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Characteristics of Good Poker Players

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Abstract

Poker is characterized as a "mixed" game: a game that includes both skill and chance components. But what individual differences are characteristic of skilled poker players? No previous study has sought to evaluate the full scope of characteristics contributing to playing skill. The purpose of this study was to fill this void by attempting to comprehensively examine the individual characteristics associated with good poker players. Results from a sample of undergraduate students and community members (n = 100) showed that good players are more likely to be male, to have lower susceptibility to gambling fallacies, a greater tolerance for financial risk, superior social information processing skills, and less openness to aesthetic and imaginative experience. Evidence from this study also indicates that having sufficient levels of most of these attributes is more important for poker success than having exceptional strength in just one or two of these areas.

Keywords: poker, skill, individual differences, gambling, intelligence

Résumé

Le poker est un jeu « mixte » : il repose à la fois sur le hasard et l'habileté des joueurs. Mais quels sont les traits personnels qui caractérisent les joueurs habiles? Aucune étude n'a encore cherché à évaluer l'ensemble des caractéristiques qui contribuent à l'habileté des joueurs. L'objectif de la présente recherche était donc de combler ce manque en tentant de proposer un examen exhaustif des caractéristiques personnelles associées aux bons joueurs de poker. Les résultats de l'étude, qui portait sur un échantillon composé d'étudiants de premier cycle et de membres de la collectivité (n = 100), ont montré qu'un bon joueur est plus susceptible d'être un homme, d'être peu enclin à l'illusion du joueur, d'avoir une tolérance élevée aux risques financiers et d'être peu ouvert aux expériences esthétiques et d'imagination. Les résultats indiquent également que pour réussir au poker il est plus important de posséder la plupart de ces caractéristiques à un degré suffisant que d'en posséder une ou deux à un degré exceptionnellement élevé.

Introduction

Poker is identified as a "mixed" game. A mixed game is one in which the outcomes are determined by a combination of skill and chance—regardless of the relative contribution of either. Whether poker is predominated by skill or by chance is debated within both the scientific and legal literature. Attention devoted to the relative contribution of skill in poker is an important issue, as it has practical relevance for the legal standing of the game in relation to gambling and tax revenue laws.

As skill is a component of poker that contributes to the determination of game outcomes, empirical investigation of the traits indicative of skilled poker players is also justifiable. Which individual differences are characteristic of skilled poker players? No previous study has sought to evaluate the full scope of characteristics presupposed to contribute to playing skill. However, some previous empirical investigations have shed light on the nature of poker players more generally.

Demographics

It is well established that poker players predominantly comprise young adult males who report higher rates of alcohol use than do other gambling populations (i.e., non-poker playing; Dannewitz & Weatherly, 2007; Meinz et al., 2012; Oliveira & Silva, 2001; Shead, Hodgins, & Scharf, 2008). However, beyond the research on these general demographic characteristics, there is no literature available regarding whether certain demographic characteristics are associated with superior poker skill.

Quantitative/Statistical Skill

As would be expected, better players have been shown to make more statistically optimal poker-related decisions. For example, St. Germain and Tenenbaum (2011) found that better decision-making processes, leading to higher expected value—the average amount a player can expect to win or lose on an individual bet—were consistently demonstrated by more expert players and that these players incorporated more situation-relevant cues during decision making than did novice players.

Experience[1]

Palomäki, Laakasuo, and Salmela (2012) concluded that more experienced players make more mathematically justified poker decisions. Similarly, two studies by Linnet showed that in more experienced players, probability estimation (i.e., the potential of hands winning) was superior to that in inexperienced players (Linnet et al., 2012; Linnet, Gebauer, Shaffer, Mouridsen, & Møller, 2010).

[1]Experienced players may not be more skilled. Any inconsistencies in terminology used (e.g., good player, experienced, skilled, etc.) in the Introduction is attributable to accurate representation of previous literature.

While it may well be the case that ability tends to increase with experience, there are some situations where it does not. One study found that in a sample of experienced players, those who were also classified as pathological gamblers had decision-making skills that were comparable to those of inexperienced players (Linnet et al., 2012). It should be pointed out that a potential gender confound exists in these studies. Most notably, Linnet et al.'s (2010) experienced sample was composed solely of males, whereas the inexperienced sample consisted solely of females. Palomäki et al.'s (2013) study analyzed predominantly males, with females comprising only 16% of their sample.

General Intelligence

Wechsler (1944) defined intelligence as the "global capacity of the individual to act purposefully, to think rationally and to deal effectively with his environment" (p. 3). There has yet to be an empirical investigation of the relationship between poker skill and general intelligence. Some poker bloggers, however, suggest that skill in poker requires greater intelligence (e.g., see Badger, n.d.; Pinson, n.d.), wherein intelligence is described as the ability to use multidimensional thinking and/or critical thinking. Whether the suggested superior cognitive abilities asserted by poker bloggers can in fact be empirically validated remains to be seen. Although it is not postulated herein that *superior* intelligence is necessary for poker skill, it remains a possibility that general intelligence does play a role in poker skill attainment.

Social Skills/Intelligence

Social intelligence has been shown to be a unique factor, distinct from general intelligence (Ford & Tisak, 1983). Social intelligence is another area that seems likely to play a role in poker playing skill. It certainly is the ability most endorsed in popular culture as being necessary for successful poker playing. Social intelligence includes one's tendency to attend to social information and to process information observed in the social environment, as well as being capable of controlling the social information delivered via one's own behaviour (Silvera, Martinussen, & Dahl, 2001). In the literature, studies of poker players have provided support for the necessity of social intelligence in successful poker playing. Bellin (2002), for example, notes that players often introduce fake "tells" in attempts to fool opponents (e.g., feigned excitement suggesting a good hand, when the hand is actually weak). On a related note, one study has shown that the best "poker face" may be one that conveys trustworthiness rather than neutrality (Schlicht, Shimojo, Camerer, Battaglia, & Nakayama, 2010). Schlicht et al. (2010) showed that players more often folded to a bluffer who exhibited facial characteristics associated with trustworthiness than to a bluffer who had a neutral facial expression. Wilson (2003) states that both the ability to deceive and the ability to recognize deception are crucial skills that aid in successful poker playing.

