked and non-parametric variables were compared by Mann-Whitney U test. Correlation analysis was performed employing Pearson correlations. If not stated otherwise, we report the interaction effects.

In order to determine whether different degrees of impulsivity account for different gambling-induced cardiovascular and HPA axis activity, median split of the impulsivity scale (I-7) was performed. Differences between 'low' and 'high' impulsivity score groups were performed by t test. ANOVA with repeated measures with the group factor 'low' and 'high' impulsivity were performed to test for group differences in gambling-induced heart rate levels and cortisol secretion.

## Results

*Group Characteristics and Psychometric Measures*

The mean score on the Eysenck Impulsivity subscale (I-7) was 6.72 ± 0.76 (SE) which is slightly above the range of a German reference population (6.08) [22]. In order to determine whether high or low levels of impulsivity account for different gambling-induced sympathetic and HPA axis activity, median split of the impulsivity scale was performed. The low impulsivity subgroup scored 3.47 ± 0.40 and the high impulsivity group scored 10.21 ± 0.78 on average. These subgroups were significantly different in their impulsivity scores ($t = -7.9$; $p < 0.001$) but did not differ in age ($t = 0.80$; $p = 0.43$), height ($t = 1.82$; $p = 0.08$) or weight (–0.72; $p = 0.48$) or smoking habits ($t = 1.32$; $p = 0.20$). Furthermore, correlation analysis revealed a relationship between impulsivity (I-7) and the SOGS score (0.40; $p < 0.05$), and between the I-7 percentile rank and the SOGS (0.80, $p < 0.001$). Indeed, 8 out of 9 pathological gamblers (SOGS score: 5 or more) belonged to the high impulsivity subgroup.

*Cardiovascular and Endocrine Measures*

Casino gambling led to significantly higher heart rate measures in comparison to the control condition of card playing ($F[4,112] = 11.6$, $p < 0.001$). Heart rate increased with the onset of gambling, remained elevated during the game and declined after the session. Post-hoc analyses showed significant differences for all time points including baseline and follow-up (fig. 1a).

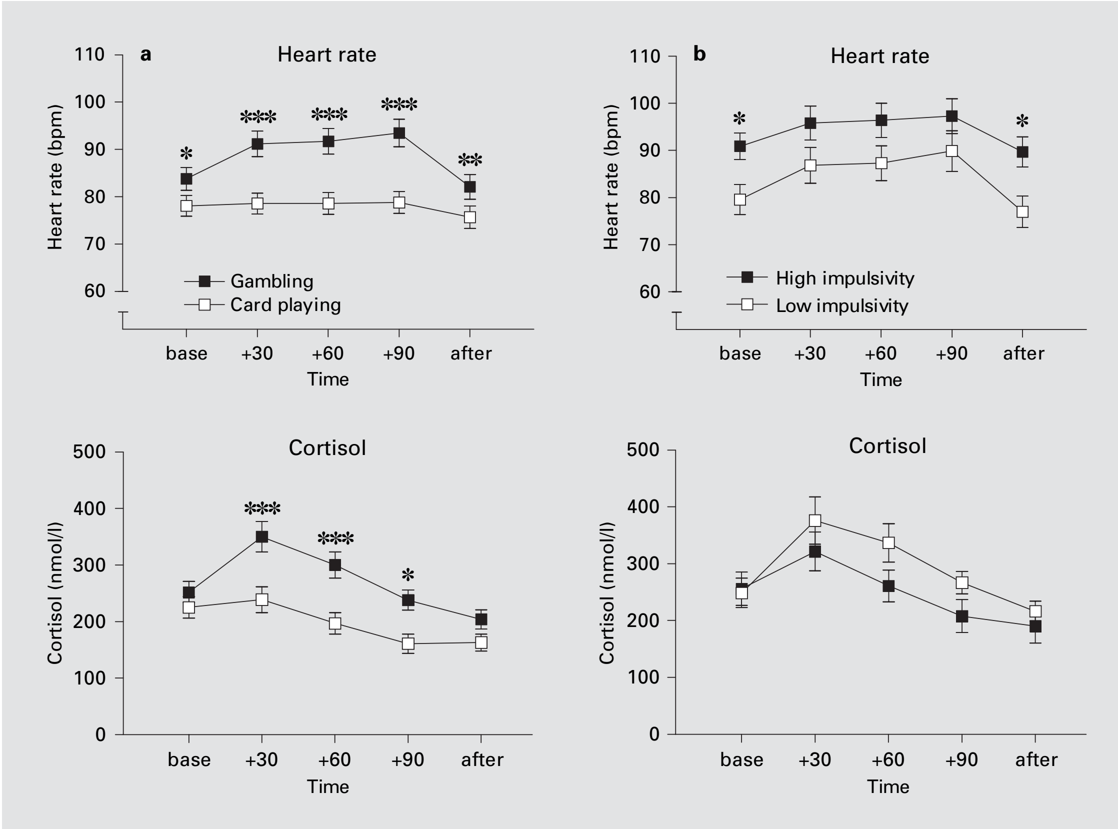


**Fig. 1. a** Heart rate and plasma cortisol levels before gambling/playing (base), during 30, 60 and 90 min of gambling/playing and after the session. Data are presented for the experimental (■) and control condition (□). **b** Heart rate and plasma cortisol levels before (base), during 30 min, 60 min and 90 min of gambling and after the session (experimental condition) in the high (■) and low (□) impulsivity subgroup. Data represent mean ± SE. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

In order to analyze the gambling-induced activation of the HPA axis, cortisol plasma levels were analyzed. Cortisol plasma levels significantly increased and reached a peak with the onset of gambling and continuously declined towards the end of the session ($F[4,112] = 4.1$, $p < 0.01$). Cortisol levels were significantly higher after 30, 60 and 90 min of gambling compared to card playing as demonstrated by post-hoc analyses (fig. 1a).

