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Profiling Online Poker Players

Are executive functions correlated with poker ability and problem gambling?

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Abstract Poker playing and responsible gambling both entail the use of the executive functions (EF), which are higher-level cognitive abilities. This study investigated if online poker players of different ability showed different performances in their EF and if so, which functions were the most discriminating for their playing ability. Furthermore, it assessed if the EF performance was correlated to the quality of gambling, according to self-reported questionnaires (PGSI, SOGS, GRCS). Three poker experts evaluated anonymized poker hand history files and, then, a trained professional administered an extensive neuropsychological test battery. Data analysis determined which variables of the tests correlated with poker ability and gambling quality scores. The highest correlations between EF test results and poker ability and between EF test results and gambling quality assessment showed that mostly different clusters of executive functions characterize the profile of the strong(er) poker player and those ones of the problem gamblers (PGSI and SOGS) and the one of the cognitions related to gambling (GRCS). Taking into consideration only the variables overlapping between PGSI and SOGS, we found some key predictive factors for a more risky and harmful online poker playing: a lower performance in the emotional intelligence competences (Emotional Quotient inven-

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tory Short) and, in particular, those grouped in the Intrapersonal Scale (emotional self-awareness, assertiveness, self-regard, independence and self-actualization).

Keywords Online poker, Executive functions, Problem gambling, SOGS, PGSI, GRCS

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1 Introduction

1.1 Poker, game theory and executive functions

Playing poker requires the use of cognition, both basic abilities (e.g., memory and attention) and higher-level abilities (e.g., monitoring and regulating behavior): the player needs to organize actions in hierarchical goals sequences (planning), to shift attention flexibly to the detected information (flexibility), to activate appropriate strategies, to inhibit inappropriate responses (response inhibition).

These processes are expressed by the executive functions (EF) of the brain, which are needed to achieve optimal performance in situations requiring planning or decision making, novel sequences of actions, error correction or troubleshooting, facing dangers or technical difficulties, overcoming a strong habitual response or resisting temptation (Norman and Shallice 1986).

Some authors (Kerr and Zelazo 2004; Anderson 2008) categorize EF into two groups: cold and hot EF. The former are more cognitive: attention controlling (selective and sustained attention, response inhibition), goal setting (initiating, planning, problem solving, strategic behavior) and cognitive flexibility (working memory, attention shifting, conceptual transfer). The latter are affect-based or reward-sensitive: self-awareness (understanding personal needs, wants), theory of mind (understanding another persons perspective) and moral judgment (making decision on a set of rules or standards).

Some gambling activities engage EF more than others. In the literature (Potenza et al. 2001; Grant et al. 2012), gambling activities are grouped in strategic (poker, stock market, sport betting) and non-strategic (dice, pull-tabs, slot machines games). A "strategic game" is a game whose outcome does not depend exclusively on chance (as it happens for slot machines or lotteries), but also on the ability of the player to think strategically (e.g., purely strategic games are chess, checkers, go, and similar boardgames). Strategic reasoning (Costa-Gomes et al. 2009; Crawford et al. 2013) is a kind of "forward thinking", where the decision maker plans his/her next moves by taking into account not only his/her desires and goals, but also the desires and goals of the competitors, and the moves that the competitors will envision for satisfying those goals.

In strategic games, strategic planning is heavily influenced by the players ability to anticipate the other players moves, in order to plan a best-response strategy. That is, the player must develop a "theory of mind" (TOM; Stahl and Wilson 1995) of the other players, and then plan his/her behavior accordingly. In poker, strategic anticipation entails recursive reasoning of the "What I think that you

think that I think" (Hedden and Zhang 2002) sort, where each subsequent iteration, namely, each subsequent occurrence of the word think, corresponds to one more step of depth of reasoning (for formal classifications of iterative reasoning depth see Camerer et al. 2004; Crawford and Iriberri 2007; Goodie et al. 2012).

In a recent study, Brevers et al. (2013) state that strategic gambling entails both cold and hot EF:

> Strategic gambling conceivably involves different cognitive demands than non-strategic gambling. Poker, for example, in addition to involve "hot" emotional self-regulation (bluffing, regulation of loss-induced frustration; Palomäki et al. 2013), requires "cool" executive processes such as, working memory and mental flexibility (e.g., keeping track of cards played to determine odds of receiving a certain card).

Behavioral economists and cognitive psychologists have shown experimentally that the iterative process required by strategic reasoning heavily taxes cognitive resources and executive functions (Nagel 1995; Cherubini and Johnson-Laird 2004; Coricelli and Nagel 2009; Mazzocco et al. 2013).

Differently from "pure" strategic games (such as chess), poker does also involve chance and probabilities, namely *risk*: that is, according to a definition based on economics, the variance of the stakes at hand, each one associated to its own estimated degree of probability. In similar settings, where decisions must be taken under uncertainty, choices are vastly affected by individual *risk attitudes*. If the expected value of a bet is kept equal, a *risk seeking* decision maker is an individual opting for the more risky choice (the choice that could entail the higher max, but also the lower min), whereas a *risk averse* agent will opt for the less risky choice (going for the higher min even if it implies a lower max). A *risk neutral* person will be indifferent between choices with the same expected value. Whether risk neutrality, seeking, or else aversion is the rational attitude depends on the circumstances (including the available resources, final goals, time perspective, and so on): no attitude is rational *a priori*. However, an *average risk neutrality*, encompassing the flexibility necessary to turn risk seeker or risk averse depending on changing circumstances, is widely seen as the decision style most associated to success in investment choices, and possibly in other gambles. This is particularly important in gambling: it has been shown that people tend to be risk seeking when they are losing, and risk averse when they are winning. In gambling, this might result in catastrophic losses (e.g., think of players bidding more than they can afford, in the desperate last attempt to recover their losses) or in under-optimized gains.

1.2 Poker profiling software

Poker has been studied with specific profiling software (Johansson and Sönströd 2009; Siler 2010). Online poker players often use software (e.g., Poker Office, PokerTracker, Hold'em Manager) able to collect data on the player his/her opponents. This kind of software gathers data on the actions of the players, the situations they face, the decisions they make and the consequent outcomes. Mining the data collected by these software, Johansson and Sönströd (2009) were able to categorize players into winners and losers, and to identify the most significant indicator for identifying Losers (cold-calling too many raises preflop). The final output of these

systems are players profiles including their poker playing style. Siler (2010) used a software to gauge the strategies adopted in more the 27 million poker hands played online in small-stakes, medium-stakes and high-stakes games. The software also examined the payoffs associated with different strategies. The author stated that

> Adopting risk-neutrality to maximize expected value, aggression and appropriate mental accounting, are cognitive burdens on players, and underpin the *rationality work* – reconfiguring of personal preferences and goals – players engage into be competitive, and maximize their winning and profit chances.

1.3 Executive functions and responsible gambling

EF are impaired in many conditions. Some are permanent, some temporary: acute and chronic stress (Jonsdottir et al. 2013), chronic alcohol consumption (Loeber et al. 2009), pathological gambling (Roca et al. 2008), addictions such as drug (Lundqvist 2005) and disordered gambling (van Timmeren et al. 2018), personality disorders (Gvirts et al. 2012), behavioral disorders (Savage et al. 1999), mood disorders (Sweeney et al. 2000), neurological disorders (Marañón et al. 2011), mental disorders (Velligan and Bow-Thomas 1999).

Pathological Gambling, from the DSM-V onwards called *Disordered Gambling* (APA 2013), is just one of the conditions, in which EF performance are impaired. Among gamblers there are not only problematic or pathological gamblers, but also users living with one or more of the above conditions (comorbidity).