Opponent modeling is the act of perceiving and interpreting opponent behaviours and adjusting one's own strategy on the basis of this information (McCormack & Griffiths, 2011). McCormack and Griffiths (2011), in a qualitative study, found that

the professional players (n = 4) created more accurate opponent models than did recreational players (n = 5). Castaldo (2007), in an interview with a professional female player, found that she would change playing strategies (e.g., choosing to bluff more or less) depending on her perception of her opponents' attitudes towards her as a female player. Slepian, Young, Rutchick, and Ambady (2013) found that experienced players were able to accurately rate players' hand strength at above-chance levels, based merely on arm movements used when the player was placing bets (i.e., chips) into the centre of the table. Thus, abilities captured under the umbrella of social intelligence, such as those used for opponent modeling, also appear to contribute to the skill set of a successful poker player.

Personality and Risk Taking

Personality traits may also differentiate good and poor players. Palomäki et al. (2013) found that greater self-evaluation, less rumination, and greater emotional control occurred more frequently in their sample of experienced players. Greater self-evaluation and less rumination is suggestive of lower levels of the personality trait neuroticism. Greater emotional control lends itself to more logically sound decision making. Browne (1989) also concluded, via an observational study, that better players demonstrate greater emotional stability, as evidenced by their staying "off tilt." To be "on tilt" is to lose one's temper and begin to make playing decisions on the basis of emotion. Another observational study found that winners were more gregarious than losers (Martinez & Lafranchi, 1969), and Brown and Mitchell (2010) found that aggressive players were more likely to be extraverted.

Barrault and Varescon (2013) noted high sensation seeking among online poker players. McCormack and Griffiths (2011) identified lower risk taking and more self-discipline in professional players as compared with recreational players (i.e., professional players expressed that they were less likely to chase losses). Similarly, Siler (2010) noted greater "risk neutrality" associated with successful play. Risk neutrality is evidenced when players consistently bet when the circumstances of the hand/round (their own cards, perception of opponents' hand strength, etc.) suggest positive expected value. It is possible that simply attending to expected value facilitates greater risk taking (i.e., aggression), which is empirically associated with more successful play. Therefore, the risk taking demonstrated by better players is best seen as *calculated* rather than reckless.

Findings related to personality must be seen with healthy skepticism, as some of the methodologies used are less than sound. For example, Brown and Mitchell (2010) defined aggressive players simply as those individuals who played three or more of 10 hands observed. Other studies (e.g., Palomäki et al., 2013) provide results that implicate personality differences but do not contain methodologies that objectively assess personality. Rather, conclusions regarding individual differences in self-control, for example, stem from qualitative judgements.

Other Differences

Three other studies have examined characteristics of poker players. One study identified higher working memory capacity in their sample of better players (Meinz et al., 2012). The other two studies reported a significant association between gambling fallacies and problem gambling among poker players (MacKay, 2012; Mitrovic & Brown, 2009).

Individual Differences Summary

Relatively little research has been reported on the characteristics differentiating good poker players from poor poker players. Existing findings tentatively indicate that in addition to better statistical knowledge about poker, the successful poker player tends to have more playing experience, as well as higher social intelligence, greater emotional control, and better working memory.

Study Goals

The goal of the current study is to begin to fill this void by attempting to more comprehensively and rigorously examine the individual characteristics indicative of skilled poker players. Specifically, the current study seeks to ascertain whether poker skill is significantly related to (a) demographic characteristics (age, gender, race/ethnicity, educational level); (b) educational achievement (i.e., grade point average [GPA]); (c) general intelligence; (d) working memory; (e) general quantitative ability; (f) resistance to gambling fallacies; (g) social intelligence; (h) problem gambling status; (i) risk perception and tolerance; and (j) personality. The findings of the present study may also inform the debate regarding the legal standing of poker, the debate regarding the taxation of poker players' profits, and the legitimacy of training programs designed to improve poker skills. Finally, by identifying the individual differences that are characteristic of skilled poker players—a novel undertaking in and of itself—this research addresses a significant gap in the scientific literature.

Method

Participants

The final study sample consisted of 100 participants recruited from both University of Lethbridge undergraduate students (82%) and Lethbridge community members (18%). The sample, predominantly Caucasian (80%), consisted of 54 males and 46 females and had a mean age of 23.48 (SD = 6.45). To recruit the undergraduate participants, we placed an advertisement on the university's psychology participant pool website, soliciting participants familiar with Texas Hold'em to participate in a study investigating the factors that predict poker playing ability. Participants recruited via this system received a 2% psychology course credit for their participation, as indicated on their consent form. Community member participants, whose consent forms did not discuss course credit, were recruited via word of mouth.

Word-of-mouth recruitment was used to ensure a broader demographic sample (e.g., age, playing experience, education level), as well as a greater variation of skill level within the sample. The consent form for both sets of participants indicated that, depending on their demonstrated poker skill, they would receive between $0 and $100 in the form of a Visa gift card. This was done to increase motivation and provide ecological validity for the task. This study was reviewed and approved by the University of Lethbridge Human Subject Research Committee.

Materials

Each participant engaged in a total of 12 tasks, including a detailed collection of demographic information, a virtual Poker Playing Assessment, our experimental Poker Skills Measure, and a series of individual difference measures. Table 1 itemizes all experimental tasks undertaken, task order by condition (an attempt was made to counter-balance the presentation of some tasks), and approximate time to complete each task. All experimental tasks and measures are described in the following subsections.

