Survival in chessland

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Abstract

CHESSMATE.

Introduction

If you are forced to play chess to the death, you are in trouble, because most people are not good at chess (for example, the author) and yet want to live.[1]

But what if you are forced to *be one of the chess pieces* to the death? That is, your little soul inhabits one of the 32 pieces or pawns and your soul is vanquished if that piece is eliminated. Now it doesn't matter whether you're good or bad at chess, because you don't get to pick what happens in the game. What matters is that your piece lives to the end of the game, when all surviving pieces are set free. Which piece should you want to be?

In formal chess, the king can never be captured: The game ends when the king is attacked but cannot move, and it is illegal to make a move that leaves the king attacked. The king's death is implied, of course, but it is seen as more poetic to end the game prior to this point.

For the sake of this question, we'll consider the the white king to "die" if white loses (i.e., is checkmated), and likewise for black. Otherwise, of course, the best chances of survival would trivially be with the two kings, since they are never formally captured. Loss includes resignation, since most high-level games actually end once the defeated player agrees that loss is inevitable. We can think of this common case like king seppuku. Many games also end in time forfeit, which is like the king's poor diet and lifestyle choices leading to a death by natural causes.

Neither side is believed to have a decisive advantage, and many games end in a draw, with both kings surviving. So the survival chances of a king are likely greater than 50%; pretty decent odds. Is it possible that any other piece has even better chances? Let's find out—our lives may depend on it!

[1] It is easy for two players to collaborate to produce a draw, especially by simply agreeing to a draw at the outset of the game (if allowed). Some tournament formats forbid the players from agreeing to a draw verbally before a certain point (e.g. 30 moves), or without the arbiter's consent, and FIDE rules technically do not allow a draw until both players have made a move (5.2.3). There are always other routes to a draw, for example by stalemate or repeating the same position three times. Collaboratively producing such situations is easy, but this strategy is not likely a stable equilibrium: Players can often gain a substantial advantage by going "off script" and instead trying to win the game. Additionally, sometimes the terms of chess-to-the-death do not allow the players to communicate at all beforehand, nor during the game. If this is the case, then it may be difficult to agree on the approach to drawing, let alone establish that this is both players' desire. Since the rules of chess-to-the-death can't forbid us from colluding right now as you read this paper, I hereby declare that the following is the correct approach:

1. Nf3. This is a reasonable opening move for white (begins the Réti) which can transpose into several common systems (e.g. King's Indian). Since the knight can move back to g1 on the next move, knight moves are the fastest route to a draw by repetition. This has a good chance of signaling to a wise player that a draw is desired. The player should make this move after pondering carefully for some time, and then looking meaningfully into the other player's eyes.

1. . . . Nf6. This is both a strong response for black in a real game, and simultaneously a signal that a draw is desired. The other advantage is that very weak players[3] may simply copy what white does. In doing so, they will also play this move.

2. Ng1?!. White moves the knight back to its starting square. This is a terrible move for white, but clearly signals the intention to draw.

2. . . . Ng8!. "Fool's Draw Accepted." The starting position is reached for a second time.

3. Nf3 Nf6. At this point the game should clearly continue repeating the sequence, although since we are in the start position, white has any number of strong opening moves available. Signaling the draw line and then 3. d4!? may be pyschologically devastating.

4. Ng1 Ng8 1/2-1/2. The starting position is reached for the third time, which by rule[2] is a draw.

Since this is one of the shortest possible routes to a draw, I hereby dub this line the "Fool's Draw," by analogy with the Fool's Mate. In this line all pieces survive, which is anyway humane and also advantageous in the case that you or someone is simultaneously being one of the chesspieces to the death!

If 1. . . . Nc6 or another Knight's move, white can also consider continuing in the obvious way. However after 1. . . . d5, black has refused or not noticed the draw. Fortunately, white is still in a good position to play the game normally (this is the main line of the Réti opening, followed by 2. c4). White can try to be more obvious with 2. Ng1, but if black is choosing to just play normally, white takes a distinct handicap by doing so.

The biggest risk for white is that black does not play 2. . . . Ng8 but rather a normal move like 2. . . . g6 ("Fool's Draw Betrayed"). This can happen if black is not metagaming at all (for Nf6 is a normal response to the normal Nf3), or if black is an exceptionally shrewd metagamer (tricking white into wasting two tempos with Ng1 by pretending to be cooperating).

Of course, this all relies on the assumption that if chess-to-the-death ends in a draw, the players are spared or allowed to repeat indefinitely. If both players are actually executed, then this line is truly a Fool's Draw!

[2] But is it?

First of all, although either player is allowed to *claim* a draw after three repetitions of the same position, it is not automatic. However, FIDE rules do declare that the game simply ends in a draw upon *five* repetitions. Of course it is easy to extend the Fool's Draw to accommodate this.

Second: The lichess implementation (although known to be buggy[2])

1 Hypotheses

Like all good scientific research, I clearly laid out my hypothesis and wrote down the motivation before performing the study. This helps prevent presentation bias where the results appear more satisfactory because they are framed as a natural conclusion from the idea that motivated the research in the first place (when in fact, of course, if you write the motivation after witnessing the results, backflow is inevitable). It is also much more exciting. I literally don't know the answer as I'm writing this, nor whether it is interesting in any way!

Here are my guesses.

- Black and white are probably not substantially different. That is, the a1 and a8 rooks probably have about the same survival chances (it's known that white has a slight statistical advantage [4] but it is probably only around 1%). So these guesses will be written about white's pieces.
- The d2 and e2 pawns are very active in common openings, and are frequently captured as part of those openings. I think they are the least likely to survive overall.
- Bishops and knights are often involved in the opening and midgame, and often exchanged nonchalantly. I think they all have relatively low survival chances.
- Although the queen is very valuable, a queen exchange is often forced for games that enter the endgame.
- Rooks tend to be late-game pieces, because they are difficult to get out of their corners (and at most one can be activated by the fastest method, castling) and are relatively valuable.
- This leaves the non-central pawns. These are the hardest to predict, and they are hard to think about (at least for me) because when e.g. the a2 pawn recaptures the b3 pawn that it supported, I just think of this as the b3 pawn. Of these pawns, b2 and g2 are somewhat weak because they are undefended once the bishop is developed (cf. the famous "poison pawn" at b2). On the other hand, in the fianchetto configuration, this pawn is very strong and often survives the entire game without leaving the third rank. Since pawn chains usually progress towards the middle of the board, the a2 pawn is more likely to be supporting than supported. This both leaves it weak to capture, but prone to recapturing. Outside pawns block one's own rook, although for this same reason they often clear the file by capturing (and so survive). They are also commonly used to push into a well-defended king's territory (e.g. in the fianchetto); kingside castling is more common, so this means that the h pawns are often lost to this fate.

