Is poker a game of luck or skill?

Winning a hand in poker takes luck and skill – but which contributes most to victory? **Frederic Paik Schoenberg** sets out to quantify these two elements of the game using real-life examples

Las Vegas, Nevada, 11 July 2015. Day 4 of the World Series of Poker (WSOP) main event. The tournament began with 6420 players paying $10 000 apiece to enter. Now only about 400 remain. Some are legendary poker professionals, while others are amateurs taking a shot at glory. The tension and drama increase with each card that is dealt. Millions of dollars – and the title of World Champion – hang in the balance. To win takes great skill, but also a huge amount of luck.

But which is more important: skill or luck? This has been the subject of intense legal debate for decades. For instance, in 2007 an English court ruled that poker is primarily a game of luck in finding the owner of London's Gutshot Club guilty of violating the Gaming Act, which requires a licence to host games of chance but not games of skill (bbc.in/2IcMYLa). However, in 2009 the organiser of a poker club in Colorado was found not guilty of illegal gambling on games of chance in a trial where the jury agreed with a statistician's testimony contending that poker is a game of skill.[1]

Two courts and two different rulings offer little in the way of clarity. So, to determine whether poker is primarily a game of skill or luck, we first need to define what those two words mean in this particular context. That is what this article sets out to do. It offers a definition of luck and skill in poker, and highlights certain scenarios involving real poker hands in which the luck and skill components can readily be quantified. Our focus will be on the game Texas hold 'em, the most popular version of poker played today, and we will begin with an example illustrating basic rules, concepts and terminology surrounding the game.

Explaining the game

Let us return to the 2015 WSOP. At this late stage of the tournament, before the cards are dealt, one player – called the

small blind – must bet 5000 chips. The next player – called the *big blind* – must bet 10 000 chips. In addition, all eight players must put an *ante* of 1000 chips into the pot. The dealer then deals two cards face down to each player. Each player acts in sequence, and can either *call*, which means matching the largest bet (currently 10 000), *raise*, which means betting more than the current bet, or *fold*.

In this hand, Ryan D'Angelo raises to 22 000 with A♦ K♠. Five players fold. Daniel Negreanu, the small blind, calls with A♠ 7♠, and Fernando Perez calls from the big blind with 3♥ 2♥. The pot now totals 74 000 chips and the first betting round is complete.

At this point, the dealer places three community cards, called the *flop*, face up on the board. The cards are 3♠ 10♣ 9♠. These community cards can be used by any of the players, along with their own two cards, to form the best possible five-card poker hand. After the flop there is another betting round. All three players *check*, which means they bet zero chips.

Next the dealer reveals another community card, called the *turn*, and it is 2♠. At this point Negreanu has a *flush*, meaning five cards of the same suit, because his cards are both spades (A♠ 7♠) and there are three more spades on the board (3♠, 9♠, and 2♠). Perez, meanwhile, has two pairs – 3s and 2s. After the turn is revealed there is another betting round, and Negreanu begins by betting 35 000 chips. Perez raises to 105 000. D'Angelo folds. Negreanu re-raises to 250 000, and Perez calls. The pot now totals 574 000 chips.

The dealer now places the fifth and final community card, called the *river*, on the board, and it is 5♣. There is then a final betting round. Negreanu goes *all-in* (which means betting all his 359 000 chips). Perez folds. Negreanu collects the entire pot of 933 000 chips and the hand is over. Had Perez called, both players would *showdown* and reveal their cards, and the player with the better five-card hand, which in this case is Negreanu, would win the pot. In the event of a tie, the two players split the pot.

In this hand, Negreanu made a profit of 301 000 chips. But how much of this profit was the result of skilful play, and how much was due to luck? In order to address this question, one first needs to define these concepts, and in order to define them we will rely on the key poker concepts of *equity* and *expected profit*.

Equity is a player's expected portion of the pot assuming no future betting, and assuming only knowledge of the cards previously mentioned or revealed in the hand. For instance, Negreanu's *equity* on the turn is the expected value of X, where X is the amount Negreanu would win, assuming no further betting or folding after 2♠ is revealed as the turn. At this point the pot consists of 74 000 chips, and – assuming no further betting – X will either be 74 000 or zero, depending on whether Negreanu wins or loses the hand, so Negreanu's equity will simply be 74 000 times the probability of him winning the hand, assuming no player will fold. (If ties are possible, X could also equal some fraction of the pot.) A player's *expected profit* during a portion of a poker hand is her increase in equity minus the cost incurred during this portion of the hand.