Demographics and Poker Playing Survey. The Demographics and Poker Playing Survey was designed specifically for this study. Information was collected on age, sex, ethnicity, years of education, and university major. For students, their GPA was also collected (maximum = 4.0). In addition, we collected years of poker

Table 1
Experimental Tasks, Task Times, and Task Order by Condition

Task	Time (min)	Condition 1 (n = 24)	Condition 2 (n = 24)	Condition 3 (n = 27)	Condition 4 (n = 25)
Consent	3	S1-1	S1-1	S1-1	S1-1
Demographics	3	S1-2	S1-9	S2-1	S2-8
Stanford-Binet Matrices*	15	S1-3	S1-8	S2-2	S2-7
Digit span	3	S1-4	S1-7	S2-3	S2-6
Stanford-Binet Equation Building*	15	S1-5	S1-6	S2-4	S2-5
Poker Quantitative[a]	5	S1-6	S1-5	S2-5	S2-4
Gambling Fallacies Measure	5	S1-7	S1-4	S2-6	S2-3
Tromso Social Intelligence Scale	5	S1-8	S1-3	S2-7	S2-2
PSM1	22	S1-9	S1-2	S2-8	S2-1
PSM2[b]		S2-1	S2-5	S1-2	S1-6
PPGM[c]	4	S2-2	S2-4	S1-3	S2-5
DOSPERT[d]	7	S2-3	S2-3	S1-4	S2-4
NEO-Personality Inventory	25	S2-4	S2-2	S1-5	S2-3
Poker Playing Assessment	15	S2-5	S2-1	S1-6	S2-2

Note. Time = approximate time, in minutes, to complete each experimental task. Conditions 1 through 4 present task orders; n = number of participants included in final sample by condition. Condition task orders are represented by S = Session number (1 or 2) and task number (e.g., S2-3 = Session 2, 3rd task completed). Tasks marked with an asterisk (*) were timed tasks; thus the time to complete is the maximum allotted time, rather than an approximate time.
[a] This 10-item paper-and-pencil test of poker quantitative skill is not used or mentioned in the subsequent analyses, as it was thought to be too closely related to the Poker Skills Measure (PSM). [b]PSM2 was administered for test-retest purposes and was included for only 50 participants. [c]Problem and Pathological Gambling Measure. [d]Domain-Specific Risk-Taking Scale.

playing experience, typical poker playing habits (i.e., online vs. live play; with friends/family vs. strangers), and self-rating of playing ability (assessed by making a vertical mark along a horizontal line with anchoring endpoints described as *novice* and *expert* and converting the mark to a score from 0 to 100).

General intelligence. Participants completed the Matrices subtest of the Stanford-Binet Intelligence Scale, 4th edition (Thorndike, Hagen, & Sattler, 1986). The 26 items in this subscale from the Abstract/Visual Reasoning Area of the Stanford-Binet provide a pictorial matrix of either four or nine items with one cell blank. The person uses his or her reasoning ability to determine the pattern or principle contained in the matrix so as to determine which of the four options provided best fits the missing cell. The Matrices subtest is normally untimed, but participants in the present study were given 15 min to complete it. The Matrices subtest is modeled after the Raven Progressive Matrices, which is intended to be a culture-free measure of general intelligence (*g*). Factor analytic studies have confirmed that the Stanford-Binet Matrices is a good measure of *g* (accounting for 55% of the variance) and has a Pearson correlation of.78 with the overall Stanford-Binet Composite IQ (Sattler, 1988).

Digit span task. This digit span task (Della Sala, Foley, Beschin, Allerhand, & Logie, 2010) is intended to be a measure of working memory capacity. For this task, the experimenter reads a list of numbers with a 1-s delay between each number. Participants are then required to repeat the list back. Six lists per digit span length are used, and testing ends when a participant repeats fewer than five of the six lists correctly. Participants' scores are recorded as the greatest span that the person was able to accurately reproduce.

Quantitative ability. The 18-item Equation Building subtest is from the Quantitative Reasoning Area of the Stanford-Binet Intelligence Scale, 4th edition (Thorndike et al., 1986). This subtest requires respondents to use given numbers and numerical operators to create a mathematical equation. For example, given the following information: "2 3 5 = +," respondents would create the true mathematical statement: "2 + 3 = 5." Although this test is normally untimed, participants were again given 15 min to complete it. This measure assesses respondents' working understanding of numerical operations and is intended to be a measure of crystallized quantitative ability (Sattler, 1988). The Equation Building subtest has a test-retest reliability of .91 (Sattler, 1988).

Gambling Fallacies Measure. The Gambling Fallacies Measure (Williams, 2003) is a 10-item questionnaire developed to assess erroneous beliefs associated with gambling. By assessing respondents' ability to take statistical probabilities and the random nature of most gambling games into account, this measure assesses respondents' tendency to succumb to (or to resist) gambling fallacies, including the illusion of control, the perception of personal luck, and the gambler's fallacy. Internal reliability is low (Cronbach's alpha = .51), which reflects the fact these 10 questions assess a wide range of different fallacies. However, the 1-month test-retest

reliability of this measure is relatively good (r = .70). Its validity is established by its significant correlation with problem gambling status, gambling frequency, number of gambling activities engaged in, and paranormal beliefs (Williams, 2003).

Tromso Social Intelligence Scale (TSIS). The TSIS measures three components of social intelligence: Social Information Processing (SP), Social Skills (SK), and Social Awareness (SA; Silvera et al., 2001). Silvera et al. (2001, Study 3) report the internal reliabilities for each subscale (SP, SK, and SA) to be α = .79, .85, and .72, respectively. The criterion and construct validity of this scale has also been established (Silvera et al., 2001, Study 1; Tayfun & Cetin, 2009). The TSIS consists of 21 items and yields three scores for each of the three components of social intelligence. A social intelligence composite score is also derived.

Poker Skills Measure (PSM). The PSM (Leonard, Staples, & Williams, 2014) measures respondents' current poker skill level. For each of the 35 items in this measure, respondents are presented with a poker scenario for which they must decide which playing action is most appropriate. The scenarios presented tend to increase in complexity from Scenario 1 to Scenario 35. The scenarios vary in terms of which stage of the game is occurring (pre-flop, flop, turn, river), the documented actions or inactions of the other players at the table, the number of other players remaining in the hand (two to six), the amount that has been bet, and the described playing style of the opponents (tight/loose; aggressive/passive). Each question is presented on a single page with a colour pictorial and text. Participants are also provided with a glossary of Texas Hold'em terminology, as well as a tutorial page that itemizes each pictorial component (e.g., folded cards, cards in play, pot and stack sizes). Respondents are provided with three response actions for each scenario. The PSM has a test re-test reliability of .82 and high internal consistency (Cronbach's α = .79); its validity is established by its significant correlation with objective measures of poker playing performance.

Problem and Pathological Gambling Measure (PPGM). The PPGM measures respondents' self-reported gambling behaviour over the past 12 months. This instrument contains questions pertaining to all areas of potential harm related to gambling and has been shown to be better able to detect problem gamblers who are in denial than are other commonly used measures (Williams & Volberg, 2010, 2014). The PPGM yields high classification accuracy (sensitivity = 94.44%, specificity = 99.81%), minimizing both false positives and false negatives, which is confirmed by high agreement (k = .93) between the instrument and clinical assessment (Williams & Volberg, 2010, 2014).