The final ranking that I predict, from most surviving to most dead: ♙f, ♙c, ♙g, ♙a, ♙h, ♙b, ♖h, ♖a, ♔, ♕, ♗f, ♘g, ♙e, ♙d.

As already copped to, while the author is an aficionado and also knows how to spell the difficult word aficionado without spell-check, he is not good at chess. A few drinking buddies with varying chessperience were also consulted for their wagers; these are compared to each other and to the actual results in Section 4.

2 Methodology

To compute the chances for survival, I legally acquired 506,000,416 chess games from lichess.org. This is all of the standard variant, rated games from Jan 2013 to November 2018, in any time format. Only games that are completed and valid are included (about 200,000 games did not meet this criteria). The total data size is 875 gigabytes, so processing these took some care for efficiency and parallelism. Fortunately, I have a computer with just an obscene number of cores and truly excessive RAM, so you gotta use that for something.[3]

Other than that, I simply implemented the rules of chess, wrote a PGN parser, then parsed and simulated each game. For each of the 32 pieces in the starting position, I tracked its current location, and whether it is alive; multiple dead pieces could occupy the same square. At the end of the game, one of the kings is killed if his side has lost.

For a piece, there is a single factual survival rate in these games, given just by $\frac{\text{num survived}}{\text{num games}}$. What we're really interested in, however, is estimating the underlying true survival probability for each piece. In order to do this with reasonable efficency, we divide the games into 32 separate buckets, and

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does not permit a threefold repetition claim in this situation, which got me thinking that maybe there is some subtlety here. Is the starting position special somehow, not counting as having occurred? The relevant statute, from the FIDE Laws of Chess[1]:

> **9.2**. The game is drawn, upon a correct claim by a player having the move, when the same position for at least the third time (not necessarily by a repetition of moves):
>
> a. is about to appear, if he first writes his move, which cannot be changed, on his scoresheet and declares to the arbiter his intention to make this move, or
>
> b. has just appeared, and the player claiming the draw has the move.
>
> Positions are considered the same if and only if the same player has the move, pieces of the same kind and colour occupy the same squares and the possible moves of all the pieces of both players are the same. Thus positions are not the same if:
>
> 1. at the start of the sequence a pawn could have been captured en passant.
> 2. a king or rook had castling rights, but forfeited these after moving. The castling rights are lost only after the king or rook is moved.

So the question is, has the starting position "appeared" before white's first move? The rules are not totally clear on this point. Note that "positions are considered the same" only when the same player "has the move." FIDE defines "have the move" as

> 1.3. A player is said to 'have the move' when his opponent's move has been 'made'.

A strong case can therefore be made that white does not 'have the move' in the formal sense at the beginning of the game, since black has not made a move!

Nonetheless, it does seem clear that white can claim a draw by 9.2.a, by committing the move 5. Nf3 and declaring to the arbiter that the position is now *about to appear* for the third time. This seems unambiguously legal.

[3] To torture your own desktop computer, source code is available at `sourceforge.net/p/tom7misc/svn/HEAD/tree/trunk/chess/`.

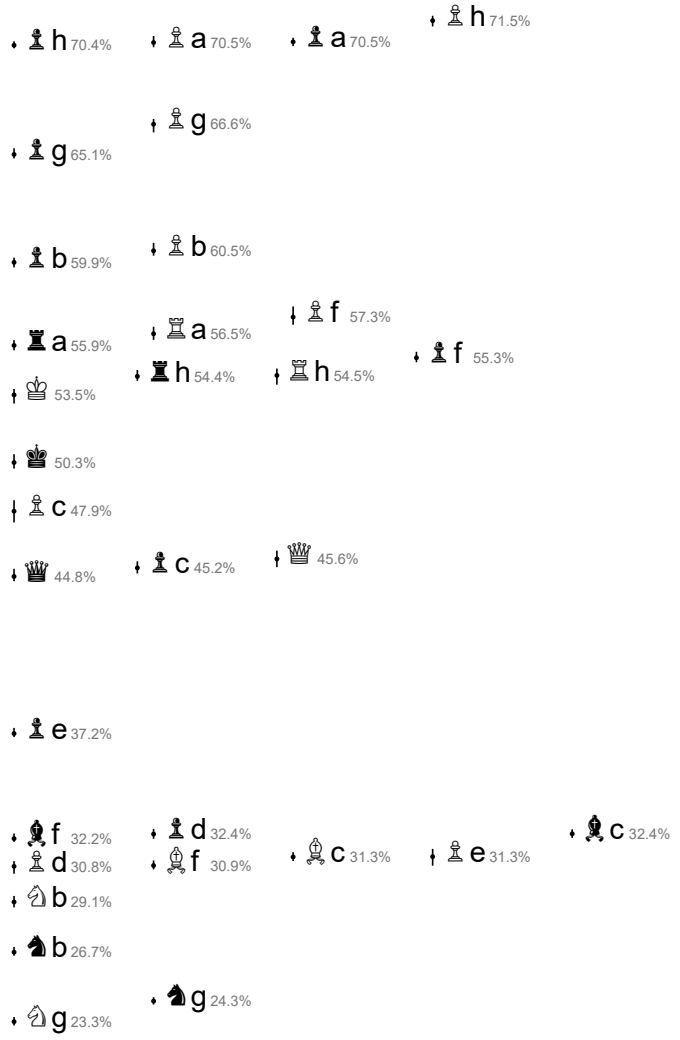


Figure 1: Survival probabilities for each of the 32 pieces in standard chess, in 500 million games. The number is the mean survival rate across all samples. The vertical position of the dot is this mean rate, with a line drawing the span between the smallest and largest sample bucket (this is usually a very tiny range). Horizontal position is purely presentational, to avoid overlap.

count statistics separately for each. From these samples we can then estimate variance, for example. The games are bucketized by a deterministic hash of the White player's username. This way, if there exist some players who are highly unusual (perhaps automated accounts), their games are grouped together and pessimistically represented in the variance estimate. This also helps account for different opening preferences; the chosen opening certainly affects the survival chances.