Recently (Dowling et al. 2015), a systematic review of 36 studies on *treatment-seeking problem gamblers* meta-analyzed the prevalence of comorbid psychiatric disorders classified trough the DSM-IV criteria. The study identified high rates of comorbid current (74.8%, 95% CI 36.5-93.9) and lifetime (75.5%, 95% CI 46.5-91.8) Axis I clinical disorders. There were high rates of current mood disorders (23.1%, 95% CI 14.9-34.0), alcohol use disorders (21.2%, 95% CI 15.6-28.1), anxiety disorders (17.6%, 95% CI 10.8-27.3) and substance (non-alcohol) use disorders (7.0%, 95% CI 1.7-24.9). Nicotine dependence (56.4%, 95% CI 35.7-75.2) and major depressive disorder (29.9%, 95% CI 20.5-41.3) showed the highest mean prevalence of current psychiatric disorders. They found also the following comorbidity prevalences: alcohol abuse (18.2%, 95% CI 13.4-24.2), alcohol dependence (15.2%, 95% CI 10.2-22.0), social phobia (14.9%, 95% CI 2.0-59.8), generalised anxiety disorder (14.4%, 95% CI 3.9-40.8), panic disorder (13.7%, 95% CI 6.7-26.0), post-traumatic stress disorder (12.3%, 95% CI 3.4-35.7), cannabis use disorder (11.5%, 95% CI 4.8-25.0), attention-deficit hyperactivity disorder (9.3%, 95% CI 4.1-19.6), adjustment disorder (9.2%, 95% CI 4.8-17.2), bipolar disorder (8.8%, 95% CI 4.4-17.1) and obsessive-compulsive disorder (8.2%, 95% CI 3.4-18.6).

Taking into consideration *Pathological Gambling*, a very recent study on 599 patients (Rodriguez-Monguio et al. 2017) conducted in Massachusetts (USA), showed high prevalence of psychiatric comorbidity and substance abuse disorders. The most prevalent were impulse control disorders (50%), episodic mood disorders (31%), anxiety disorders (14%) and psychoactive substances (9%).

Another recent study (Assanangkornchai et al. 2016), conducted on the Thai general population (n=4,727 participants), showed high prevalence rates of psychi-

atric comorbidities in *pathological gamblers*. The most common ones were alcohol abuse (57.4%), nicotine dependence (49.5%), and any drug use disorder (16.2%). Pathological gambling was highly prevalent among those who ever experienced major depressive episodes (5.5%), any drug dependence (5.1%), and intermittent explosive disorder (4.8%). The association between pathological gambling was strongest with a history of major depressive episode [adjusted odds ratio (AOR)=10.4, 95% CI: 2.80-38.4].

Moreover, a recent review (Rash et al. 2015) focusing on *Gambling Disorder* (GD), showed that 96% of individuals with lifetime DG had comorbidity with at least one other lifetime psychiatric disorder. The lifetime rates of mood disorders (49%-56%), anxiety disorders (41%-60%), alcohol use disorder (73%) and drug use disorder (38%) were highly prevalent in disordered gamblers.

Therefore, the literature on the performance of executive functions in mental disorders and the literature on the prevalences of comorbities in problem, pathological and disordered gamblers suggest that there is an unknown amount of gamblers, who cannot count permanently or temporarily on well performing executive functions, needed to play responsibly.

The Ontario Problem Gambling Research Centre developed a *Conceptual Framework of Harmful Gambling* (Abbott et al. 2013). Factors influencing harmful gambling were identified and grouped in Gambling specific factors (Environment, Exposure, Type and Resources) and General factors (Cultural, Social, Psychological and Biological). Some of these factors, such as judgment, decision-making, perception of self and problem-solving are high-level cognitive processes controlled by the executive functions.

Recently a study on a population of pathological gamblers, assessed with DSM-IV criteria, showed that "strategic and non-strategic gamblers did not differ in terms of cognitive function; both groups showed impairments in cognitive flexibility and inhibitory control relative to matched healthy volunteers" (Grant et al. 2012). Brevers and Noël (2013) stated:

> studies on gambling addiction have yielded a consistent view of disadvantageous decision-making in pathological gamblers. In this review, we advanced that this aberrant profile of decision-making may be underlined by a hyperactivity of impulsive processes toward high-uncertain rewards, which can interfere with hot and cool reflective resources necessary for self-regulation.

1.4 The aim of this study

This research is a preliminary study to evaluate the feasibility of a software system aimed to support responsible gambling in online poker environments. The collected data will be used to build a battery of quick and effective tests in electronic form to outline the executive functions of online poker players in order to support them in improving the awareness of their own playing skills and ability to play responsibly before they start a game session.

Currently, existing software systems (e.g., Playscan) that try to identify problematic players are mostly based on behavioral data analysis and they try to limit problematic and pathological gambling by monitoring and evaluating gaming and gambling habits and by providing the users with information and opportunities to

change behavior while playing. Complementary to this, our main idea is to base the new system on dynamic cognitive profiling (executive functions), improving the awareness of players' own cognitive performance from time to time and informing them about their expected ability to play before problematic behaviors and financial ruin should occur.

2 Research objectives and methods

2.1 Objectives

Poker and responsible gambling both entail the use of executive functions. Despite this fact, up to date there was a lack of contributions on the study of EF in professional and recreational online poker players.

Therefore, the main objective of this work was assessing if online poker players of different ability show different performance in their EF and, if so, which functions are the most discriminating ones. The secondary objective was assessing if the EF performance is related to the different aspects of gambling as measured by the Problem Gambling Severity Index (PGSI), the South Oaks Gambling Screen (SOGS) and the Gambling Related Cognition Scale (GRCS) (see Section 2.4.2).

2.2 Study design

In order to collect the information needed to answer our research questions, we organized a two-stage study based on volunteer online poker players.[1]

The inclusion criteria were the following: the persons participating the study had to

- be in the age range 18–70,
- have played at least 10,000 hands of cash poker (*No limit Texas Hold'em* and/or *Omaha pot limit*) in the last 3 months.

We considered only these two varieties of poker for three reasons: (i) they are by far the most popular among online players (PokerStars 2017; CardsChat 2017); (ii) the quantity of information shared in this type of games (community card poker) is much more than in traditional poker (5-card-draw) and this reduces the amount of randomness and, thus, enhances the importance of skills and EF; (iii) the most popular poker profiling software packages analyze only these two varieties of poker.

First stage A call for volunteers was published on Poker forums and in Facebook addressed to online poker players respecting the aforementioned inclusion criteria. Furthermore, a professional poker player was consulted both as expert in the field and as recruiter. All the interested players were invited to visit the website containing all the relevant information about the study. The players interested in participating clicked on a link leading to a secure web site, produced by a company specialized in collecting health-related sensitive information.

[1] The study design was approved by the Ethical Committee of the University of Milano-Bicocca and it complies with the guiding policies and principles for experimental procedures of both the World Medical Association of Helsinki and the Oviedo Convention.

Once logged in, read and approved the informed consent, the volunteers were invited to create an anonymous nickname and email account to communicate with the researchers. Then, they filled in a questionnaire on three socio-demographic characteristics (age, gender, education) and the Problem Gambling Severity Index. As last task, they were requested to upload their own poker hands history files.

Second stage All participants fulfilling the inclusion requirements were given the opportunity to take part in the second stage, which consisted in the individual administration of an extensive neuropsychological test battery by a trained professional psychologist blinded to poker skill at the University of Milano-Bicocca. Each test battery was performed in the same office at the only presence of the psychologist. All participants signed the informed consent which was previously emailed to them. All tests and questionnaires were administered following the official prescriptions: some tasks had a time limit while some did not.

Each battery of tests lasted between 3 and 5 hours, the time depending on the speed of reaction of each volunteer and on the fact that some tests do not impose any time limit to be completed (e.g., Raven's Standard Progressive Matrices and Wisconsin Card Sorting Test). Therefore, since it was possible that during the administration of tests and questionnaires, participants may feel tired or agitated, the examiner evaluated from time to time whether to suspend or terminate the administration, following the requirements of Good Clinical Practice of the European Union.

The times needed by each participant to complete tasks without a fixed time deadline were measured and included as explanatory variables in the data analysis. Thus, the effect of the duration of the tests was considered in our analysis.

2.3 Participants

The first stage involved 46 Italian active players (41 males; Mean age M = 32ys, SD = 7.1ys; Mean education M = 14.8ys, SD = 3ys). Among them, 36 (31 males; Mean age M = 33ys, SD = 7.3ys; Mean education M = 15ys, SD = 3ys) accepted to be evaluated through the test battery in the second stage.

2.4 Measures

2.4.1 Poker ability assessment

During the planning of the study design, the three consulted international online poker players agreed on the methodology to apply in the research study to evaluate the abilities of the poker players: they analyzed the hand history files with the help of a poker profiling software (Hold'Em Manager 2 and PokerTracker 4; see Section 1.2) and *hand history replayers*. While the former kind of software statistically generates measures referring to the actions made by the players, the situations in which the decisions were taken and their consequent effects, the latter kind of software is able to recreate the online poker table and all the moves made by the players, allowing to go back through previously played hands, to increase/decrease the speed of the playing time and to pause and replay at will.