Domain-Specific Risk-Taking (Adult) Scale (DOSPERT), Risk Perception subscale. The DOSPERT Scale Part II (Blais & Weber, 2006) is a 30-item scale that assesses risk tolerance for decisions in five domains: financial (separate subscales for investing vs. gambling), health/safety, recreational, ethical, and social. The reported internal consistency for these domains is adequate at .74, .83, .74, .79, and .83, respectively (Blais & Weber, 2006). The DOSPERT Part II Scale used herein is the short version of the original DOSPERT for which convergent and discriminant validity were established

and for which internal consistency values similar to those reported for the long version were obtained (Weber, Blais, & Betz, 2002).

NEO Personality Inventory Revised Edition (NEO-PI-R). The NEO-PI-R provides a measure of the five personality domains, Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness, as well as six subfacets associated with each of the five domains (Costa & McCrae, 1992a). Thus, there are 30 facets in all. Scores for each domain are the summation of relevant facet scores. The NEO-PI-R is currently the dominant instrument in the assessment of personality. Its validity, concurrent and discriminant, has been well established in both normal and clinical populations (Costa & McCrae, 1992a). Internal reliability of the domain scores are high, ranging from .86 to .92, and the internal reliabilities of the facets range from .58 to .82 (Costa & McCrae, 1992b).

Poker Playing Assessment.[2] For this assessment, participants were asked to play 30 hands in a virtual game of no limit Texas Hold'em against artificial intelligence (AI) players (maximum of five AI players) on a laptop computer. *No-Limit Hold'em Cash Game Version 1* (2011) was used, as this program (a) uses a random number generator to determine cards dealt; (b) allows for automatic buy-ins (e.g., if a player loses all of his or her money, the account is automatically replenished so that the person can continue playing); and (c) allows for the manipulation of both the skill level and the style of play of the AI players. It was statistically determined that playing 30 hands reduced the overall pre-flop equity variance between players to 4%. With a maximum of 4% pre-flop equity variance, it was thought that no participant would be unduly advantaged or disadvantaged by playing so few hands. This program did not permit the predetermined selection of cards dealt so as to altogether eliminate variability in the pre-flop equity between players. Also unclear is the extent to which 30 hands were sufficient to (a) eliminate the variability in the strength of the post-flop cards between participants and (b) eliminate the variability in the strength of the opponents' hands between participants. We suspect that many more than 30 hands would have been needed.

The five AI opponents had a wide range of skill levels and playing styles to simulate what often happens in social games of poker. More specifically, there were two loose/aggressive players, two tight/aggressive players, and one loose/weak player. "Loose" players are defined as people who play more hands and tend to continue with weaker hands; hence, they do not often fold. "Tight" players play fewer hands and tend not to continue with weaker hands; hence, they often fold. An "aggressive" player is more likely to bet and raise compared with a "passive" player, who is more likely to check and call. "Loose/weak" players differ from loose/passive players in that (a) they often will not fold prior to all community cards being dealt and (b) they tend not to adjust their playing style (e.g., play more aggressively when holding a good hand).

[2]Because this assessment was used to evaluate unrelated working hypotheses, the results associated with it are not discussed herein.

After 30 hands, participants' net profit, number of hands folded pre-flop, percentage of hands won, percentage of hands raised pre-flop, and percentage of hands bet on the flop were recorded. For the purpose of participant remuneration, a composite score for the Poker Playing Assessment was derived by averaging the rank earned on four variables: net profit, hands won, aggression (bets) at pre-flop, aggression (bets) at the flop. Betting aggression is generally correlated with skill level because increasing the price to stay in a round (a) has a tendency to induce players with stronger cards to fold and/or (b) increases the payoff from players who remain in the round with weaker cards (Potter van Loon, van den Assem, & van Dolder, 2015; Siler, 2010). In general, skilled poker players have also been documented to play fewer hands ("playing tight") than poorer players, reflective of their better understanding that only a minority of hands have a good chance of winning (Siler, 2010). So as not to penalize better players for this tendency, the percentage of hands won was calculated as follows: (total number of hands won divided by total number of hands played) multiplied by 100. Participant remuneration was based on this composite ranking averaged with participant ranking on the PSM.

Procedure

Each participant was tested individually, in two 1-hr sessions, spaced 1 week apart. Written informed consent was obtained prior to the commencement of Session 1. Two word-of-mouth participants were not of the age of majority at the time of data collection. Written informed consent was given by these participants' parents and written informed assent given by the participants. Verbal indication of continued consent was sought before engaging in Session 2. As part of written informed consent, in addition to the 2% course credit indicated for undergraduate participants, all participants were informed that they could potentially be eligible for financial remuneration. It was explained that their eligibility for receiving monetary compensation would be based on their ranking, compared with the other participants, on a composite score of both poker playing measures (the PSM and the Poker Playing Assessment). They were reminded of this fact when we introduced the PSM and the Poker Playing Assessment.

After informed consent was obtained, participants were assigned to one of four test order conditions. Four different experimental task orders were used so as to reduce order effects such as fatigue while also preventing potential priming effects (if, for example, the PSM and the Poker Playing Assessment were completed in succession). Instructions preceded each experimental task and were delivered either verbally by the experimenter, or they were included in the written instructions provided with the task. The consent form and all measurements were completed in a paper-and-pencil format with the exception of the Poker Playing Assessment, which was conducted on a 17-inch Acer laptop computer in full-screen mode.

Upon completion of the second session, participants were thanked and debriefed, and they were told that remuneration would follow after all data were collected. The top poker performer received $100, those ranked 2 to 10 received $50 each, those ranked 11 to 40 received $30 each, those ranked 41 to 75 received $25 each, and those ranked below 75 received $0.

Results

Data Screening and Cleaning

Less than 0.005% of data were missing. Of these, most missing data points were from the NEO personality questionnaire. Missing values from the NEO were replaced with the individual's mean score for the personality facet from which the data point was missing. Two participants each left one answer blank on the Gambling Fallacies Measure. Scores for these participants were calculated out of nine rather than 10. Twelve percent of data was missing from the GPA scores, due either to participants not being students or to participants not knowing or reporting their GPA. This variable was omitted from the multivariate analysis because of the large proportion of missing data.