The basic survival chances appear in Figure 1. Indeed, many pieces are more likely to survive than the kings. Even as black, the extremal pawns (♙a and ♙h) have over a 70% survival rate. Across the board, the survival chances for a white piece and its black twin are similar, usually with a small edge to white. Notable exceptions are the ♘g (the overall most doomed piece), and both white bishops, which die more than their Schwarzdoppelgangers. The ♙e is vastly more dead than ♟e. Note somewhat satisfyingly that the ♙c has the highest variance; this was the most controversial among the drinking buddies (Section 4). Note that ♙c is the sacrificed pawn in the popular Queen's Gambit (1. d4 d5 2. c4), where accepting and declining the pawn are both common and sound responses. This may be a good example of a piece that has substantially different survival rates in different opening preferences. Since the variance is otherwise extremely low, I only report means for the remainder of the paper.

Despite my impression that many games end in a draw, ties are actually rare in the lichess database. In January 2018, only 3.8% of games were drawn; as a result, the survival chances for the kings are both close to 50%. Although the database contains games in many time formats and with all varieties of human skill (including over a thousand games by Magnus Carlsen, the world champion and highest rated player of all time[4]), blitz (~ 5 minutes per side) and bullet (~ 1 minute) games are predominant. Nonetheless, the results are fairly robust across different time formats and skill levels. In Section 4.1 I show some slices of the data for comparison.

3 Safest spaces

The fate of each piece is to either survive or die, and it does so on one of the 64 squares. With the same replay of the 500 million games I also kept statistics on the fates of each piece. If being a chess piece to the death, and possessing some influence over where your piece moves, it may be helpful to know where to go. Even without influence, such knowledge could help calibrate your anxiety.

Other than the bishops—which have no legal way to reach half of the squares—every piece ends on every square in at least a thousand games. So we have enough samples to have reasonable confidence in our statistics, even for the most unlikely odysseys. The least mobile pieces are the pawns, who can technically reach any square by promoting, but are usually confined to cones emanating from their start squares. The overall rarest fate is for ♙f2 to die on the a7 square, which only happened 1,244 times (however, it survived on this square 31,438 times). This square is actually reachable without promoting, but it would need to capture 5 times in order to get there, which seems quite unlikely! There may even be a hidden achievement for reaching this square this way! Aside from pawns, the weirdest fate is for ♘g to die on h1, which happened 47,307 times. Corners are of course garbage for the knight, although it is twice as likely to survive on this square.

There are characteristic patterns for each of the pieces, which make sense given their starting positions movement rules. You could probably guess the piece just by looking at one of the heat maps below, although—spoiler alert—the piece is just listed right there and they are in order. Two independent things are communicated in these graphics: The chance that the piece ends the game on some square (alive or dead), and its survival chances there. In each map, a darker background color indicates that the piece ends on that square more often. The shade is based on the rank (64/64 black is most common, 63/64 black is next most common, etc.) rather than

[4] Although to be fair, his username "DrDrunkenstein" suggests he may not play at full strength.

the absolute probability, since otherwise the graphic looks boring. The number on the square is the percentage survival of the piece when it is last seen (either being captured or surviving to the end of the game) on that square. The four squares with the highest survival rates are underlined for your convenience.

81.1	64.1	57.7	56.1	51.5	59.3	65.5	65.3
47.7	40.9	39.3	37.5	38.3	39.5	47.0	47.4
40.7	45.2	34.6	31.4	33.3	41.9	51.3	57.1
42.1	37.6	34.9	29.3	31.2	41.2	47.8	60.0
45.6	47.2	37.7	30.6	33.6	40.9	49.0	61.4
54.0	45.2	34.7	34.4	32.8	35.0	42.3	61.6
67.6	60.6	51.3	40.3	41.0	40.7	50.7	72.5
30.5	35.0	21.9	17.5	25.8	26.5	46.8	63.0

♜a8

52.4	90.9	55.1	60.5	51.4	62.1	56.8	60.0
52.2	49.4	45.6	42.5	44.4	40.2	51.7	46.8
43.5	49.5	24.5	34.2	30.2	33.3	39.2	42.8
46.1	21.7	26.6	18.3	8.3	27.9	27.9	38.5
32.4	31.7	16.7	9.2	17.6	27.2	33.4	38.4
36.6	11.2	23.0	15.6	21.0	9.9	21.9	36.4
34.3	32.3	35.9	21.2	19.1	29.0	22.1	36.2
30.4	20.6	12.5	18.8	17.5	11.3	20.5	23.6

♞b8

64.7		86.3		56.0		57.8	
	60.8		36.3		44.8		61.4
44.7		37.8		25.3		30.6	
	23.4		20.8		27.9		44.2
39.4		24.0		19.8		31.2	
	21.5		14.5		5.8		29.3
41.5		34.8		7.9		12.0	
	19.3		18.3		9.9		37.6

♝c8

55.5	56.3	52.7	59.2	46.7	42.2	45.6	54.3
58.9	51.8	59.1	43.6	43.5	31.6	36.8	41.0
51.4	52.8	42.2	38.0	31.9	33.6	40.0	50.0
59.7	34.9	43.9	25.4	31.1	34.8	36.7	51.8
48.8	44.6	37.5	26.7	32.6	37.3	36.8	59.9
61.5	28.2	39.2	33.0	36.7	28.5	41.3	65.0
76.4	70.3	57.3	33.5	32.0	61.1	75.5	83.2
68.0	55.4	51.3	14.9	52.3	53.6	60.1	79.8

♛d8

30.8	46.9	54.1	29.2	49.1	33.5	57.4	40.3
41.1	52.3	49.5	46.6	46.1	54.1	56.5	49.5
31.7	46.8	48.5	46.3	48.3	51.2	50.4	38.4
29.0	48.8	51.2	51.7	51.8	52.0	49.3	32.0
31.4	53.4	56.0	54.2	53.7	57.2	53.0	33.1
37.8	66.5	66.4	62.0	64.7	70.6	71.2	42.8
38.6	60.2	63.1	59.7	59.1	70.5	66.3	46.2
27.9	37.0	37.1	34.3	34.3	41.3	42.3	32.6

♚e8

	65.6		51.7		82.8		68.1
60.1		54.7		35.9		50.9	
	47.0		29.9		32.0		38.6
49.6		36.3		17.9		18.8	
	34.9		22.9		22.0		36.7
23.3		6.3		15.7		19.3	
	26.5		6.9		18.0		22.6
21.9		16.2		23.2		26.8	

♗f8

48.9	53.6	53.9	50.0	63.5	59.0	87.6	64.5
39.4	42.8	45.1	44.1	42.8	37.1	53.2	52.7
44.8	48.4	36.4	28.4	34.7	23.5	37.9	28.3
46.0	29.0	28.7	9.1	14.0	24.3	17.9	30.3
38.6	36.1	25.4	18.9	10.1	20.1	28.0	27.8
42.4	24.0	8.4	22.0	13.0	16.0	12.0	32.9
44.0	36.5	41.0	10.1	23.7	19.4	20.9	22.6
26.4	18.5	16.3	16.0	18.4	7.9	21.1	26.3