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Defining luck and skill

The terms luck and skill are difficult to define, and rigorous definitions of these terms seldom appear in books and journal articles on game theory. A few articles have defined skill in terms of the variance in results among different players, with the idea that players should perform more similarly if a game is mostly based on luck, but their results may differ more substantially if a game is based on skill.[2] Another definition of skill is the extent to which players can improve; Dedonno and Detterman, for instance, argued that poker is a game of skill by showing that participants who were given strategic instruction outperformed those who were given no instruction.[3]

But these definitions are problematic for various reasons. They seem somewhat arbitrary and only very loosely tied to one's conceptions of luck and skill. It is also easy to think of counterexamples and major flaws in the definitions, especially when considering their application to other games. For example, there are many contests of skill wherein the differences between players are small, or where one's results vary wildly. In Olympic trials of the 100-metre sprint, for instance, the differences between finishers are typically just hundredths of a second. This hardly implies that the results are based on luck. Or when pitching in baseball, an individual's results may vary widely from one day to another, but that does not mean luck plays a major role. Some players might not be able to improve beyond a certain point in chess, but this does not render chess a game of luck.

To quantify the amount of luck or skill in a particular game of poker, one possibility is to define luck as expected profit gained when cards are dealt by the dealer, and skill as expected profit gained by a player's actions during betting rounds. A player might gain expected profit during a hand by several actions:

- The cards dealt by the dealer give the player a greater chance of winning a hand in a showdown, thus increasing her equity in the pot.
- The size of the pot is increased while the player's chance to win the hand in a showdown is better than those of her opponents.
- Through aggressive betting, the player gets others to fold and thus increases her probability of winning the pot.

It seems natural to classify the first case as luck, and the second and third cases as skill. That is, we define skill as *the expected profit gained during the betting rounds*, and luck as *the expected profit gained simply by dealing the cards*. Both are easily quantifiable, and one may dissect a particular poker game and analyse how much expected profit each player gained due to luck or skill.

Example 1

Continuing with our example hand from the 2015 WSOP, how much expected profit does Negreanu gain due to skill during betting on the turn?

After 2♠ is revealed as the turn, the pot consists of 74 000 chips and – assuming no folding, and assuming knowledge only of the cards held by the three players still in the game –

the probability of Negreanu winning this pot is the probability of the river being anything other than 2♣, 2♦, 3♣, or 3♦. This is equal to 1 – 4/42, because 10 of the 52 cards have either been revealed on the board or are in the hands of the three players, leaving 42 remaining cards equally likely to appear on the river. If the river were a 2 or 3 then Perez would have a *full house* (e.g. 3♠ 3♥ 3♣ 2♥ 2♠) which would defeat Negreanu's flush. Thus, Negreanu's equity when the turn is revealed is 38/42 × 74 000 ~ 67 000 chips.

During betting on the turn, the pot increased from 74 000 chips to 574 000 chips. Thus, Negreanu's expected share of the pot increased from 67 000 to approximately 520 000 (38/42 × 574 000), for an increase of 453 000 chips. The cost to Negreanu on the turn was 250 000 chips, so his increase in expected profit during betting on the turn was 203 000 (453 000 – 250 000). That is, Negreanu gained 203 000 chips in expected profit due to skill.

Example 2

Table 1 summarises a selection of 27 hands from the end of a tournament on *Poker After Dark*, televised on NBC in October 2009, involving Dario Minieri and Howard Lederer. This portion of the tournament involved only these two players and all the hands were televised. (For a full description of all 27 hands, see Example 4.4.3 in my book, *An Introduction to Probability with Texas Hold'em* Examples.[4]) How much of Lederer's win was due to skill and how much of it was due to luck?

Overall, as seen from the second-to-last row of Table 1, although Lederer's gains were primarily (81.9%) due to luck, Lederer also gained more expected profit due to skill than Minieri. On the first 19 hands, Minieri actually gained 20 836.41 in expected profit due to skill and appeared to be outplaying Lederer quite substantially. But because of bad luck – particularly on hand 16 – Minieri lost a total of 2800 chips over these 19 hands.