For regression analysis, all variables were assessed for skew above or below 0.4 and for outliers, with outliers defined as having a standard score of $\pm$ 3.29. Outliers were detected in age, total playing experience, the PPGM composite, the NEO domains Neuroticism and Agreeableness, the NEO facets Activity level (Extraversion domain) and Tendermindedness (Agreeableness domain), and the Social skills subsection of the TSIS. Outliers accounted for less than 0.9% of all data, and all outliers were determined to be accurate data points because participants whose age and playing experience contributed to the detection of outliers in these variables were known to the experimenter. Outliers in all other variables were considered accurate because, despite being statistically rare, they were not errors in data entry or impossible figures (e.g., scores beyond the response endpoints on a given survey). Thus, original values were retained (and reported) for the descriptive statistics. An inverse transformation corrected for outliers and non-normality of the PPGM composite variable. As no transformation adequately corrected for skew and outliers in these variables, the variables were winsorized. Winsorization significantly reduced the skew of Agreeableness, Activity level, and Social Skills. Winsorization removed the outliers and attenuated the skew of Neuroticism, Tendermindedness, age, and total playing experience). Of final note, a point biserial correlation was conducted for the dichotomous variables of gender (male; female) and ethnicity (Caucasian; non-Caucasian).

Univariate Results

Pearson's *r* correlations were calculated between PSM scores and all the individual difference measures. As can be seen in Table 2, surprisingly few variables were significantly associated with PSM scores, and the magnitude of the correlation was low for the few that were.

The relationship between poker skill and all five NEO personality domains (Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness) was near zero. Similarly, there was no significant correlation with general intelligence

Table 2
Full Sample Assessment Scores and Correlation with Poker Skills Measure

Assessment	Scores (n = 100)				Pearson's r	FDR
	M	*SD*	Min	Min		
Gender	.54		0	1	.38**	.00
Ethnicity	.80		0	1	.007	
Age	23.28	6.45	17	57	.17	
Grade point average	3.14	0.55	1.50	4.00	-.01	
Years of education	14.58	2.07	10.64	20	-.04	
Poker experience	4.68	5.13	0	40	.26**	.05
Digit span	5.6	1.02	4	8	.16	
SB Matrices	55.19	7.29	41	68	.13	
SB Equation Building	57.65	10.45	35	76	.04	
Gambling Fallacies Measure	7.36	1.52	3	10	.26**	.03
Risk Perception						
Ethical	30.00	4.96	15	40	.06	
Monetary	29.34	5.11	16	40	-.25*	.03
Gambling only	17.05	3.41	7	21	-.21*	.05
Investing only	12.29	3.09	6	21	-.19	
Health/Safety	27.11	6.09	11	39	-.05	
Recreational	23.14	6.76	8	38	.09	
Social	16.42	4.92	7	26	-.001	
Social IQ						
Social Information Processing	5.21	0.69	3.29	7	.27**	.03
Social Skills	4.81	.07	2.43	6.14	.12	
Social Awareness	5.12	.82	3	7	.10	
Social IQ composite	105.94	12.41	78	137	.20*	.05
PPGM total score[a]	.045	1.06	0	5	-.24*	.04
Personality domains and facets						
Extraversion	3.56	0.44	2.58	4.58	-.05	
Assertiveness	3.25	0.64	1.75	4.75	-.006	
Activity level	3.27	0.56	1.38	4.50	-.02	
Excitement seeking	3.81	0.54	2.5	5.00	-.05	
Gregariousness	3.36	0.72	1.62	5.00	.03	
Positive emotions	3.79	0.67	1.88	5.00	-.06	
Warmth	3.88	0.57	2.62	5.00	-.06	
Agreeableness	3.37	0.45	1.58	4.29	-.05	
Trust	3.27	0.71	1.38	5.00	.06	
Straightforwardness	3.21	0.59	1.62	4.50	-.15	
Altruism	4.00	0.56	2.25	5.00	-.09	
Meekness	2.96	0.67	1.12	4.50	.08	
Modesty	3.23	0.73	1.00	4.88	-.15	
Tendermindedness	3.56	0.56	1.62	4.75	.06	
Conscientiousness	3.48	0.41	2.54	4.60	-.06	
Competence	3.55	0.42	2.62	4.5	.10	
Achievement	3.50	0.55	2.12	4.75	-.12	
Discipline	3.53	0.71	2.00	5.00	-.08	
Order	3.36	0.56	2.12	4.50	-.07	
Dutifulness	3.74	0.51	2.62	5.00	-.05	
Deliberation	3.21	0.68	1.62	4.50	-.01	

Table 2. Continued

Assessment	Scores (n = 100)					
	M	*SD*	Min	Min	Pearson's *r*	FDR
Neuroticism	2.79	0.45	1.29	3.65	-.02	
Anxiety	3.01	0.66	1.12	4.50	-.07	
Hostility	2.71	0.63	1.25	4.62	-.08	
Depression	2.68	0.69	1.12	4.25	.02	
Self-consciousness	2.77	0.67	1.00	4.38	.05	
Impulsivity	3.33	0.56	2.00	4.50	.05	
Vulnerability	2.25	0.52	1.00	3.62	-.07	
Openness	3.54	0.43	2.56	4.54	-.11	
Aesthetics	3.22	0.82	1.38	5.00	-.20*	.05
Fantasy	3.44	0.70	1.50	5.00	-.23*	.04
Feelings	3.64	0.64	2.25	5.00	-.07	
Ideas	3.72	0.68	2.00	5.00	.11	
Actions	3.31	0.42	2.38	4.25	-.09	
Values	3.88	0.53	2.25	5.00	.09	

Note. Min = lowest score detected; Max = highest score in sample; FDR = false discovery rate adjusted probability; SB = Stanford-Binet; PPGM = Problem and Pathological Gambling Measure.
[a] Correlation calculated with inverse transformation of PPGM scores.
* $p \leqslant .05$. ** $p \leqslant .01$.

(Stanford-Binet Matrices), working memory capacity (digit span), quantitative skills (Stanford-Binet Equation Building), GPA, age, or years of education.