♞g8

$57^{.8}$	$56^{.8}$	$52^{.3}$	$47^{.9}$	$54^{.3}$	$73^{.3}$	$65^{.1}$	$79^{.5}$
$43^{.0}$	$41^{.3}$	$38^{.9}$	$36^{.4}$	$37^{.5}$	$31^{.9}$	$45^{.3}$	$46^{.2}$
$51^{.3}$	$46^{.6}$	$37^{.6}$	$31^{.6}$	$32^{.7}$	$37^{.4}$	$48^{.6}$	$49^{.2}$
$56^{.8}$	$45^{.1}$	$38^{.8}$	$30^{.7}$	$28^{.1}$	$34^{.8}$	$41^{.8}$	$48^{.1}$
$63^{.9}$	$53^{.1}$	$43^{.7}$	$33^{.0}$	$29^{.7}$	$33^{.7}$	$44^{.6}$	$45^{.8}$
$69^{.5}$	$54^{.3}$	$43^{.9}$	$37^{.1}$	$29^{.3}$	$27^{.3}$	$35^{.7}$	$50^{.6}$
$76^{.1}$	$66^{.2}$	$55^{.6}$	$42^{.1}$	$38^{.1}$	$40^{.6}$	$47^{.6}$	$63^{.7}$
$64^{.0}$	$51^{.4}$	$33^{.7}$	$21^{.3}$	$19^{.5}$	$18^{.5}$	$38^{.5}$	$45^{.6}$

♜h8

$69^{.0}$	$72^{.8}$	$76^{.9}$	$86^{.7}$	$75^{.8}$	$69^{.3}$	$64^{.5}$	$62^{.6}$
$74^{.9}$	$87^{.4}$	$84^{.3}$	$84^{.5}$	$83^{.6}$	$80^{.6}$	$84^{.2}$	$70^{.8}$
$82^{.8}$	$88^{.1}$	$69^{.3}$	$59^{.4}$	$55^{.1}$	$80^{.4}$	$85^{.5}$	$82^{.5}$
$87^{.4}$	$37^{.1}$	$42^{.2}$	$22^{.8}$	$20^{.6}$	$52^{.3}$	$85^{.1}$	$87^{.6}$
$71^{.9}$	$25^{.9}$	$12^{.1}$	$35^{.5}$	$13^{.6}$	$21^{.7}$	$83^{.9}$	$88^{.7}$
$55^{.0}$	$11^{.9}$	$15^{.4}$	$26^{.6}$	$19^{.9}$	$8^{.7}$	$40^{.2}$	$90^{.1}$
$50^{.8}$	$32^{.8}$	$37^{.9}$	$37^{.7}$	$35^{.7}$	$23^{.8}$	$37^{.1}$	$83^{.9}$
$67^{.3}$	$59^{.0}$	$41^{.5}$	$44^{.7}$	$46^{.9}$	$44^{.8}$	$71^{.2}$	$91^{.7}$

♟d7

$95^{.6}$	$85^{.7}$	$74^{.1}$	$78^{.4}$	$73^{.9}$	$64^{.5}$	$62^{.0}$	$75^{.5}$
$82^{.8}$	$91^{.2}$	$84^{.9}$	$85^{.4}$	$84^{.6}$	$78^{.9}$	$82^{.6}$	$76^{.1}$
$76^{.0}$	$52^{.9}$	$84^{.7}$	$84^{.0}$	$82^{.7}$	$83^{.2}$	$85^{.4}$	$84^{.6}$
$65^{.2}$	$24^{.2}$	$38^{.4}$	$82^{.2}$	$83^{.6}$	$82^{.6}$	$85^{.8}$	$87^{.2}$
$55^{.0}$	$20^{.2}$	$26^{.5}$	$75^{.5}$	$83^{.2}$	$83^{.4}$	$87^{.0}$	$88^{.8}$
$50^{.8}$	$18^{.2}$	$21^{.0}$	$61^{.3}$	$85^{.6}$	$84^{.9}$	$89^{.3}$	$91^{.4}$
$50^{.9}$	$42^{.7}$	$44^{.1}$	$75^{.9}$	$91^{.0}$	$91^{.3}$	$95^{.0}$	$95^{.8}$
$48^{.4}$	$49^{.7}$	$65^{.5}$	$83^{.6}$	$91^{.5}$	$85^{.7}$	$95^{.1}$	$96^{.5}$

♟a7

$64^{.5}$	$68^{.7}$	$72^{.1}$	$79^{.6}$	$87^{.6}$	$74^{.4}$	$66^{.5}$	$62^{.1}$
$71^{.0}$	$85^{.6}$	$82^{.2}$	$85^{.8}$	$76^{.8}$	$81^{.6}$	$86^{.3}$	$69^{.9}$
$81^{.4}$	$86^{.8}$	$82^{.3}$	$44^{.3}$	$65^{.5}$	$62^{.8}$	$86^{.0}$	$80^{.9}$
$87^{.5}$	$87^{.0}$	$47^{.4}$	$27^{.8}$	$30^{.9}$	$37^{.3}$	$39^{.8}$	$86^{.8}$
$89^{.7}$	$84^{.4}$	$19^{.2}$	$11^{.3}$	$29^{.7}$	$16^{.3}$	$27^{.8}$	$79^{.6}$
$92^{.6}$	$33^{.7}$	$8^{.2}$	$21^{.9}$	$29^{.2}$	$16^{.2}$	$19^{.1}$	$56^{.1}$
$88^{.2}$	$10^{.0}$	$32^{.0}$	$36^{.2}$	$40^{.3}$	$30^{.8}$	$29^{.6}$	$42^{.4}$
$75^{.1}$	$70^{.0}$	$46^{.4}$	$41^{.6}$	$49^{.9}$	$43^{.1}$	$68^{.5}$	$81^{.8}$