Since the hand history files contain the nickname used by the players while playing, to ensure anonymity and avoid identification, also the hand history files were anonymized by one of the researchers. The poker experts independently evaluated the volunteers, without exchanging any information during the whole process and delivered their final evaluations to one of the researchers.

The poker evaluation process was based on two kinds of measures: the individual opinion of each poker expert, built during the vision of the poker hands (*hand history replayers*) and the analysis of hundreds of statistical indexes provided by the poker profiling software. These indexes are grouped into clusters giving clear indications of both the abilities and the poker style of the player.

During the planning of the design study, the consulted poker experts also agreed to classify the players using a 0-100 score scale. To build the final 0-100 score, they weighted 50% their own personal opinion on the player and 50% the information gathered by the statistical analysis (indexes and graphs) provided by Holdem Manager and PokerTracker.

Although the three poker experts took into consideration all the hundreds of statistical indexes provided by the poker profiling software, the main attributes they analyzed are the following:

- All-In EV Line in Graph (also $ EV Adjust) – based on when a hand goes all-in before the river (since equity on the river will always be 0% or 100%) and calculated by taking the actual amount won and either deducting or adding the amount the player would have won with average luck;
- AF (Aggression Factor) – the number of bets plus raises divided by the number of calls;
- BB/100 (Big Bets) – amount of large bets won (twice the big blind or more) per every 100 hands dealt;
- CCPF (Cold Call Preflop) – percentage of times a player calls a preflop 3bet when he/she doesn't have any money in the pot yet, including blinds;
- 3Bet% – percentage of times a player reraises preflop when facing single raised pot;
- 4Bet% – percentage of times a player reraises preflop when facing 3Bet;
- CR (Check-raise) – Percentage of time a player checkraises after checking the flop, turn or river;
- cbet (Continuation Bet) – percentage of times player bets on the flop after having raised on preflop;
- Steal – percentage of hands player raises first in unopened pot preflop from CO, BTN, SB;
- VPIP (Voluntarily Put money in the Pot) – the percentage of hands where player voluntarily put money in the pot;
- PFR (PreFlop Raise) – percentage of hands where player raised preflop;
- WTSD% (Went To ShowDown) – percentage of hands where player went to showdown
- WonSD% – percentage of hands player won at showdown;
- Win Rate – player winrate in bb/100

These quantities are routinely computed by most poker profiling software packages such as the ones used by our evaluators (Holdem Manager Team 2009; PokerTracker Team 2013).

2.4.2 Gambling assessment

The self-reported questionnaires used in the study provide different kinds of classifications/evaluations and request the individual to refer to different periods of his/her life:

- Problem Gambling Severity Index (PGSI) (Ferris and Wynne 2001; Wynne 2002): this is the 9 item gambling screener for the Canadian Problem Gambling Index scale (CPGI). It was specifically created for use with the general population and it was designed to differentiate between degrees of problem gambling: "the PGSI presents a viable alternative to the SOGS for assessing degrees of problem gambling severity in a non-clinical context"(Holtgraves 2009). It divides gambling in 4 classes: non-problem; low level of problems with few or no identified negative consequences; moderate level of problems leading to some negative consequences; problem gambling with negative consequences and a possible loss of control. It refers to the last 12 months of the individual's life. According to Wynne's work (Wynne 2002, see Appendix 3), it classifies 4 gambler sub-types: non-problem gambler, low risk gambler, moderate risk gambler, problem gambler.
- South Oaks Gambling Screen (SOGS) (Lesieur and Blume 1987, 1993) : it was created for use in clinical context and it assesses if the subject is a gambler or not and if he/she is a problem gambler/probable pathological gambler or not. It evaluates maladaptive behaviors associated with gambling that affect personal, family, and work. It refers to the entire course of the individual's life.
- Gambling Related Cognition Scale (GRCS-I) (Raylu and Oei 2004; Iliceto et al. 2015): This 23-item scale assesses gamblers cognitions related to gambling, including levels of irrational beliefs. It shows five factors, which include interpretative control/bias (GRCS-IB), illusion of control (GRCS-IC), predictive control (GRCS-PC), gambling-related expectancies (GRCS-GE) and a perceived inability to stop gambling (GRCS-IS). It refers to the current time. The GRCS has good psychometric properties and it is a useful instrument for identifying gambling related cognitions among non-clinical gamblers (Raylu and Oei 2004). A study showed that perceived inability to stop gambling and illusion of control are good predictors for pathological gambling among poker players (Barrault and Varescon 2013).

2.4.3 Executive functions assessment

The battery included the following tests and questionnaires (in order of administration):

- Wisconsin Card Sorting Test Computer Version (WCST) (Berg 1948; Grant and Berg 1948). WCST is a test of "set-shifting", the ability to display flexibility in the face of changing schedules of reinforcement. The WCST assesses: flexibility in choosing strategies of problem solving; abstraction inability; perseveration; strategic planning, organized searching, utilizing environmental feedback to shift cognitive sets, directing behavior toward achieving a goal, and modulating impulsive responding (Robinson et al. 1980) . A study showed that patients with problem gambling had abnormalities emerging from the WCST,

in particular they could not learn from their mistakes and look for alternative solutions (Marazziti et al. 2008);
- Frontal Assessment Battery (FAB). It assesses: conceptualization, mental flexibility, motor programming, sensitivity to interference, inhibitory control and environmental autonomy (Dubois et al. 2000);
- Free Drawn Clock Test (FDCT) following the Freedman method (Freedman et al. 1994), for the assessment of visuospatial abilities, planning abilities and praxic abilities. "The clock drawing test appears to be useful in discriminating people with cognitive decline from normal healthy individuals" (Caffara et al. 2011);
- Raven's Standard Progressive Matrices (SPM) (Raven et al. 2003; Raven 2008). This test measures fluid intelligence, the ability to think logically and solve problems in novel situations. It is independent of acquired knowledge. Furthermore SPM measures sustained attention, the ability to focus attention on a task over time;
- Phonemic and Semantic Verbal Fluency Test (FLUF and FLUS) (Novelli et al. 1986). These tasks requires the use of divided and alternating attention. The test allows a rapid and efficient assessment of the ability to evoke words (lexical access) and it is also used as frontal test to evaluate the ability to generate an appropriate searching strategy (Novelli et al. 1986);
- Memory with Interference (MEMINT); the Brown-Peterson procedure (Brown 1958; Peterson and Peterson 1959) has been used to assess working memory.
- Attentive Matrices (MAT) (Spinnler and Tognoni 1987). Instrument to evaluate selective and sustained attention;
- Digit Span (Forward and Back) (DIGIT). Short-term Memory and Working Memory;
- Trail Making Test (TMT) (TMT-A, TMT-B) (Reitan 1955), which assesses the ability of spatial planning in a visuo-motor task, motor speed attention functions, attention shifting and response inhibition;
- Stroop Color Word Interference Test (STR) (Golden 1978; Venturini et al. 1983). Assessment of visual attention and response inhibition. In a controlled study a sample of medication-free pathological gamblers showed an impaired and significantly slower and less accurate performance than healthy subjects at this test (Kertzman et al. 2006);
- Cognitive Estimation Test (COGST) (Shallice and Evans 1978; Della Sala et al. 2003). The test measures deductive reasoning, self-monitoring and evaluation accuracy. The former is the ability to reason from one or more statements to reach a logically certain conclusion. The latter is the ability to be aware of what one knows and to be able to make accurate assessment of his/her knowledge and skill. Evaluation accuracy is the capacity of providing measurements of a quantity, that are close to the true value;
- Tower of London (TOL) (Shallice 1982; Phillips et al. 1999, 2001). Assessment of goal setting (includes initiating, planning, problem solving, strategic behavior). Planning is the ability to think about and organizing the activities required to achieve a desired goal; problem solving is the capacity of moving from a given state to a desired goal (able to understand the problem goal and the rules to be applied); strategic behavior is the ability to select a more profitable strategy;

– Emotional Quotient inventory Short (EQi:S) (Bar-On 1996, 1997, 2002). Based on the Bar-On model of emotional-social intelligence (Bar-On 2005), this short version of the inventory takes into consideration the five main scales (Intrapersonal, Interpersonal, Adaptability, Stress Management and General Mood). In addiction, also three validity indexes are calculated (Positive Impression, Incoherence Index, Item 52). It assesses those psychological dimensions that are not strictly related to cognitive intelligence, but oriented to psychological well-being and success in life (e.g.: understanding oneself and others, adapting to changes and demands of the environment).