However, PSM had a significant negative relationship with two personality facets from the Openness domain: Aesthetics (r = -.20, p = .04) and Fantasy (r = -.23, p = .02). This result is a reflection that appreciation of art and beauty, as well as having a rich fantasy life and imagination, are both negatively related to poker skill.

Poker skill was also significantly related to lower levels of gambling fallacies (r = .26, $p <$ .01; higher scores on the GFM indicate greater resistance to gambling fallacies). This result implies that the behaviour of good poker players is more strongly guided by the statistical probabilities involved rather than by hunches, beliefs, and other erroneous notions.

On the DOSPERT, poker skill was also negatively related to a perception that engaging in gambling (r = -.21, p = .04) or financial investment (r = -.19, p = .06) constituted a significant risk. The overall correlation with the Monetary scale was also significant (r = -.25, $p <$ .01).

A significant positive relationship was obtained between poker skill and the Information Processing section of the TSIS (r = .27, $p <$ .01), indicating higher levels of social information processing among skilled players.

Of final note, a significant relationship was established between poker skill and an inverse transformation of the PPGM composite score (r = -.24, p = .02). This result

indicates that problem gambling symptomatology is greater among more skilled poker players.

Multivariate Results

Multiple univariate correlations capitalize on the chance occurrence of significance. In addition, they do not indicate the unique contribution of each variable to poker skill. Thus, a multiple regression was also undertaken. Univariate outliers and skew were corrected as previously explained. A number of variables were excluded so as to eliminate singularity and/or multicollinearity, as well as to reduce the overall number of independent variables in light of the relatively small sample size of 100. More specifically, the following variables were not included in the multiple regression: social intelligence composite score, all subfacets of each of the personality domains, the Extraversion domain, and the two subareas of the Monetary section of the DOSPERT. GPA was also excluded because 12% of the data was missing. All other variables were included. No multivariate outliers were found as assessed by Mahalanobis distance ($\chi^2 \geqslant 49.7$). All other variables were entered simultaneously. The poker skill index (PSM score) was significantly related to the combination of individual difference measures, $F(22, 77) = 2.60$, $p = .001$. The adjusted R-squared value was .26, indicating that in this sample, 26% of the variance in the poker skill scores can be accounted for by the combination of these individual differences. Table 3 displays the unstandardized and standardized regression coefficients, as well as the semi-partial squared correlations. Variables are listed in order of largest to lowest standardized regression coefficient. Only two variables contributed significantly to the prediction of higher PSM scores: Social Information Processing and gender. However, four additional variables approached significance: scores on the Gambling Fallacies Measure ($p = .07$), age ($p = .09$), and both the Financial subscale ($p = .09$) and the Ethical subscale ($p = .07$) of the DOSPERT.

Highest Skill Cases

The multiple regression analysis identified several variables that are generally associated with skill levels, but these variables do not indicate whether having strength in all of these attributes is required for individual poker success, or whether having strength in any one or more would be sufficient. Thus, a final analysis examined the consistency of individual attributes among the highest skilled players in the sample: those with PSM scores greater than 2 SDs above the mean PSM score. Four participants fit the criteria for this analysis of having PSM scores greater than 2 SDs above the mean; their scores were 32, 32, 29, and 29.

The scores of each case participant, as well as the mean scores of the whole sample, can be seen in Table 4. Variables where all four players scored above or all scored below the average are in bold.

This table illustrates that, as expected, the four skilled players all had higher than average self-rated poker ability, played fewer hands, and had higher flop aggression.

Table 3
Multiple Regression Results

	Regression Coefficients (B)	Standardized Regression Coefficients (β)	Squared Semi- Partial Correlations (sr_i^2)
Social Information Processing	2.21	0.27*	0.03
Gender	2.74	0.25*	0.04
Age	0.25	0.21	0.02
Risk - Ethical	0.24	0.21	0.03
Gambling Fallacies Measure	0.68	0.18	0.02
Risk - Financial	-0.19	-0.18	0.02
Risk - Health/Safety	-0.15	-0.17	0.01
Years of education	-0.41	-0.15	0.02
Neuroticism	1.67	0.14	<0.01
Openness	-1.75	-0.13	0.01
PPGM	-7.06	-0.13	0.01
Conscientiousness	-1.43	-0.11	<0.01
Stanford-Binet Matrices	0.07	0.09	<0.01
Playing experience (years)	0.11	0.07	<0.01
Digit span	0.38	0.07	<0.01
Risk - Recreational	0.05	0.07	<0.01
Agreeableness	-0.62	-0.05	<0.01
Social Awareness	0.29	0.04	<0.01
Ethnicity	-0.54	-0.04	<0.01
Stanford-Binet Equation Building	0.02	0.03	<0.01
Social Skills	0.18	0.02	<0.01
Risk - Social	0.02	0.01	<0.01
Constant	-0.39		

Note. PPGM = Problem and Pathological Gambling Measure.
* $p \leqslant 0.05$.

The other variables where all four players were consistently different from average were male gender, higher intelligence, greater resistance to gambling fallacies, lower perception of risk involved in gambling and investing, better social information processing, better social skills, lower modesty, lower openness, and lower aesthetic appreciation. The fact that the highest skilled players consistently scored higher or consistently scored lower than most people on these variables contributed to these variables being identified as statistically important in both the univariate and multivariate analyses. Despite this obvious confound, however, (a) the consistency in these attributes across the four players, (b) the fact that virtually all of these attributes were previously identified in either the multivariate and/or univariate analysis, and (c) the low magnitude of these univariate and multivariate correlations suggests that having sufficient levels of most of these attributes is more important for poker success than having exceptional strength in just one or two of these areas.