♟e7

$82^{.1}$	$92^{.4}$	$83^{.7}$	$79^{.4}$	$74^{.9}$	$63^{.6}$	$60^{.4}$	$64^{.5}$
$84^{.0}$	$75^{.4}$	$87^{.8}$	$86^{.3}$	$83^{.8}$	$79^{.1}$	$82^{.0}$	$74^{.1}$
$45^{.6}$	$73^{.2}$	$47^{.4}$	$83^{.6}$	$82^{.8}$	$80^{.8}$	$84^{.8}$	$82^{.1}$
$32^{.8}$	$50^{.8}$	$35^{.0}$	$35^{.0}$	$80^{.7}$	$83^{.6}$	$84^{.8}$	$87^{.4}$
$19^{.9}$	$42^{.3}$	$23^{.2}$	$22^{.1}$	$42^{.9}$	$82^{.8}$	$86^{.8}$	$88^{.5}$
$20^{.9}$	$33^{.2}$	$16^{.7}$	$29^{.8}$	$39^{.6}$	$71^{.2}$	$88^{.3}$	$91^{.2}$
$45^{.2}$	$47^{.5}$	$40^{.2}$	$39^{.8}$	$60^{.6}$	$77^{.4}$	$93^{.5}$	$95^{.5}$
$51^{.6}$	$52^{.2}$	$45^{.6}$	$54^{.9}$	$77^{.7}$	$81^{.7}$	$94^{.4}$	$96^{.4}$

♟b7

$61^{.1}$	$63^{.7}$	$67^{.1}$	$76^{.1}$	$83^{.6}$	$89^{.5}$	$74^{.7}$	$65^{.1}$
$68^{.4}$	$84^{.5}$	$80^{.1}$	$85^{.3}$	$88^{.1}$	$72^{.9}$	$90^{.4}$	$74^{.9}$
$80^{.4}$	$86^{.3}$	$81^{.6}$	$83^{.0}$	$35^{.0}$	$55^{.0}$	$52^{.4}$	$83^{.1}$
$86^{.8}$	$87^{.6}$	$83^{.6}$	$30^{.6}$	$22^{.6}$	$43^{.6}$	$32^{.4}$	$32^{.2}$
$89^{.9}$	$89^{.2}$	$51^{.4}$	$27^{.6}$	$21^{.0}$	$40^{.3}$	$23^{.1}$	$34^{.5}$
$92^{.9}$	$87^{.8}$	$32^{.9}$	$25^{.8}$	$25^{.9}$	$36^{.5}$	$17^{.7}$	$33^{.8}$
$95^{.8}$	$87^{.5}$	$59^{.6}$	$38^{.7}$	$40^{.6}$	$45^{.1}$	$36^{.9}$	$38^{.3}$
$96^{.9}$	$96^{.2}$	$81^{.1}$	$56^{.6}$	$47^{.8}$	$53^{.7}$	$59^{.1}$	$75^{.9}$

♟f7

$70^{.5}$	$80^{.0}$	$89^{.4}$	$81^{.9}$	$73^{.9}$	$64^{.4}$	$59^{.4}$	$59^{.5}$
$77^{.6}$	$90^{.0}$	$73^{.1}$	$86^{.6}$	$83^{.4}$	$78^{.0}$	$81^{.6}$	$67^{.3}$
$83^{.7}$	$52^{.3}$	$60^{.4}$	$40^{.4}$	$82^{.2}$	$79^{.9}$	$83^{.9}$	$81^{.1}$
$36^{.4}$	$25^{.4}$	$44^{.2}$	$30^{.9}$	$32^{.1}$	$82^{.2}$	$85^{.3}$	$86^{.8}$
$29^{.4}$	$21^{.9}$	$41^{.2}$	$6^{.8}$	$22^{.9}$	$63^{.8}$	$86^{.3}$	$88^{.5}$
$18^{.7}$	$15^{.2}$	$23^{.9}$	$23^{.1}$	$19^{.8}$	$25^{.9}$	$85^{.2}$	$90^{.9}$
$44^{.7}$	$35^{.1}$	$43^{.8}$	$38^{.5}$	$35^{.1}$	$38^{.3}$	$80^{.9}$	$95^{.2}$
$62^{.8}$	$49^{.4}$	$46^{.2}$	$44^{.1}$	$56^{.9}$	$63^{.2}$	$92^{.4}$	$96^{.1}$

♟c7

$66^{.0}$	$64^{.6}$	$65^{.3}$	$75^{.9}$	$78^{.3}$	$82^{.6}$	$91^{.4}$	$76^{.6}$
$76^{.2}$	$84^{.2}$	$81^{.0}$	$85^{.0}$	$86^{.7}$	$87^{.3}$	$82^{.7}$	$80^{.1}$
$81^{.4}$	$87^{.2}$	$82^{.6}$	$83^{.5}$	$84^{.0}$	$47^{.5}$	$70^{.7}$	$42^{.4}$
$86^{.8}$	$86^{.7}$	$85^{.6}$	$82^{.6}$	$35^{.1}$	$34^{.9}$	$47^{.1}$	$32^{.0}$
$89^{.3}$	$89^{.4}$	$84^{.5}$	$57^{.8}$	$24^{.9}$	$24^{.4}$	$36^{.5}$	$26^{.3}$
$93^{.6}$	$91^{.6}$	$82^{.0}$	$50^{.0}$	$31^{.4}$	$22^{.2}$	$35^{.0}$	$26^{.7}$
$96^{.2}$	$96^{.2}$	$89^{.3}$	$68^{.9}$	$42^{.1}$	$38^{.3}$	$47^{.7}$	$41^{.3}$
$98^{.1}$	$97^{.7}$	$94^{.2}$	$82^{.9}$	$62^{.6}$	$51^{.9}$	$60^{.6}$	$59^{.0}$

♟g7

76.8	66.1	65.3	73.9	75.9	72.4	82.4	95.2
76.7	85.1	80.0	85.2	85.3	84.7	91.8	84.5
83.9	86.4	84.3	82.5	83.8	82.9	56.5	74.1
86.2	87.3	83.2	85.0	81.7	36.7	25.1	62.1
89.5	88.8	84.9	83.9	73.0	24.4	21.6	52.5
93.3	92.1	87.0	86.5	60.5	24.3	16.6	51.9
96.1	96.1	92.9	90.8	74.3	30.4	36.1	51.7
97.7	97.4	94.2	90.9	84.0	60.7	56.5	53.7

♟h7

61.1	57.3	40.5	43.0	44.8	40.3	70.0	90.4
50.1	28.3	36.3	36.7	32.9	19.4	32.0	87.7
52.6	13.7	12.5	24.8	14.9	9.5	47.5	90.4
80.9	23.7	11.4	31.6	16.1	22.9	84.6	88.1
87.5	41.0	40.1	24.2	27.0	60.6	84.8	87.8
81.6	88.1	64.6	64.5	55.3	80.6	85.2	83.1
73.3	87.4	82.2	87.3	84.6	79.6	83.3	71.3
66.6	71.7	74.6	86.2	78.7	70.0	65.3	65.1