2.4.4 Impulsivity, Gratification delay, Risk attitude assessments

– Frederick's Cognitive Reflection Test (CRT) evaluates the ability of the person to avoid an impulsive and obvious response in favor of the correct one, which needs more time and reflection. It correlates with intelligence quotient, temporal discounting, risk and gambling preference (Frederick 2005);
– Frederick's Risk Seeking Behavior Questionnaire (RSBQ); requesting to choose between alternative possibilities - a certain gain/loss versus an higher/lower expected value gamble(gain/loss), this questionnaire evaluates the risk seeking behaviour (Frederick 2005);
– Frederick's Intertemporal Behavior Task (IBQ) (Frederick 2005); the individual shall make choices between alternative possibilities: an immediate reward or a delayed one. Furthermore it is requested a self-evaluation about impulsivity, procrastination, thinking about his/her own future and worries about inflation comparing him/herself to the other participants to the research (he should make an effort to imagine their characteristics).

2.4.5 Mood assessment

A mood assessment was performed, because mood can influence performances. A lack of motivation, for example, like the one experienced in a depressive mood, can generate a decrement of specific executive abilities (Sweeney et al. 2000). Furthermore, patients with unipolar major depressive disorder show impaired decision-making disorder in static and dynamic environments: they have difficulties perceiving when a previously bad contingency becomes good, making poor adjustment to a changing environment (Cella et al. 2010). Moreover, depression and anxiety are good predictors for pathological gambling among poker players (Barrault and Varescon 2013). In an analysis of 11 populations studies, 37.9% of problem and pathological gamblers suffered from at least one co-morbid mood disorder (Lorains et al. 2011). Recent critical literature review found that depression has consistently been demonstrated to be a pathological gambling risk factor (Johansson et al. 2009).

As mentioned in Section 1.3, a very recent review (Rash et al. 2015) showed high lifetime prevalence rates of mood (49%-56%) and anxiety disorders (41%-60%) in disordered gamblers.

Hamilton Rating Scale for Depression (HAM-D) and Hamilton Anxiety Scale (HAM-A) were administered at the end of the battery.

Table 1 Tests and questionnaires: order of administration, acronyms and full names.

Order	Acronym	Full name
13	COGST	Cognitive Estimation Test
16	CRT	Cognitive Reflection Test
10	DIGIT	Digit Span
15	EQIS	Emotional Quotient Inventory Short
3	FAB	Frontal Assessment Battery
4	FDCT	Free Drawn Clock Test
6	FLUF	Phonemic Verbal Fluency Test
7	FLUS	Semantic Verbal Fluency Test
21	GRCS	Gambling Related Cognition Scale
20	HAMA	Hamilton Anxiety Scale
19	HAMD	Hamilton Depression Scale
18	IBQ	Intertemporal Behavior Questionnaire
9	MAT	Attentive Matrices
8	MEMINT	Memory with Interference
1	PGSI	Problem Gambling Severity Index
17	RSBQ	Risk Seeking Behavior Questionnaire
22	SOGS	South Oaks Gambling Screen
5	SPM	Ravens Standard Progressive Matrices
12	STR	Color Word Interference Test
11	TMT	Trail Making Test
14	TOL	Tower of London
2	WCST	Wisconsin Card Sorting Test

2.5 Statistical methods

While in the clinical practice the neuropsychological tests are used to measure psychological functions and provide a diagnostic classification (e.g., normal, borderline, impaired), the main aim of this step of the research is identifying which items of the gold standard tests for EF are the most predictive of poker ability and gambling quality. Indeed, the selected test items will be candidates for the second step of the research in which quick test-games will be implemented to approximate their outcomes in a card-based web environment.

Thus, each single item of a test or questionnaire was considered potentially useful and we did not use only the general score of a test or questionnaire (e.g., total correct answers; total time needed to complete the task). Furthermore, we used raw scores instead of weighted scores (raw scores corrected for age, gender and education) in all tests but one (EQ-i Short, which provided us automatically with both raw and weighted), because we correlated the neuropsychological data with the scores given by the experts for the poker ability, which are not weighted. Actually, poker expert did not take into account the age, gender and education of the players while judging them.

The dataset we have built consists of 511 variables observed on 36 poker players. Now, few of these variables (6) have some missing values and some (62) are constant and so we exclude them from the analysis. Some variables are collinear by construction because built as linear combinations of other variables (e.g., when a total score is obtained as sum of partial scores).

In the search for variables that predict poker ability as measured by the experts' ability score, even after the deletion of missing and constant variables, we faced a total of 442 predictors and only 36 observations. As for the quality of gambling,

we want to find predictors for the total scores of the three tests PGSI, SOGS and GRCS among the remaining 405 variables in the dataset.

Thus, we are in the non desirable situation in which the number of predictors is much larger than the sample size. Furthermore, the possible relations between ability and EF is corrupted by a noise due to the different times at which the poker playing data were sampled and the EF tests submitted. If we formalize the relation between poker ability and one particular EF measurement using a simple linear model, we can think of the performance Y_{it} of the player i at time t as sum of two components: one, say $\bar{EF}_i$, represents the average EF level of i and the other, say $EF_{it}^{\perp}$, represents deviations from the average level at time t. In formula

$$Y_{it} = \alpha + \beta EF_{it} + \epsilon_{it} = \alpha + \beta(\bar{EF}_i + EF_{it}^{\perp}) + \epsilon_{it},$$

with ϵ_{it} a zero-mean error. We only observe the values Y_{it} for some $t = t_0$ and the value of EF_{it} for some $t = t_1$, with $i = 1, 2, \ldots, 36$. This is the classical *errors-in-variables* problem because we observe EF_{it_1} and not $\bar{EF}_i$ or, better, EF_{it_0}. The well known effect on the least-squares estimates of β and on the correlation coefficient between Y_{it} and EF_{it} is a bias toward zero: the higher the variability of $EF_{it}^{\perp}$, the stronger the bias.

Now, we can summarize our statistical problem as follows:

1. we have to identify significant relations between a response variable and a large number of candidate predictors,
2. the number of predictors is much larger than the number of observations,
3. the predictors are measured with errors.

The strategy that we developed to deal with this set-up is the following

1. state the (theory-based) expected sign of the linear correlation between the response and each predictor (in few cases the expected sign could be unknown),
2. compute all sample correlations between response variable and predictors and select those predictors for which the modulus of the correlation coefficient is greater that a given threshold (we used 0.33, which is the approximate 95% critical value for the test of zero correlation under our sample size[2]),
3. for the selected predictors, count the number of times the sample correlation sign is equal to the expected sign and test (at an usual level) if this number of matches is not random[3].

For all computations and plots we used R (R Core Team 2016).

3 Results

3.1 Poker ability

Each poker expert examined individually the players and after having evaluated the poker attributes mentioned in Section 2.4.1, they assigned them an overall ability score ranging 0–100. We used as measure of poker ability the average of the scores provided by the poker experts (Mean score = 47; SD = 24.7). The

[2] Computed as $\tanh(1.96/\sqrt{33}) \approx 0.33$.

[3] Here, by random it is meant that either sign has 50% probability of being extracted.

agreement among the scores formulated by the experts is extremely strong: the mutual correlations of the three evaluations are above 93% and the correlations between each evaluation and the average score around 98%. According to that mean overall scores, the sample has been divided in 3 subgroups: 6 Strong players (ST; Mean overall score ranges= 100–71); 12 Medium players (MD; Mean overall score ranges= 70–51) and 18 Weak players (WK; Mean overall score ranges= 50–0).

3.2 Gambling

PGSI. The Problem Gambling Severity Index was submitted online in the first stage ($n = 46$). The sample was classified as follows: 8% non-problem gambling; 22% low level of problems with few or no identified negative consequences; 63% moderate level of problems leading to some negative consequences; 7% problem gambling with negative consequences and a possible loss of control. Referring to Wynne's work (Wynne 2002, see Appendix 3), the 4 gambler sub-types are: 8% non-problem gamblers, 22% low risk gamblers, 63% moderate risk gamblers, 7% problem gamblers. Considering the volunteers that accepted to be administered with the test battery ($n = 36$), we had: 11% non-problem gambling; 17% low level of problems with few or no identified negative consequences (low risk gamblers); 72% moderate level of problems leading to some negative consequences (moderate risk gamblers). Among the volunteers in this group none was classified as problem gambling with negative consequences and a possible loss of control: all the problem gamblers ($n = 4$) did not show for the second stage of the research, even though the test results were unknown to the volunteers.