Discussion

The current study was conducted to comprehensively examine the individual characteristics indicative of good poker players. First, we found that age, race/

Table 4
Highest Skill Participant Scores Versus Total Sample Scores

	Sample Scores (n = 100)		Case Scores			
Assessment	*M*	*SD*	Case 1	Case 2	Case 3	Case 4
PSM	17.63	5.57	29	29	32	32
Age	23.28	6.45	23	23	20	22
Gender[a]			**M**	**M**	**M**	**M**
Ethnicity[b]			**C**	**C**	**C**	**C**
Self-rated poker ability (%)	33.42	21.15	**68**	**87**	**65**	**67**
Playing experience (years)	4.68	5.13	2.5	10	7	3
Digit span	5.6	1.02	4	6	7	7
Stanford-Binet Equation Building	57.65	10.45	70	46	56	72
Stanford-Binet Matrices	55.19	7.29	**60**	**64**	**60**	**60**
Gambling Fallacies Measure	7.36	1.52	**8**	**8**	**9**	**10**
Risk Perception						
Ethical	30.00	4.96	28	31	30	33
Financial	29.34	5.11	**22**	**19**	**26**	**20**
Gambling only	17.05	3.41	**10**	**10**	**16**	**13**
Investment only	12.29	3.09	**12**	**9**	**10**	**7**
Health/Safety	27.11	6.09	25	27	31	16
Recreational	23.14	6.76	26	35	21	17
Social	16.42	4.92	18	9	15	23
Social IQ						
Social Information Processing	5.21	0.69	**5.43**	**7.00**	**6.57**	**5.71**
Social skills	4.81	.07	**4.86**	**6.14**	**5.86**	**5.29**
Social Awareness	5.12	.82	3.71	6.43	5.86	5.29
Composite Social IQ	15.14	1.78	13.90	19.57	18.29	16.29
Composite PPGM	.045	1.06	2	3	0	3
Personality domains and facets						
Extraversion	3.56	0.44	3.21	3.56	3.71	3.88
Assertiveness	3.25	0.64	3.25	3.13	4.38	3.13
Activity level	3.27	0.56	2.13	3.25	4.25	3.5
Excitement seeking	3.81	0.54	3.88	2.88	3.63	4.38
Gregariousness	3.36	0.72	3.00	3.63	3.38	3.89
Positive emotions	3.79	0.67	3.38	4.00	3.25	4.63
Warmth	3.88	0.57	3.63	4.50	3.38	3.75
Agreeableness	3.37	0.45	2.50	3.92	2.83	3.63
Trust	3.27	0.71	2.50	4.75	3.25	3.38
Straightforwardness	3.21	0.59	2.00	3.63	2.38	3.13
Altruism	4.00	0.56	2.50	4.88	3.00	4.50
Meekness	2.96	0.67	2.13	3.38	2.38	3.50
Modesty	3.23	0.73	**2.50**	**3.13**	**2.13**	**2.88**
Tendermindedness	3.56	0.56	3.38	3.75	3.88	3.38
Conscientiousness	3.48	0.41	2.58	3.71	4.21	2.88
Competence	3.55	0.42	3.25	3.63	4.38	3.63
Achievement	3.50	0.55	2.63	3.75	4.25	2.75
Discipline	3.53	0.71	2.00	3.75	4.88	3.00
Order	3.36	0.56	2.38	3.50	4.25	2.63
Dutifulness	3.74	0.51	2.75	4.13	4.25	3.13
Deliberation	3.21	0.68	2.50	3.50	3.25	2.13

Table 4. Continued

Assessment	Sample Scores (n = 100)		Case Scores			
	M	*SD*	Case 1	Case 2	Case 3	Case 4
Neuroticism	2.79	0.45	2.89	2.65	2.60	2.60
Anxiety	3.01	0.66	3.00	3.13	2.63	2.25
Hostility	2.71	0.63	3.00	1.63	3.13	2.13
Depression	2.68	0.69	2.50	2.75	2.25	2.00
Self-consciousness	2.77	0.67	3.25	2.38	2.75	2.63
Impulsivity	3.33	0.56	3.50	4.00	3.25	4.38
Vulnerability	2.25	0.52	2.13	2.00	1.63	2.25
Openness	3.54	0.43	**3.52**	**3.48**	**3.15**	**3.48**
Aesthetics	3.22	0.82	**3.13**	**2.63**	**2.13**	**2.88**
Fantasy	3.44	0.70	3.50	3.75	2.13	3.50
Feelings	3.64	0.64	3.50	4.38	3.50	2.75
Ideas	3.72	0.68	4.63	2.00	4.13	4.25
Actions	3.31	0.42	3.13	3.75	2.88	3.38
Values	3.88	0.53	3.25	4.38	4.13	4.13

Note. PSM = Poker Skills Measure; PPGM = Problem and Pathological Gambling Measure. Total sample scores were compared with case scores, which are the scores of the four participants who scored at least 2 SDs above the group mean on the PSM. Variables where all four players scored above or all scored below the average are in bold.
[a] M = Male. Total sample included 54 males and 46 females.
[b] C = Caucasian. Total sample included 80 Caucasians.

ethnicity, educational level, and educational achievement were not significantly correlated with poker playing skill. None of these variables had a strong theoretical basis for expecting them to be associated with poker skill, and so the failure to find a relationship was not unexpected.

More surprising is the fact that being male was significantly and consistently related to poker skill. Although most professional poker players are male, we presume that cultural attributes associated with male gender (e.g., aggression), rather than biological attributes of male sex, facilitated success. Being female certainly does not preclude one from being an excellent player, as there are several well-known professional female poker players. Nonetheless, as poker remains a male-dominated game, it is also possible that females—despite knowing how to play, and even playing well—tend to devote less time or attention to the game to hone their skill and perhaps have a less competitive drive to win at the game.

We also found general intelligence to have little or no relationship to poker skill level or poker skill attainment. Higher intelligence was never postulated as a necessary attribute (and certainly does not appear to be a preeminent feature among the world's best poker players). Thus, it is not surprising that high intelligence was not strongly related to poker skill, although it is still possible that at least average or above average levels are required.

More surprising is the failure to find a relationship between quantitative ability and poker skill. As poker is recognized to be a game in which mathematical ability is

necessary, this finding may seem counterintuitive. There are two possible explanations for this finding. First, when one reviews the types of calculations required in the game of poker, it becomes evident that much of the math is relatively simple. In determining the likelihood of winning, for the most part, a poker player (a) simply adds up the number of remaining cards in the undealt deck that could complete the hand being created, (b) judges the likelihood that these cards will appear in the five community cards, and (c) is familiar with the strength of that particular hand if it does appear. Thus, the quantitative abilities necessary for poker skill may not demand a high level of mathematical ability. Second, poker skill was consistently associated with low levels of gambling fallacies. Many gambling fallacies hinge on the misunderstanding of statistics. The fact that better poker players are more resistant to fallacies suggests that they understand the basic tenets of statistics. Understanding statistics, however, is both a specific and a learned ability. Thus, it is possible that better poker players have attained a greater understanding of the specific mathematical calculations and statistics necessary for successful poker playing without necessarily increasing their general quantitative skills. Put another way, although exceptional quantitative skills may not be necessary to poker success, basic quantitative ability and adherence to poker-specific statistical probabilities is essential.