♙d2

47.5	49.5	64.2	82.3	91.4	85.1	95.1	96.3
49.8	42.7	44.2	72.5	90.1	91.2	94.7	95.5
49.2	18.7	21.6	54.1	84.5	85.2	89.0	91.6
54.5	18.0	29.1	71.0	82.1	82.8	86.9	88.7
63.6	24.7	38.0	81.1	83.1	81.3	85.9	87.1
74.3	55.0	83.4	83.7	82.2	83.2	85.2	85.2
83.2	91.3	84.4	84.9	84.4	78.5	82.5	76.5
94.8	83.6	72.6	77.5	73.0	65.1	63.4	76.3

♙a2

72.4	68.7	40.9	37.8	46.3	36.5	59.3	77.5
91.6	19.3	27.6	32.7	34.2	24.5	19.3	43.6
92.6	54.2	7.7	13.7	23.5	10.6	16.7	65.4
89.4	87.9	25.3	9.5	28.6	16.0	30.1	84.8
87.4	86.5	64.6	30.8	34.5	39.4	48.5	86.8
81.3	87.1	81.5	44.1	69.1	63.6	85.3	82.4
72.1	85.9	81.5	84.4	80.5	81.2	85.6	73.0
64.5	67.9	69.6	78.4	86.1	74.8	69.5	66.7

♙e2

51.9	52.2	46.0	56.6	78.9	82.0	94.6	96.7
45.3	47.3	41.2	39.5	59.1	76.3	93.8	95.3
21.8	35.6	18.7	30.4	35.4	71.7	88.4	91.7
20.1	40.0	24.0	19.5	43.6	82.3	86.9	88.1
31.6	48.7	34.2	38.9	80.7	82.9	85.1	87.1
45.3	71.4	47.4	83.6	82.7	81.2	85.1	83.7
81.5	74.1	87.0	85.9	83.7	78.9	81.8	75.2
78.1	91.4	83.1	79.2	75.4	64.1	62.8	65.8

♙b2

96.7	96.3	78.1	52.2	46.1	51.3	55.9	73.2
96.1	90.4	55.3	33.7	38.8	41.4	33.5	37.1
93.1	89.5	39.5	20.2	19.9	33.3	14.1	33.5
89.9	88.9	57.7	26.5	22.7	33.7	25.1	34.1
86.4	87.8	83.7	33.9	27.3	44.4	32.0	33.7
79.0	86.1	81.3	83.3	40.2	61.5	54.5	84.2
66.3	84.6	80.4	85.7	88.1	79.1	90.1	77.2
59.0	62.4	65.7	75.9	84.6	90.5	78.7	69.3

♙f2

62.8	49.5	46.7	42.8	54.0	59.2	90.6	95.7
44.8	39.1	44.0	37.7	32.8	30.0	77.2	94.9
17.6	14.3	30.4	25.3	15.4	24.7	85.4	90.8
29.8	18.9	38.7	11.8	25.9	66.3	85.8	88.1
35.7	24.9	40.2	28.8	36.1	80.6	85.0	86.3
82.2	52.7	60.5	42.3	82.3	79.7	84.7	81.7
74.6	89.8	74.0	86.7	84.0	78.2	81.4	68.2
66.9	78.0	88.5	82.6	75.5	65.9	60.7	60.7

♙c2

98.1	97.5	93.6	80.4	62.3	50.2	59.3	57.3
96.4	96.3	89.3	65.6	39.4	34.9	47.5	41.3
93.8	91.8	83.7	49.8	27.4	21.7	33.2	26.9
89.2	89.6	84.3	61.9	23.7	21.0	39.4	24.1
86.4	86.7	85.7	82.7	37.8	34.3	47.4	33.5
81.0	86.8	82.2	83.7	84.6	49.1	72.9	41.7
73.9	84.3	80.5	85.5	86.8	87.8	84.8	83.4
64.1	63.1	64.4	75.7	79.2	83.7	92.5	79.7

♙g2

97.5	97.4	93.3	90.2	83.3	58.2	55.0	53.2
96.3	96.3	92.6	90.0	74.3	26.8	34.7	51.7
93.2	92.1	86.8	86.7	55.7	25.0	13.0	54.2
89.4	88.5	84.7	83.2	75.4	22.6	23.2	51.7
86.2	87.5	83.2	85.2	81.6	37.7	25.5	62.6
82.5	86.4	84.6	82.7	84.5	83.5	58.8	76.5
75.1	84.5	80.2	85.5	85.6	85.4	91.3	87.7
74.9	65.2	65.3	74.8	77.7	74.1	84.5	95.7

♙h2

69.8	55.6	51.8	14.6	51.5	54.4	60.9	79.0
75.2	69.8	57.6	36.4	36.2	66.8	74.5	85.3
60.5	28.4	41.3	33.1	39.8	30.7	46.1	69.2
49.3	43.2	35.5	27.5	31.4	36.2	36.6	61.9
58.7	36.8	43.5	25.4	32.4	35.6	39.0	52.7
53.7	52.0	39.3	43.7	36.7	36.8	43.0	51.7
59.3	49.1	58.6	45.1	44.2	34.4	35.7	45.2
52.8	55.5	50.8	59.3	47.6	41.5	44.9	55.3

♕d1

31.0	35.9	22.1	17.9	25.7	25.9	46.8	60.4
66.0	61.3	52.0	41.1	42.1	41.4	50.3	72.1
52.2	47.3	36.5	35.5	34.3	36.2	42.3	62.1
46.2	47.5	37.0	30.5	33.8	39.0	48.3	60.2
42.3	38.9	33.3	29.6	32.1	40.4	47.7	60.9
42.1	45.7	33.0	35.3	37.1	43.7	53.5	59.9
48.3	38.7	39.0	39.4	40.9	41.0	46.7	49.6
81.7	64.2	55.9	59.7	55.3	60.9	67.0	67.2

♖a1

28.6	38.2	38.1	34.3	33.6	40.2	41.3	31.9
38.3	60.4	64.1	59.7	58.7	69.6	66.2	46.2
37.9	66.8	67.0	62.1	64.7	70.2	71.2	43.3
32.4	54.5	57.1	55.1	54.2	58.4	53.0	34.3
30.1	49.6	52.1	51.8	51.6	52.3	49.3	33.1
32.7	48.1	50.5	47.3	48.9	52.0	51.4	38.9
42.6	53.7	51.2	48.9	48.5	55.5	57.7	51.0
33.0	51.7	59.2	32.2	56.6	36.8	61.5	44.1