SOGS. South Oaks Gambling Screen was part of the battery administered at the university ($n = 36$). The sample was composed by 50% with no problem gambling, 36% with problem gambling and 14% with probable pathological gambling.

GRCS. The Gambling Related Cognition Screen was administered together with SOGS. No normative data for the Italian population are available at the moment of writing, but we were interested in the variability of the intermediate and final variables and not to reference threshold values (see 4.3.5 and 4.4.3).

3.3 Primary objective: Poker ability and EF tasks

For poker ability (see Table 2) the strongest seven correlations have the expected sign and this event is associated with a probability of 0.008 under the null of zero correlation, and thus, random sign. If we take into account all the correlations stronger than 0.33, then the probability of having a number of matches equal to or greater than the one observed (under the null of zero correlations) is 0.025. In both cases these p-values are smaller than the usual 5% and so we reject the hypothesis that these correlations are different from zero only because of the action of chance.

Table 2 Correlations with poker ability score.

Variable	Measure of	Corr.	Exp. sign	No. of match.	Prob.
IBQ_N_HOW_MUCH_IMPULSIVE	impulsivity (self-reported)	-0.50	-1	1	0.500
EQIS_ADEQ_LOW_80_89	low adaptability*	-0.47	-1	2	0.250
COG_ST_TOT_BIZ_0_21	cognitive bizarreness	-0.44	-1	3	0.125
EQIS_INTER_EQ_STD_50_150	social skills standard score	0.42	1	4	0.063
EQIS_INTEREQ_VHI_120_129	very high social skills*	0.40	1	5	0.031
SPM_D_COR_0_12	fluid intelligence	0.40	1	6	0.016
EQIS_INTER_EQ_RAW	social skills raw score	0.38	1	7	0.008
FLUF_F_ER_VAR	perseverative errors	0.37	-1	7	0.035
EQIS_SM_EQ_RAW	stress manag. raw score	0.37	1	8	0.020
TOL_2_TOT_FA	false alarms in easy task	0.37	-1	8	0.055
TOL_10_NUMBTRY_0_3	goal setting in difficult task	-0.36	-1	9	0.033
FLUF_P_ER_VAR	perseverative errors	-0.36	-1	10	0.019
TOL_2_TOT_MOVE_2	goal setting in easy task	0.36	-1	10	0.046
EQIS_SM_EQ_STD_50_150	stress management std score	0.35	1	11	0.029
FLUF_ALLER_OTHER	tot non-perseverative errors	0.34	-1	11	0.059
COG_ST_TOT_SCORE_0_42	lack of evaluation accuracy	-0.34	-1	12	0.038
TOL_10_TOT_FA	false alarms in difficult task	-0.33	-1	13	0.025

* dummy variable (i.e., scores are either 0 or 1).

3.4 Secondary objective: Gambling and EF tasks

For the problem gambling scores, all signs of the 28 correlations of the PGSI are matched (see Table 3). The probability of having this or a better results in guessing a random sign has probability $1.1 \cdot 10^{-7}$ (virtually zero). All but one sign of the 21 correlations of the SOGS are matched (Table 4). The probability of having this or a better results in guessing random signs has probability 0.0001. All 37 correlations signs of the GRCS are matched (Table 5). The probability of this event under the null of random signs is $5.1 \cdot 10^{-8}$ (virtually zero).

4 Discussion

The aim of this preliminary study was to gather data on the characteristics of the EF performance in a population of professional and recreational online poker players and to verify whether and eventually which EF were related to different levels of ability to play poker and different gambling quality. This step was fundamental to evaluate the feasibility of the main goal of the research: designing and creating new EF tests able to support online poker players to gamble responsibly.

The main limitation of this study is related to the different timing of the evaluation of the EF performance and of the gambling ability and quality. Indeed, the assessment of poker ability has been based on the observation of a large number of hands played months before the administration of the EF tests. Since EF vary over time, our study is able only to capture the somewhat noisy relation between the average level of poker ability shown by the participant in the last few months and the level of the executive functions during the day of administration. In an ideal study, the EF assessment and the poker ability evaluation should take place almost simultaneously. The implementation of such a design would require that the psychologist administrates the tests, then the participant is asked to play online

Table 3 Correlations with PGSI severity score.

Variable	Measure of	Corr.	Exp. sign	No. Of match.	Prob.
EQIS_INTRA_VHI_120_129	Very high self-awareness & self-expression*	-0.55	-1	1	0.500
FLUS_FR_ER_RIP	Perseverations in searching strategy task	0.48	1	2	0.250
FLUS_ALLER_TOT	Tot. errors in searching strat. task	0.47	1	3	0.125
FLUS_ALLER_RIP	Tot. perseverations in searching strat. task	0.46	1	4	0.063
FLUS_FR_TOT_ER	Tot. errors in a specific category	0.46	1	5	0.031
TOL_11_TOT_VIOL	Tot. rules violations in the 11th run	-0.45	1	5	0.109
EQIS_GM_EQ_STD_50_150	General mood std score	-0.45	-1	6	0.063
EQIS_TOTEQ_VHI_120_129	Very high emot. quotient*	-0.43	-1	7	0.035
EQIS_GM_EQ_RAW	General mood raw score	-0.43	-1	8	0.020
EQIS_TOT_EQ_RAW	Total emotional quot raw score	-0.42	-1	9	0.011
EQIS_SMEQ_VHI_120_129	Very high stress management score	-0.40	-1	10	0.006
EDUCATION	Years of schooling	-0.39	-1	11	0.003
EQIS_GMEQ_VHI_120_129	Very high general mood*	-0.38	-1	12	0.002
EQIS_INTRA_EQ_STD_50_150	Self-awareness & self-expression std score	-0.38	-1	13	0.001
EQIS_TOT_EQ_STD	Total emotional quot std score	-0.38	-1	14	0.000
IBQ_M_SMALLEST_AMOUNT_4DYS	Ability to delay gratification	-0.38	-1	15	0.000
EQIS_INTRA_EQ_RAW	Self-awareness & self-expression emotional quotient raw	-0.37	-1	16	0.000
EQIS_PIEQ_HI_110_119	High social desirability	-0.37	-1	17	0.000
MAT_FA_TOT_0_270	Tot errors in visual select attention task	0.36	1	18	0.000
MAT_INTRUS_TOT_0.40	Tot perseverations in visual select attention task	0.36	1	19	0.000
IBQ_TOT_AK_IMMED_VS_PATIENT	Immediate rewards vs patient options	0.35	1	20	0.000
IBQ_G_400_NOW	Immediate reward	0.35	1	21	0.000
FDCT_N_COR_POS_0_1	Accuracy of praxic abilities	-0.35	-1	22	0.000
FLUF_P_ER_RIP	Perseverations in searching strategy task	0.34	1	23	0.000
EQIS_TOTEQ_MED_90_109	Average total emotional quotient	0.34	1	24	0.000
FDCT_MN_IND_0_1	Attention to details	-0.34	-1	25	0.000
MEMINT_10SEC_JL_TOT_0_9	Working memory errors	0.33	1	26	0.000
EQIS_INTER_EQ_RAW	Social skills raw score	-0.33	-1	27	0.000

* dummy variable.