Then, on hands 20 and 21, Minieri tried two huge unsuccessful bluffs in cases (especially hand 20) where he should probably have strongly suspected that Lederer would be likely to call. On those two hands combined, Minieri lost 40 117.40 in expected profit due to skill.

The bottom row of Table 1 shows the proportion of variation (PV) in profits attributable to luck or skill, respectively. The 27 hands between Minieri and Lederer yield an estimate of 52.73% for the percentage of variation due to luck, and 47.27% for the percentage of variation due to skill.

One might view these percentages as reflecting the contributions of luck and skill to the game of poker, though further study should be done to see if these proportions are stable across different poker players and for different tournaments.

Drawbacks

At this point, it is important to note that there are some problems with our proposed definitions of luck and skill.

First, situations can occur where a terrible player may gain expected profit during betting rounds against a better player, and attributing such gains to skill may be objectionable. For instance, if there are two players and one is dealt a pair of aces and the other a pair of kings, one would expect the player with the kings to put a great number of chips in while way behind, anticipating that they had a decent shot at winning. This situation seems more like bad luck for the player than a deficit in skill. However, virtually any definition of skill can be objected to on such a basis. One might argue that skill is too strong a word, and that when analysing hands, one should perhaps instead refer to expected profit gained *during betting rounds* rather than expected profit gained *due to skill*.

Another issue with the definitions proposed here is that luck and skill will often be correlated in practice. This is explored further in the next example.

TABLE 1 Quantification of luck and skill for some of the 27 hands played between Dario Minieri (M) and Howard Lederer (L) on *Poker After Dark*, NBC, October 2009. Each hand is assessed from Minieri's perspective; that is, a skill gain of –1948.84 for Minieri means Lederer gained 1948.84 chips in expected profit during betting rounds. The total and proportion of variation (PV) are for all 27 hands. PV_{luck} = sum of squared luck gains / (sum of squared luck gains + sum of squared skill gains). Blinds were initially 800/1600 and switched to 1000/2000 in hand 15.

Hand	Minieri's cards	Lederer's cards	Betting actions	Minieri's luck gain	Minieri's skill gain
1	6♠ 6♦	A♣ 7♠	L raises from 1600 to 4300, M raises to 47 800, L folds.	206.88	4093.12
12	7♦ 3♥	A♦ 4♦	L raises to 4300, M raises to 11 500, L folds.	–491.04	4791.04
16	A♣ J♦	5♠ 5♥	L calls 1000, M raises all in for 26 800, L calls. The board is 3♠ 9♠ K♠ 10♦ 9♦.	–24 858.16	–1941.84
18	10♠ 6♥	5♠ 5♣	L calls 1000, M checks. Flop 7♣ 8♣ Q♥. M checks, L bets 2000, M calls. Turn J♥. M bets 4000, L folds.	–1711.00	5711.00
20	7♣ 2♠	Q♠ 9♠	M raises to 6000, L calls 4000. Flop A♦ A♠ Q♦. L checks, M bets 6000, L calls. Turn J♣. L checks, M bets 14 000, L raises all in for 35 800, M folds.	–556.20	–21 443.80
21	10♥ 3♦	Q♥ J♠	M calls 1000, L checks. Flop 8♠ 4♥ J♣. L checks, M bets 2000, L raises to 7500, M raises to 18 500, L raises all in, M folds.	–1826.40	–18 673.60
27	A♣ 5♠	Q♣ 9♣	L goes all in for 29 200, M calls. Board is 7♣ 6♣ 10♠ Q♠ 6♦.	–32 013.88	2813.88
Total				–61 023.59	–13 478.41
PV				52.73%	47.27%

Example 3

In a hand from the 2015 WSOP, Mike Cloud raised to 15 000 with A♣ A♠, Phil Hellmuth, Jr, called with A♥ K♠, Negreanu called from the big blind with 6♦ 4♥, and the flop came K♣ 8♥ K♥. Before the flop, the pot was 57 000 chips, and the probabilities of winning the hand in a showdown at this point were 74% for Cloud, 19% for Negreanu, and only 6% for Hellmuth (plus an approximately 1% chance of a split pot). After the flop, Hellmuth became the favourite. All three players checked. The turn was J♥; Negreanu checked, Cloud bet 15 000, Hellmuth called, and Negreanu folded. Then came the river, 7♠. This time, Cloud checked, Hellmuth bet 37 000, and Cloud called.