♔e1

27.2	21.7	11.4	19.5	19.2	11.4	21.7	24.8
35.8	28.3	39.8	21.0	18.1	29.1	20.2	37.7
35.9	17.8	23.9	19.2	24.0	10.1	22.7	36.0
35.7	29.4	19.9	9.7	18.4	25.3	34.4	37.9
42.5	24.6	27.7	19.5	10.2	28.4	30.0	38.1
44.2	50.7	29.9	37.2	33.3	36.0	42.0	45.1
51.4	45.4	46.1	45.6	46.2	43.8	51.5	51.8
48.5	92.4	53.6	61.7	50.8	62.0	58.0	61.9

♘b1

21.9		15.7		24.3		22.1	
	20.3		5.7		16.8		21.4
19.5		6.1		15.5		20.8	
	31.9		19.9		18.5		37.0
46.2		37.3		17.7		22.6	
	46.1		33.2		33.8		43.6
65.2		59.7		38.6		53.6	
	71.3		54.1		83.2		66.1

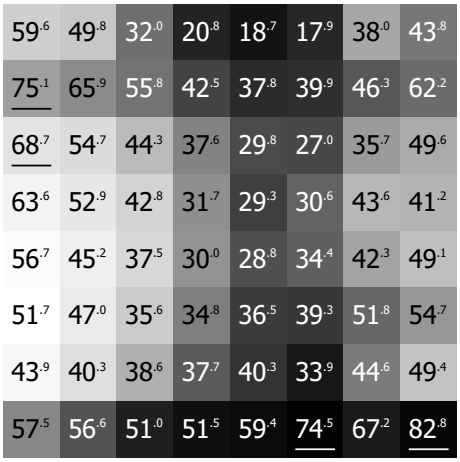
♗f1

	19.0		17.7		9.4		40.2
42.8		38.0		6.5		8.8	
	25.4		18.5		6.6		28.2
44.3		22.8		19.4		30.4	
	26.1		21.3		29.5		41.8
49.1		37.6		30.9		33.3	
	57.9		37.3		47.3		64.9
62.5		86.3		55.2		61.3	

♗c1

25.6	17.5	14.8	17.4	20.2	7.5	21.7	33.8
42.5	32.1	43.7	8.3	20.9	18.7	18.9	23.8
41.1	28.9	6.8	24.6	15.8	16.5	12.3	32.0
40.9	33.0	26.5	19.7	10.1	18.5	28.5	31.9
44.0	30.8	27.5	9.0	15.2	27.9	19.1	28.6
43.9	47.9	37.0	32.6	37.2	25.6	43.9	35.5
38.5	41.4	45.0	43.3	44.1	42.7	52.8	58.1
47.9	51.8	53.7	50.0	60.2	58.3	91.6	63.6

♘g1



Aside from admiring the groovy pictures, the data can also be used as the basis of an algorithm for playing chess. There are several things to try; we could move pieces towards squares where they are more likely to survive than die (keeping pieces alive is good), or just towards squares where they are more likely to be positioned at the end of the game (our moves are more likely to resemble real chess moves because they put pieces in their proper places). Alas, it turns out that these are bad approaches to chess, both because they are boring (most pieces are actually most comfortable in their starting positions) and because they perform badly against even weak opponents [3].

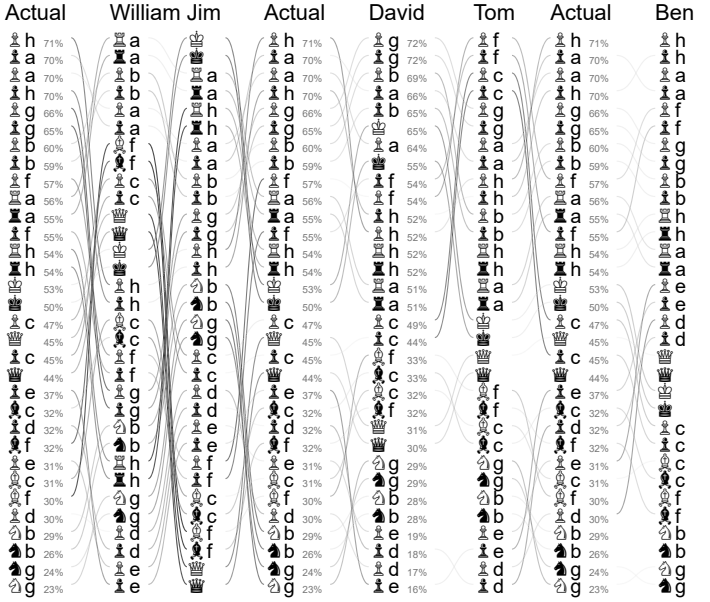


Figure 2: Piece rankings (from most surviving to most dead); either a human or hypothesis or the actual results across all games. The **actual** column appears multiple times so that each human gets a chance to be adjacent to it; this makes for the easiest visual comparison. Lines connect the same piece in adjacent columns, and are darker if the pairs have more different ranks.

4 Guesses and slices

Like all good scientific research, I explicitly compare the actual results to the hypotheses gathered before the experiment; this is an hygenic and humbling exercise. Figure 2 compares the ranking across all games (slice **Actual**) to the author author (slice **Tom**) and his drinking buddies (slices **Ben**, **Jim**, **David**, **William**). There are a number of different reasonable ways to measure the accuracy of this type of position; a very simple one is the sum of the absolute differences in rank for each piece (e.g. if in one ranking ♔is #3, and in the other #5, then this contributes 2 to the total error). By this metric, Ben has the best prediction (98 error), followed by David (138) and Tom (148). Tom and David had the most similar predictions (116) and Jim and William the most different (312). The expected error between two completely random permutations is about 341, so all of these guesses are significantly better than chance. Note in the actual ranking, many pieces have very similar survival probabilities, and many guesses are ambivalent about groups of pieces. Weighting each rank difference equally is therefore an oversimplification. It would have been better to ask each participant to give probabilities, as David did; this would give us more sensitive error metrics and more opportunities to spend the afternoon making visualizations.

Several drinking buddies gave rationales for their hypotheses (mine appear in Section 1).