Table 4 Correlations with SOGS score

Variable	Measure of	Corr.	Exp. sign	No. Of match.	Prob.
FDCT_HND_PROP_0_1	Attention to details in visuospatial task	-0.43	-1	1	0.500
MEMINT_10SEC_PMT_JL_0_3	Working memory errors	0.43	1	2	0.250
TOL_12_TOT_RA	Right answers in the 12th TOL run	-0.43	-1	3	0.125
WCST_TR_COMP_1CAT	Environomental feedbacks needed to solve a problem	0.41	1	4	0.063
MAX_DAILYBET_10_100EUR	Max daily bet in Euro (10-100)*	-0.38	-1	5	0.031
EQIS_INTRA_VHI_120_129	Very high self-awareness & self-expression*	-0.38	-1	6	0.016
FLUF_L_ER_VAR	Persevative errors in searching strategy task	0.37	1	7	0.008
RSBQ_C_1000_CERTGAIN	Low risk seeking behavior	-0.36	-1	8	0.004
EQIS_INTEREQ_LOW_80_89	Very low social skills	0.36	1	9	0.002
GRCS_TOT_SCORE_23_161	Gambling-related distortions	0.36	1	10	0.001
GRCS_TOT_AVER_1_7	Average Gambling-related distortions	0.36	1	11	0.000
EQIS_INTRA_EQ_STD_50_150	Self-awareness & self-expression std score	-0.35	-1	12	0.000
EQIS_INTRA_EQ_RAW	Self-awareness & self-expression raw score	-0.35	-1	13	0.000
EQIS_TOT_EQ_RAW	Total emotional quotient raw	-0.35	-1	14	0.000
FAB_MOTOR_0_3	Motor programming ability	-0.35	-1	15	0.000
EQIS_TOTEQ_VLW_70_79	Very low total emotional quotient	0.35	1	16	0.000
EQIS_ADEQ_XLW_.70	Extra low adaptability	0.35	1	17	0.000
EQIS_GMEQ_VLW_70_79	Very low general mood	0.35	1	18	0.000
TOL_4_TOT_MOVE_3	Goal setting ability	-0.35	1	18	0.000
HAMA_NOA_0_13	No Anxiety	0.34	-1	18	0.000
RSBQ_F_100_CERTGAIN	Very low risk seeking behavior	-0.34	-1	19	0.000

Table 5 Correlations with GRCS score

Variable	Measure of	Corr.	Exp. sign	No. Of match.	Prob.
FDCT_HND_PROP_0_1	attention to details in visuospatial task	-0.61	-1	1	0.500
MEMINT_10SEC_PMT_JL_0_3	working memory errors	0.61	1	2	0.250
TOL_12_TOT_RA	right answers in difficult goal setting task	-0.61	-1	3	0.125
FAB_MOTOR_0_3	motor programming ability	-0.58	-1	4	0.063
EQIS_GMEQ_VLW_70_79	very low general mood	0.58	1	5	0.031
FDCT_N_COR_POS_0_1	accuracy in visuospatial task	-0.56	-1	6	0.016
WCST_TR_COMP_1CAT	environmental feedbacks needed to solve a problem	0.55	1	7	0.008
MEMINT_10SEC_PMT_LP_0_3	working memory accuracy	-0.53	-1	8	0.004
MEMINT_10SEC_LP_TOT_0_9	working memory accuracy	-0.48	-1	9	0.002
MEMINT_ALLPERS_INTRUS_0_18	perseveration errors (working memory)	0.45	1	10	0.001
FDCT_CLK_CENTRE_0_1	accuracy and attention to details	-0.45	-1	11	0.000
SPM_TOT_COR_0_60	fluid intelligence	-0.43	-1	12	0.000
MEMINT_10SEC_JL_TOT_0_9	working memory errors	0.43	1	13	0.000
FDCT_TOT_0_15	visuosp., planning, praxic abilities	-0.43	-1	14	0.000
SPM_E_COR_0_12	fluid intelligence	-0.42	-1	15	0.000
HAMD_SCORE_0_51	depression score	0.42	1	16	0.000
RSBQ_G_500_CERTGAIN	low risk seeking behavior	0.42	1	17	0.000
EQIS_TOTEQ_MED_90_109	average intelligent quotient	0.40	1	18	0.000
EDUCATION	years of schooling	-0.40	-1	19	0.000
HAMD_NOD_0_7	no depression	-0.40	-1	20	0.000
HAMD_LOW_D_8_17	low depression score	0.40	1	21	0.000
EQIS_SMEQ_MED_90_109	average stress management ability	0.38	1	22	0.000
IBQ_TOT_AK_IMMED_VS_PATIENT_OPT_0_11	impulsivity, immediate gratification	0.37	1	23	0.000
MEMINT_10SEC_PERS_INTRUS_TOT_0_9	perseveration errors (working memory)	0.37	1	24	0.000
STR_DN_ER_0_30	errors in visual attention task	-0.37	-1	25	0.000
STR_TOT_ER.2_RD_DN	average errors in visual attention tasks	-0.37	-1	26	0.000
SPM_D_COR_0_12	fluid intelligence	-0.37	-1	27	0.000
IBQ_G_400_NOW	immediate gratification	0.37	1	28	0.000
STR_EFF_T_SEC	speed in response inhibition task	0.36	1	29	0.000
IBQ_TOT_FH_IMMED_VS_SEQ_DR_0_3	immediate gratification	0.35	1	30	0.000
FAB_GONOGO_PERS_ANSW_INTRUS	perseveration errors	0.35	1	31	0.000
MEMINT_30SEC_PERS_INTRUS_TOT_0_9	perseveration errors	0.35	1	32	0.000
FLUF_P_ER_RIP	perseveration errors	0.35	1	33	0.000
IBQ_L_PAY_OVERNIGHT_SHIPPING	impulsivity	0.35	1	34	0.000
EQIS_PIEQ_MED_90_109	average social desirability	0.34	1	35	0.000
FAB_TOT_0_18	frontal abilities performance	-0.34	-1	36	0.000
EQIS_GM_EQ_STD_50_150	general mood std score	-0.33	-1	37	0.000

poker and his/her playing session is recorded, so that the experts can evaluated it. This limitation is less salient for the gambling quality variables, since the relative questionnaires were administered in the same day of the EF tests (with the exception of PGSI, which was filled online by the participants weeks before the administration of the EF tests). On the other hand, the questions in these questionnaires refer to a long time span in the present and past life of the respondent. The second limitation of the study is the moderate sample size. Budget and time constraints prevented us from overcoming these limitations. However, as the next sections document, the results of this study provide important pieces of information about the most relevant EF influencing the ability and game quality of online poker players.

4.1 Poker ability predictors

We found significant predictors of the poker ability score in 6 tests. In particular, there are good predictors 1) in a Ravens Standard Progressive Matrices (SPM) variable that measure the fluid intelligence and sustained attention in a hard part of the test, 2) in those Cognitive Estimation Task (COGST) variables related to deductive reasoning, evaluation accuracy, problem solving, development of an appropriate strategy and self-monitoring (better total score and lower cognitive bizarreness), 3) in the Emotional Quotient Inventory Short (EQIS) Stress Management score (EQIS_SM), composed by the Stress Tolerance and Impulse Control scores, in the Interpersonal score (EQIS_INTER - Empathy, Social Responsibility, Interpersonal Relationship) and Adaptability scale (EQIS_AD - Reality-Testing, Flexibility, Problem Solving), 4) in those Tower of London variables (TOL) evaluating errors (perseverative and non-perseverative) in easy and hard runs of this goal setting task (Initiating, Planning, Problem Solving and Strategic Behavior); 5) in those variables of the Phonemic part of the Verbal Fluency Test (FLUF), measuring errors (perseverative and non-perseverative); 6) in the Intertemporal Behavior Questionnaire variables related to the ability to inhibit responses (IBQ).

4.1.1 Not discriminating for poker ability

The variables that don't appear in the results of data analysis were used to understand which characteristics (e.g., executive functions, mood, risk attitude) was not able to discriminate poker players on the basis of their ability: education (years), depression (HAMD), anxiety (HAMA), gambling related cognition (GRCS), gambling quality (PGSI; SOGS), risk seeking behavior (RSBQ), attention shifting (TMT), praxic abilities (FDCT), sensitivity to interference (FAB, MEMINT, STROOP). We found no correlations between poker ability and gambling quality as assessed by SOGS, PGSI and GRCS. Furthermore, no correlations between poker ability and depression and anxiety have been found. According to these results, also strong poker players can be problematic/pathological gamblers and can have cognitive distortions related to gambling. The fact that risk attitude does not correlate with poker ability seems to confirm the outcomes about the quality of gambling. Furthermore, strong poker players can be depressed and/or anxious and these are conditions that the literature on poker players (Barrault and Varescon 2013) already showed to be correlated with pathological gambling (see Section 2.4.5). An higher level of education is not necessary to become a strong poker player.