### *Heart Rate and Cortisol Measures after Median Split of Impulsivity Scores*

Heart rate increased in the low and high impulsivity subgroup with the onset of gambling and declined after the end of the session (time effect: $F[4,108] = 17.41$, $p < 0.001$). However, the high impulsivity subgroup had significantly higher heart rate measures compared to the low impulsivity group (group effect: $F[1,27] = 4.50$, $p < 0.05$). Plasma cortisol levels significantly increased in both subgroups with the onset of gambling and immediately declined thereafter towards the end of the session (time effect: $F[4,108] = 12.85$, $p < 0.001$). There were no significant differences between the groups. Analysis of heart rate and cortisol measures during the control condition revealed neither significant alteration over time nor between the groups (fig. 1b).

## Discussion

This study investigated the effects of casino gambling on parameters of the sympathetic nervous system and the HPA axis in relation to impulsivity measures in male blackjack players. We hypothesized that higher levels of impulsivity would lead to an increase in heart rate and cortisol levels during the game. Additionally, we were interested whether previous reports of impulsivity being a dispositional factor for the development and maintenance of problem and pathological gambling could be confirmed [4, 25].

Concurring with previous studies [7, 26], the current investigation demonstrates a significant increase in heart rate levels with the onset of gambling in a casino compared to a control condition where subjects played cards for accumulation of points. This indicates a significant sympathetic or psychophysiological activation and may confirm a distinct stimulatory psychotropic potential of casino gambling as described in subjective reports and experimental data [27]. As hypothesized, after median split of impulsivity scores, the high impulsivity subgroup revealed significantly higher heart rate levels throughout the experimental session in the casino compared to their low impulsivity counterparts. Furthermore, impulsivity scores correlated with the SOGS scores; 8 out of 9 pathological gamblers belonged to the high impulsivity group. Thus, higher impulsivity levels are correlated with increased sympathetic nervous system activity and a higher probability of problem or pathological gambling. Subjects with reduced impulse control make impulsive decisions without risk balancing, which represents a potential risk factor for pathological gambling. During gambling, an additional narrowing of view and attention occurs caused by increased arousal (possibly seen as elevated heart rate), which in turn encourages risky behavior. Experimental data indicate that in a state of elevated arousal information, judgement is less differentiated and an intensive search for alternatives less probable [28]. The results are supported by earlier observations in disruptive boys that depicted higher resting heart rate levels than controls [29] and in subjects with borderline personality disorder with signs of increased cardiac autonomic function [30]. Further studies on the relationship between psychophysiological measures and impulsivity are lacking.

In parallel to heart rate measures, cortisol levels substantially increased with the onset of gambling in the casino and subsequently decreased towards the end of the session compared to the control condition. A similar increase of HPA axis activity can be observed during acute psychological stress [31–33], thus indicating that casino gambling elicits a moderate stress response with increased levels of plasma cortisol. Surprisingly, cortisol levels in subjects with higher impulsivity measures did not significantly differ from low impulsivity subjects, although high impulsivity subjects displayed higher sympathetic activity. Thus, this data indicates that higher sympathetic activity in high impulsivity subjects cannot simply be interpreted as a more pronounced stress response but may underscore previous observations of increased monoaminergic activity in pathological gamblers [34–36].

Due to methodological challenges the generalizability of the findings in this study and the representativeness are limited. The study focused only on a small number of male gamblers and did not reproduce the same environment for the experimental and control session. However, the environment of the casino plays an integral part of gambling behavior and is also involved in psychophysiological phenomena such as conditioned place preference. Therefore, in the control situation we controlled for two factors: 'wager' and 'environment'. Our research design of a quasi-experimental field study had the advantage of a high external validity. Nevertheless, this advantage is limited by internal validity, as results may be influenced by numerous uncontrollable confounding variables, such as the social context of gambling (changing gamblers at the table with different gambling behavior), the course of gambling events (wagers, wins and losses) or the smoking habits during the game.

Another limitation is that only one type of gambling was used. According to gamblers, blackjack has a reduced potential of stimulation compared to faster games with high payoffs like slot machines or roulette. As these forms of gambling might induce more pronounced changes of cortisol levels and heart rate measures, they should be incorporated in future studies. Moreover, future studies should include further types of psychopathological measures (including subjective arousal) and examine whether other characteristics than impulsivity may contribute to the observed alterations. Specifically, it has been shown that the personality trait 'sensation seeking' may play an important role in moderating impulsivity and that both traits modulate gambling interest and behaviors [37]. It has been hypothesized that sensation-seeking persons may have an attenuation of the sympathetic nervous system activity with an underarousal in risky situations. Venturous gambling behavior could be a way to compensate for the lack of arousal and to achieve a pleasurable level of stimulation. An evaluation of sensation-seeking measures could further elucidate the role of personality traits and the accompanying physiological mechanisms in gambling behavior.

In summary, this study demonstrates that casino gambling induces an increased autonomic nervous system activity and HPA axis activation in males in comparison to a control condition. High impulsivity measures in casino gamblers may cause increased heart rate levels but no alterations of HPA axis activity. Increased autonomic nervous system activity in high impulsivity gamblers may be an indicator of altered monoaminergic mechanisms in the CNS underlying motivation and action-oriented decision-making [3, 38]. As high impulsivity levels were especially found in problem and pathological gambling, ongoing studies are needed to further elucidate the relationship between this personality trait and psychophysiological and neuroendocrine parameters in problematic gambling.


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