Ben does not prefer to use the shift key, a typographic quirk I replicated faithfully here even though it burns my eyes:

> edge pawns almost never played til endgame let alone traded off (♙h, ♙a)
>
> not quite sure where these should go (pb more likely to see play in queenside minority attacks in k-side castle games?) (♙f, ♙g, ♙b)
>
> rook play more likely to be active on q side than on k side (also the classic Nxc7 fork in low rank play), but overall more likely to stay tucked away compared to q (♖h, ♖a)
>
> i think IQP positions are more likely than not saccing e in e4 openings but on the other hand d is often traded off in e4 openings while vice versa is not as true (♙e, ♙d)
>
> q probably involved in many checkmates (low ranked play) or resignations before traded off (high ranked play) (♕)
>
> just randomly guessing k dies in about 1/3 of games, times 1/2 for 2 sides (♔)
>
> this pawn is a super goner (sicilian, QGA, ...) (♙c)
>
> most doomed seem to be the minor pieces as i'd guess at least half of them get traded off on c/f/3/6 or e/d/4/5 in near every game so (♗c, ♗f, ♘b, ♘g)

Jim "barely understands the rules of chess" and "rarely plays." His justifications get "increasingly nonsensical:"

> Most-to-least-survival hero tier list for chess (patch 1.0):
>
> 1.: King — If I estimate that about 2/3rds of all regular pieces are captured in an average game, and the probability of any non-king piece being captured is uniform, then the king is clearly the most likely to

survive. (I'm going to break symmetry here and rank black king less likely to survive than white king.)

2. Both Rooks — Kept in reserve for castling purposes.

3. The A, B, G, and H pawns — maybe people will forget to move them because they are far from the center.

4. Both Knights — They are slippery, but they often get deep into enemy territory quickly.

5. The C,D,E,F pawns — Moved forward to release various more important pieces ⇒ more likely to die.

6. Both Bishops — https://youtu.be/gDnE-5lD7w8

7. The Queen — A high-value target, seems unlikely to survive.

David simply provided a ranking, along with survival probabilities, in typical understated style.

William notes that his guesses are "pretty much off the cuff," but provides some motivated reasoning:

> I figure the king has got to be somewhere near the middle of the pack since he dies in half of games featuring a winner—but with slightly higher-than-even odds of surviving, since some games end in a draw. I'm probably mixing up means and medians here somehow..
>
> I'm gonna assume castling happens more often on the King's side, so let's give Kingside Rook and F, G, and H Pawns a better shot than their fellows on the left. But maybe it should actually be worse, since if they die, it's because they failed to protect the king. Plus, having heard the tip about C Pawn[5] loud and clear, I'm gonna assume that bad boy most often becomes a new Queen, which means he gets more survival points than the real Queen herself.
>
> D and E Pawn are nothing but pawns, and they mostly sacrifice themselves to the cause.
>
> Randomizing within these constraints gives us our starting point. Then the wildcard Bishops and Knights get randomly distributed through what remains to come up with this final answer shown above.

4.1 Slices

The survival probabilities differ depending on the conditions of the game; Figure 3 compares some of those slices. Here the **All** slice is the same as the **Actual** column in Figure 2, and consists of all acceptable games in the database.

The **Titled** slice includes only games where at least one of the players has an official title (Grandmaster, International Master, FIDE Master, etc.[6]). These games have high-quality

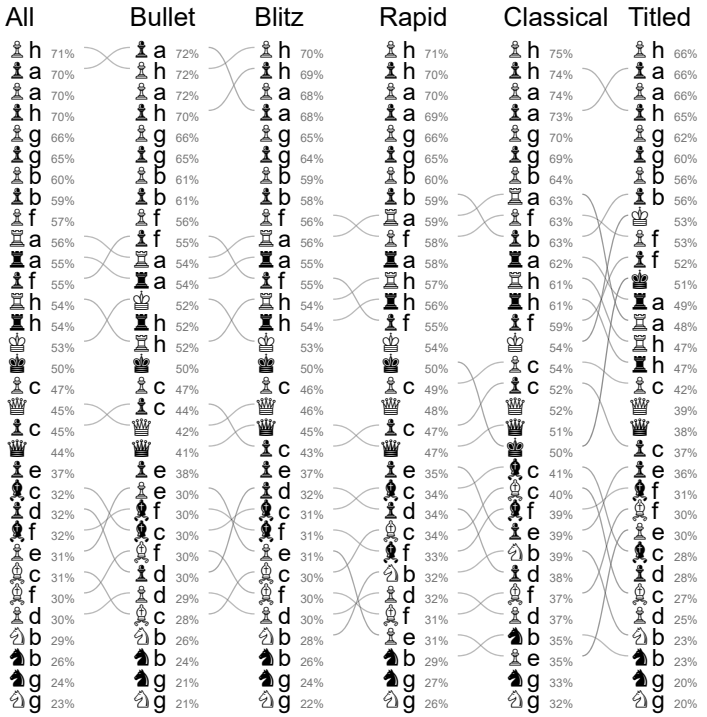


Figure 3: Ranks and survival probabilities for different subsets of games. The same piece in adjacent rows is connected to highlight differences in the ranking, as before. The time formats all exhibit similar ranking with only small perturbations. Games including a titled player (rightmost column) are the most different, although we have far fewer samples in this set, so variance becomes significant.

play, but far fewer samples ("only" 3.4 million). This set exhibits significant variance; for example, the survival rate of ♙c ranges from 38–46%. This is both because of the small sample size and the bucketization by player name; there are few enough titled players that an individual's preference in openings and style of play changes the values of their entire bucket. I caution against reading too much into this column. It seems we can at least conclude that these games tend to be much bloodier (Kings aside, survival rates are lower across the board); top players are less likely to fall for traps early in the game, perhaps more willing to sacrifice material, and more likely to play into endgames where almost every piece is exchanged. If being a chesspiece to the death, you do *not* want to have a Grandmaster playing the game!

On the other hand, the other slices all have enough samples that the variance is minimal. These slices, **Bullet** (151,261,707 games), **Blitz** (236,050,938 games), **Rapid** (98,606,558) and **Classical** (13,886,352) are different time control formats. Games on Lichess are played with a starting clock (per side) and an increment added to the clock after each player's move. The game is classified according to the estimated total time: The starting time plus 40× the increment (with the idea that an average game has 40 moves per side); this is the same formula that Lichess uses. A bullet game is when the total time per side is between 30 seconds and 3 minutes; blitz is between 3 and 8 minutes; rapid is between 8 and 25 minutes; classical is any more than this (including untimed games). Each of

[5] I believe the "tip" here was that I described the rest of us (William was the last respondant) as disagreeing most on ♙c. I think William misinterpreted this "tip."

[6] Lichess used to award the LM "Lichess Master" title to notable players on the site; this title is excluded from the sample.

these slices has enough samples that the variance is very low. Here we see that the ranking is rather stable across the range of time formats, which was not what I expected. This should increase our confidence that the results are really inherent to chess, not just the particulars of this data set.

References

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