One component of social intelligence was consistently found to be significantly related to PSM scores: social information processing. High scores on this component of social intelligence speak to an individual's ability to accurately interpret the behaviour of others. This finding supports previous research that indicates that better players make mental models of opponents (Castaldo, 2007; McCormack & Griffiths, 2011; Wilson, 2003) and, at least in part, use this information to direct their own playing strategy. That the relationship detected between PSM scores and this component of social intelligence was only moderate, and that no other component of social intelligence was found to significantly relate to poker skill, indicates, however, that high social intelligence is neither essential nor sufficient in the making of a skilled poker player.

Working memory capacity was a significant predictor of poker performance in one prior study (Meinz et al., 2012). The current study findings did not indicate any relationship between working memory, evaluated by a digit span task, and poker skill, nor was there a consistent trend, higher or lower, in the working memory capacity of the four high PSM scorers in comparison to the whole sample. Thus, it does not appear that working memory capacity has any important bearing on poker skill level or poker skill attainment, although it is always possible that working memory evaluated by different means would reveal results similar to those of previous research (e.g., Meinz et al., 2012, used one verbal and one spatial complex span task).

Previous research regarding risk perception and tolerance found that better poker players have a greater tolerance for poker-specific risk taking (i.e., betting/raising; Siler, 2010). In the current study, risk perception was assessed across five domains: health/

safety, recreational, social, ethical, and financial. Findings from the current study add support for, and extend, previous findings. Better poker players demonstrated greater tolerance for all financial risk, rather than only for gambling-specific financial risk. Importantly, no other significant relationships were detected between poker skill and risk perception or tolerance. This finding indicates that despite the greater tolerance for financial risk, better poker players are not more tolerant of risk in general.

Previous studies indicated that better players had traits indicative of extraversion such as gregariousness (Martinez & Lafranchi, 1969) and sensation seeking (Barrault & Varescon, 2013) and that better players were lower in traits presumably associated with neuroticism such as rumination (Palomäki et al., 2013). In the current study, however, no relationships between PSM scores and personality domains or facets were found that would support previous research claims. In fact, with two exceptions, there was virtually no association between any aspect of personality and poker skill. The two exceptions to this finding were the significant negative relationships detected between poker skill and two personality facets of the Openness domain: Aesthetics and Fantasy. Low scores for the Fantasy personality facet are indicative of individuals who prefer practicality and realism. Individuals who score low on the personality facet Aesthetics are not swayed by art and beauty. It could be that the tendency of better players towards realism, both in the avoidance of fantasy and of art and beauty, aids their poker playing by reducing susceptibility to distraction (e.g., maintain focus on the game rather than slipping off into a spell of daydreaming).

The final individual characteristic of interest in the current study was susceptibility to problem gambling behaviours. Susceptibility to problematic gambling behaviour did increase significantly in association with higher skill. Specifically, higher skilled players reported a greater tendency to spend more time and money on gambling than planned, as well as problems with family or spouse because of the time spent gambling. These findings suggest that better players tend towards over-involvement with the game of poker. It may well be the case that the time spent playing poker, however, at least in part, is a facilitator of poker skill attainment. This possibility is supported by the significant univariate correlation between years of playing poker and poker skill.

A final observation concerns the fact that the four most skilled players had similar profiles, with above average (but not exceptionally high) levels of virtually all of the above statistically important variables. This, combined with the observation that the magnitude of all of the statistically significant variables was low, suggests that the profile of a successful poker player is someone who has the requisite levels of all of these attributes, rather than exceptional strength in just one or two of these areas.

Implications

The current study findings lead to two important practical implications. First, these findings contribute to the ongoing legal skill versus chance debate. Herein it was found that individual characteristics are significantly associated with, or aid in, poker playing skill. Success in poker, therefore, rather than being solely reliant on chance,

is influenced by individual characteristics (e.g., social information processing) that contribute to a player's ability to influence game outcomes.

No specific individual difference was found to be sufficient for greater poker skill level, as having a profile of statistically important individual differences (i.e., greater financial risk tolerance, greater social information processing skills, etc.) appears to provide the foundation on which poker players can build skill. To an extent, individual differences that were found to relate to skill level were differences that could be developed or learned (e.g., increasing calculated risk taking, possibly through statistical education). This result supports previous research by DeDonno and Detterman (2008) and Dixon and Jackson (2008), who found that poker training increased poker performance. Thus, the second implication of the current study pertains both to players who desire to improve their poker playing ability or skill level and to businesses and individuals seeking to aid players in game improvement. Given the appropriate training, skill increases are likely attainable. The extent to which poker skill can be increased in general is, however, a topic for future investigations.

Future Directions

An examination of gender differences associated with poker ability should be undertaken. Nearly half of the current study sample was female and the PSM scores of females ranged from 9 to 22 (of 35), indicating that the higher PSM scores were not solely attained by males. Yet skill level did differ between males and females. Given the sample composition, however, it was beyond the capabilities of the current study to evaluate the individual differences of male and female players matched by skill level. Gender differences and similarities in player attributes, therefore, remain unknown.

Some of the individual differences found to be associated with good poker players could feasibly be enhanced by learning or training and as such, the second research direction pertains to the investigation of the impact of learning via both training and experience. Poker-specific statistical understanding, for example, may be developed by immersion (i.e., experience) or by focused training (i.e., commercially available training programs). Greater statistical understanding may in turn lead to changes in risk-taking behaviours during poker playing (e.g., increases in calculated risk taking, the reduction of reckless risk taking). In the current study, however, no data were collected regarding whether or not participants had previously engaged in focused training. Playing experience was significantly related to poker skill, but only in the univariate analysis. Evaluating experience in terms of years may have attenuated the relationship, or the relationship may be spurious. Thus, the magnitude of skill increase due to experience and focused training requires further investigation. It would also be of interest to assess the similarities and differences between experience and focused training.

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