Hellmuth won the hand, with his three kings beating Cloud's two pairs of aces and kings, and clearly he got lucky with the dealing, particularly on the flop. But Hellmuth also made gains due to skill. Thus, luck and skill – as defined here – will tend to be correlated: players who are lucky enough to get better cards than their opponents will typically bet when they are ahead and thus gain in skill as well.

Before the flop, Hellmuth's equity was 3420 chips (6% × 57 000). After the flop, the only way Hellmuth could have lost in a showdown would have been if the turn or river contained the A♦ without the K♦, which had a probability of 4.54%. So Hellmuth's equity suddenly increased to 54 412.2 chips (95.46% × 57 000), for a gain of 50 992.2 in equity due to luck. There was no betting on the flop, so Hellmuth gained zero expected profit due to skill.

Next, when the turn was dealt, Hellmuth's probability of winning in a showdown increased to 97.62%, so his equity increased from 54 412.2 to 55 643.4, for a gain in expected profit of 1231.2 due to luck. During betting on the turn, Hellmuth's expected return increased by 29 286 chips (97.62% × 30 000), but he put 15 000 chips into the pot, so his expected gain in profit on the turn due to skill was 14 286 chips.

After betting on the turn was over, the pot contained 87 000 chips. When 7♠ was revealed on the river, Hellmuth was certain to win. His equity increased from 84 929.4 to 87 000, for an increase of 2070.6 chips due to luck. Hellmuth's gain in expected profit due to skill on the river is simply 37 000 chips, since the pot size increased by 74 000 while Hellmuth had a 100% chance of winning, but the cost to Hellmuth was 37 000.

This analysis attributes 54 294 of his profits to luck, and 51 286 due to skill.

A counterexample

In the above examples, we have calculated equity in a pot assuming no future betting. However, the assumption of no future betting may seem absurdly simplistic and unrealistic in some cases. The following example, from the seventh season of *High Stakes Poker*, illustrates some of the limitations of making inferences based on equity, where one assumes no future betting or folding in calculating the expected winnings for each player.

We begin with eight players at the table. After Phil Galfond raised to $3500 with Q♠ 10♥, the next five players folded. Robert Croak called with A♣ J♣ and Bill Klein called with 10♠ 6♠. The flop came J♠ 9♥ 2♠. Croak bet $5500, Klein raised to $17 500, and Galfond and Croak called.

At this point, it is tempting to compute Klein's chance of winning as the probability of exactly one more spade coming on the turn and river without making a full house for Croak, or the turn and river including two 6s, or a 10 and a 6. This yields a probability of 31.12%. Klein could also split the pot with a straight if the turn and river were KQ or Q8 without a spade, which has a probability of 1.99%. These seem to be the combinations Klein needs, and one would not expect Klein to win the pot with a random turn and river combination not on this list, and especially not if the turn and river contained a king or a jack with no spades.

However, look at what actually happened. The turn was K♣, giving Galfond a straight, and Croak checked. Klein bet $28 000, Galfond raised to $67 000, Croak folded, and Klein called. The river was J♥. Klein bluffed $150 000, and Galfond folded, giving Klein the $348 200 pot. This example illustrates how the assumption of no future betting or folding in simple equity calculations can lead to significant overestimates or underestimates of the probability of winning a hand.

Showdown

The definitions proposed here for luck and skill in poker can be used to quantify how much of one's winnings in a given poker hand, session, or tournament are attributable to luck and how much are attributable to skill. Further, by combining results from many sessions one may estimate the contribution of luck and skill to poker more generally, to get a sense of whether poker is indeed primarily a game of chance or a game of skill. That is, one could use this method to assess, for a typical game of poker, what proportion of the variation in profits is due to luck and what proportion is due to skill. However, the proposed definitions have limitations and caveats as they rely on the assumption of no future betting or folding and will tend to yield positively correlated estimates of luck and skill.

For now, the debate over poker's status as a game of skill or chance rumbles on, and courts and experts will continue to wrestle with the question of what contributes most to a player's likelihood of success. All we can say for certain is that luck and skill both play a part. ■

References

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