4.2 The strong(er) poker player's profile

On the basis of the good predictors of poker ability, the profile of the strong(er), (more) skilled online poker player is as follows:

- is less impulsive (self-reported), being able to inhibit impulsive/inappropriate responses (Response inhibition - IBQ);
- has less frequently a low adaptability (Reality-Testing, Flexibility and Problem-Solving - EQIS);

- shows lower cognitive bizarreness while estimating measurements of a quantity (COGST);
- is more able to reason from one or more statements to reach a logically certain conclusion (Deductive reasoning - COGST);
- is more able to provide measurements of a quantity, that are close to the true value (Evaluation Accuracy - COGST);
- is more aware of what he/she knows and able to make accurate assessment of his/her knowledge and/or skill (Self-Monitoring - COGST);
- is more able to think logically and solve problems in novel situations, independently of acquired knowledge (Fluid Intelligence - SPM);
- makes more perseverative and non-perseverative errors while attempting to generate an appropriate searching strategy in a fast verbal task (FLUF)
- makes less perseverative errors when that fast verbal task is harder (FLUF);
- makes more errors when a goal setting task is easy but less errors when it gets more difficult (Initiating, Planning, Strategic Behavior, Problem Solving - TOL);
- is more able to tolerate stress and control impulses (Stress Management - EQIS);
- has more frequently very high social skills and overall is more able to interact and communicate with others (Social Skills - EQIS).

4.3 Gambling predictors

Since the gambling assessment is composed by three questionnaires (PGSI, SOGS and GRCS), each one providing its own classification and referring to three different life time-frames (respectively, last 12 months, whole life, actual moment), three clusters of gambling predictors are shown below. Each cluster has been used to compose a specific profile (see sections 4.4.1, 4.4.2 and 4.4.3)

4.3.1 PGSI gambling predictors

Several assessment tools provide predictors of the gambling quality as evaluated by the PGSI: 1) Some EQ-i:S scales scores such as General Mood (EQIS_GM – Happiness and Optimism scales); Intrapersonal (EQIS_INTRA – Self-Regard; Emotional Self-Awareness, Assertiveness, Independence, Self-Actualization) and the total Emotional Quotient score (EQIS_TOTEQ); 2) the perseverative and non perseverative errors made while using the ability to generate appropriate searching strategies (Verbal Fluency Test – both FLUF and FLUS); 3) the Tower of London (TOL) variable assessing rules violations during a difficult run of this goal setting task (Initiating, Planning, Problem Solving and Strategic Behavior); 4) the Free Drawn Clock Test (FDCT) variables measuring attention to details and the accuracy of praxic abilities; 5) the lower ability to delay gratification, the seek for immediate gratifications instead of patient options (IBQ – Shane Frederick's Intertemporal Behavior Questionnaire); 6) total errors and total perseverative errors in the Attentive Matrices (MAT), a task evaluating visual selective attention; 7) errors made in the easier part of a working memory task (MEMINT).

Education is a further predictor: the lower level of schooling, the higher score in problem gambling.

4.3.2 Not discriminating for PGSI

Many assessment tools did not correlate in any way with the classifications provided by PGSI: Cognitive Estimation Task (COGST); Cognitive Reflection Task (CRT); Digit Span (DIGIT); Frontal Assessment Battery (FAB); Gambling Related Cognition Scale (GRCS); Hamilton Anxiety Scale (HAMA); Hamilton Depression Scale (HAMD); South Oaks Gambling Screen (SOGS); Raven's Standard Progressive Matrices (SPM); Stroop Color Word Interference Task (STR); Trail Making Test (TMT); Wisconsin Card Sorting Test (WCST).

4.3.3 SOGS gambling predictors

Our data analysis found good predictors in 1) a variable measuring attention to details in a visuospatial task (Free Drawn Clock Test – FDCT); 2) the errors made in the easier part of a working memory task (Memory with Interference – MEMINT); 3) the correct answers in one of the most difficult runs of a goal setting task (Tower of London – TOL); 4) the environmental feedbacks needed to solve a problem (Wisconsin Card Sorting Test – WCST); 5) some Emotional Quotient inventory Short (EQIS) scale scores such as Intrapersonal (EQIS_INTRA – Self-Regard; Emotional Self-Awareness, Assertiveness, Independence, Self-Actualization), Interpersonal (EQIS_INTER), Adaptability (EQIS_AD – Reality-Testing, Flexibility, Problem Solving), General Mood (EQIS_GM – Happiness and Optimism scales) and the total EQ score (EQIS_TOTEQ); 6) the perseverative errors made while using the ability to generate appropriate searching strategy (Verbal Fluency Test – FLUF); 7) the risk seeking behavior in tasks where it is requested to choose between certain gains or higher expected value gains (Risk Seeking Behavior Task – RSBQ); 8) the gambling related cognitions (GRCS); 9) a variable assessing the motor programming ability (FAB).

The absence of anxiety (HAMA) seems to be a predictor of gambling quality, according to SOGS scores. We need to verify this result with further investigation, possibly on a larger sample. Our data suggest that a problem/pathological player is not anxious. Furthermore, a maximum daily bet between 10 and 100 Euro is a good predictor of the SOGS gambling quality.

4.3.4 Not discriminating for SOGS

The assessing tools providing no predictors were: Cognitive Estimation Task (COGST); Cognitive Reflection Task (CRT); Digit Span (DIGIT); Semantic Verbal Fluency Task (FLUS); Intertemporal Behaviour Questionnaire (IBQ); Attentive Matrices (MAT); Problem Gambling Severity Index (PGSI); Raven's Standard Matrices (SPM); Stroop Color Word Interference Task (STR) and Trail making test (TMT).

Furthermore Depression (HAMD) did not predict SOGS scores.

4.3.5 GRCS gambling predictors

The correlations with GRCS show several good predictors in 1) a variable measuring attention to details in a visuospatial task (Free Drawn Clock Test – FDCT); 2) errors and accuracy in a working memory task (Memory with Interference); 3)

right answers in a goal setting difficult task (TOL); some variables of the Frontal Assessment Battery (FAB) evaluating the quality of motor programming and the perseverative errors; 4) the General Mood EQIS scale and the Total EQ score; 5) the environmental feedbacks needed to solve a problem (WCST); 6) two Raven's Standard Progressive Matrices (SPM) variables that measure the fluid intelligence and sustained attention in the harder parts of the test; 7) the risk seeking behavior in tasks where it is requested to choose between certain gains or higher expected value gains (Risk Seeking Behavior Task – RSBQ); 8) some Intertemporal Behavior Questionnaire (IBQ) variables assessing impulsivity and immediate gratification; 9) the speed in a response inhibition task (Stroop Color Word Interference Test – STR).

Furthermore, depression as classified by the Hamilton Depression Scale and Education (years of schooling) are good predictors for the GRCS gambling quality assessment.

4.3.6 Not discriminating for GRCS

Cognitive Estimation Task (COGST); Cognitive Reflection Task (CRT); Digit Span (DIGIT); Verbal Fluency Test (FLUF and FLUS); Attentive Matrices (MAT); Problem Gambling Severity Index (PGSI); South Oaks Gambling Screen (SOGS), Hamilton Anxiety Scale (HAMA).

4.4 The profiles based on gambling assessments (PGSI, SOGS and GRCS)

Based on the significant predictors for the PGSI, SOGS and GRCS scores, we constructed three different profiles.

4.4.1 PGSI gambling quality profile

The correlations outcomes (see Table 3) show that the online poker player with worse PGSI scores

- is less aware and able to understand his/her own emotions and to express them (Emotional Self-Awareness and Self-Expression – EQIS);
- makes more errors (perseverative and not) when attempting to generate an appropriate searching strategy in a fast verbal task (FLUS);
- has more difficulty in respecting rules in a task requiring the ability to set goals (initiating, planning, problem solving, strategic behavior) (TOL);
- has worse general mood, feeling less content with him/herself, other and life in general; less positive and less looking at the brighter side of life (EQIS);
- is less able to effectively understand and express him/herself, understand others and relate with them, and cope with daily demands (Emotional Intelligence – EQIS);
- has less frequently a very high ability to manage stress (EQIS);
- is less able to delay gratification, preferring immediate gratifications instead of patient choices (IBQ);
- has less frequently interest in having an high social desirability (EQIS);

– makes more errors (perseverative and not) in a visual selecting attention task (MAT – Attentive Matrices);
– is less able to program and control motor actions (Motor Programming – FAB);
– is less attentive to details (FDCT);
– makes more errors when distracted during an easier working memory task, requesting to manipulate and organize material transiently held in memory and to process new and already-stored information (Working Memory – MEMINT);
– is less able to interact and communicate with others (Social Skills – EQIS).

A lower level of education, measured in years of schooling, is a further characteristic of the PGSI gambling quality profile.

4.4.2 SOGS gambling quality profile

According to the results (see Table 4) the profile of the gambler having worse SOGS scores entails that he/she:

– is less accurate in practical applications or exercises (Praxic abilities – FDCT);
– has lower performance in initiating, planning, problem solving and strategic behaviour (Goal Setting – TOL – see the profile of the strong online poker player 4.2);
– makes more errors when distracted during an easier memory task requesting to manipulate and organize material transiently held in memory and to process new and already-stored information (Working Memory – MEMINT);
– is less aware and able to understand his/her own emotions and to express them (Emotional Self-Awareness and Self-Expression – EQIS);
– makes more errors when attempting to generate an appropriate searching strategy in a fast verbal task (FLUF);
– has less frequently a low or very low risk seeking behavior when facing higher expected value gains (RSBQ);
– is less able to interact and communicate with others (Social Skills – EQIS);
– has higher cognitive distortions related to gambling (GRCS);
– is less able to effectively understand and express him/herself, understand others and relate with them, and cope with daily demands (Emotional Intelligence – EQIS);
– has extra low adaptability (reality-testing, flexibility and problem-solving – EQIS);
– is less able to program and control motor actions (Motor Programming – FAB).

Furthermore, two predictors have been found: less frequency of "max daily bet between 10 Euro and 100 Euro"; absence of anxiety.

4.4.3 GRCS gambling quality profile

The gambler who obtained lower scores in the Gambling Related Cognition Scale:

– is less accurate and less attentive to details; less able to plan in a visuospatial task (FDCT);
– is less aware and able to understand his/her own emotions and to express them (Emotional Self-Awareness and Self-Expression - EQIS);

- makes more perseverative errors when attempting to generate an appropriate searching strategy in a fast verbal task (FLUF);
- has lower performance in a difficult task requiring the ability to set goals (initiating, planning, problem solving, strategic behavior - TOL);
- needs more environmental feedbacks to solve a problem (WCST);
- is less able to think logically and to solve problems in novel situations, independently of acquired knowledge (Fluid Intelligence - SPM);
- is less able to focus attention on a task over time (Sustained Attention - SPM);
- has worse general mood, more frequently a very low general mood, feeling less content with him/herself, other and life in general; less positive and less looking at the brighter side of life (EQIS);
- has more frequently a low risk seeking behavior when the higher expected value gains are less probable (15%) (RSBQ);
- has more frequently an average ability to effectively understand and express him/herself, understand others and relate with them, and cope with daily demands (Emotional Intelligence - EQIS);
- has more frequently an average ability to manage stress (EQIS);
- is less able to delay gratification, being more impulsive and preferring immediate gratifications instead of patient choices (IBQ);
- has lower executive abilities and, in particular, lower ability to program and control motor actions, making perseverative errors (FAB);
- makes more errors in a visual attention task (STR);
- makes more errors (perseverative and not) when distracted during both an easier and harder memory task, requesting to manipulate and organize material transiently held in memory and to process new and already-stored information (Working Memory - MEMINT);
- is less able to interact and communicate with others (Social Skills - EQIS);
- makes average efforts for being socially desirable (EQIS).

Furthermore, low levels of depression (HAMD) and lower education (years of schooling) are conditions distinguishing the GRCS gambling quality profile.

4.5 Harmful online poker playing protective factors according to PGSI and SOGS

Taking into consideration that PGSI and SOGS refer to different life time-frames (respectively 12 months and the whole life) and that the former classifies degrees of problem gambling severity while the latter whether a gambler is a problem/probable pathological gambler, it could be possible to identify some predictors in common between them. These overlapping skills, once appropriately trained or developed, would be the protective factors underlining a specific attitude to play online poker in a more responsible way.

4.5.1 Predictors and profile of the "harmful online poker player"combining PGSI and SOGS

Matching the results of PGSI and SOGS gambling quality, four overlapping predictors have been found:

- EQIS_INTRA_VHI_120_129

– EQIS_TOTEQ_RAW
– EQIS_INTRA_EQ_STD_50_150
– EQIS_INTRA_EQ_RAW

The Emotional Quotient inventory Short is the only tool providing good overlapping predictors: the variables assessing the Total Emotional Intelligence Quotient (TOTEQ – raw scores) and 3 variables of the Intrapersonal scale (raw and standard scores and the very high scores of the scale assessing Self-Regard, Emotional Self-Awareness, Assertiveness, Independence, Self-Actualization) are correlated with both PGSI and SOGS.

The emotional intelligence predictors could suggest that key factors at the base of the development of a more risky and "harmful"online poker playing, are lower performance/levels of the ability to:

– understand and express him/herself (emotional self-awareness);
– effectively and constructively express his/her own emotions and oneself (assertiveness);
– accurately perceive, understand and accept him/herself (self-regard);
– be self-reliant and free of emotional dependency on others (independence);
– strive to achieve personal goals and actualize his/her own potential (self-actualization).

If we take into consideration also the similar predictors, those ones measuring the same skills/competences, we find more overlapping abilities (see Table 3 and Table 4): attention to details in a visuospatial task (Free Drawn Clock Test), working memory errors (Memory with Interference), perseverative errors in searching strategy tasks (Verbal Fluencies). These predictors could be an useful adjunct to the EQiS ones for creating new cognitive tasks.

5 Conclusions

Online poker players of different ability (both professional and recreational) show different performance in their EF and in specific cognitive and emotional skills and competences. The EF performance is also related to the different aspects of gambling as measured by the South Oaks Gambling Screen (SOGS), the Problem Gambling Severity Index (PGSI) and the Gambling Related Cognition Scale (GRCS).

The highest correlations between EF test results and poker ability and between EF test results and gambling assessment (PGSI, SOGS and GRCS) showed mostly different clusters of executive functions. The most discriminating EF in the profile of the strong(er) online poker player are: stress tolerance and impulse control, social skills, deductive reasoning, evaluation accuracy, self-monitoring, fluid intelligence.

Focusing on the quality of gambling, EF allowed us to construct three profiles, each one based on its own assessment tool (PGSI, SOGS, GRCS).

For the online poker players of different PGSI quality of gambling we identified the following abilities: emotional self-awareness; happiness and optimism; emotional intelligence; social skills; goal setting; gratification delay; action control and programming, adaptability, working memory errors; stress management.

According to the quality of gambling as assessed by SOGS, best predictors were: goal setting, working memory errors, emotional self-awareness, practical accuracy, risk seeking behavior when facing higher expected value gains, social skills, cognitive distortions related to gambling, emotional intelligence, adaptability, motor control and programming.

Cognitions related to gambling (GRCS) correlated with predictors measuring: accuracy and attention to details, planning ability in visuospatial task, emotional self-awareness, perseverative errors in a searching strategy task, goal setting, environmental feedbacks needed to solve a problem, fluid intelligence, sustained attention, general mood (happiness and optimism), risk seeking behavior when the higher expected value gains are less probable (15%), emotional intelligence, stress management, impulsivity and gratification delay, executive abilities in general, motor control and programming, errors in visual attention task, social skills, efforts for being socially desirable.

Taking into consideration only those variables that PGSI and SOGS had in common, some predictors that are key factors at the base of the development of a more risky and "harmful"online poker playing, are lower performance/levels of the ability to understand and express him/herself (emotional self-awareness); effectively and constructively express his/her own emotions and oneself (assertiveness); accurately perceive, understand and accept him/herself (self-regard); be self-reliant and free of emotional dependency on others (independence); strive to achieve personal goals and actualize his/her own potential (self-actualization).

Since the results of this preliminary study led to outline a specific profile of the strong(er) online poker player and 3 different profiles of the players based on their quality of gambling (according to PGSI, SOGS and GRCS assessments), and revealed some key factors for the development of harmful online poker playing, this new knowledge, can facilitate the creation and development of two different kinds of systems having specific purposes: these aimed to evaluate and improve the EF performance outlining the strong(er) online poker players, useful for the players willing to be more aware of their poker ability and to enhance it, those focused on evaluating and training the EF performance characterizing the profiles of the gamblers with worse scores at PGSI, SOGS and GRCS. The latter ones could be part of innovative systems for proactive prevention of problem gambling, to ensure responsible gaming.

Proactive systems capable of increasing the awareness of online players' abilities in a given time and in a certain historical period and able to train the executive functions and all the skills and competences characterizing the profiles of the problem gamblers, could promote the improvement of the socio-economic life of online players and a lower social cost, related to the care and treatment of problem gamblers.

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