Time and Difficulty

Artificial Intelligence and Sustainable Computing (AISC 2024)

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[1] With grateful acknowledgment to co-authors Guy Haworth and Tamal Biswas, students in my graduate seminars, and UB's Center for Computational Research (CCR)

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- **Multiple-choice tests**: m_i are possible answers to a test question, u_i = gain/loss for right/wrong answer.

Chess and Tests—With Partial Credits (Or LLMs?)

The ____ of drug-resistant strains of bacteria and viruses has ____ researchers' hopes that permanent victories against many diseases have been achieved.

- (a) vigor . . corroborated
- (b) feebleness . . dashed
- (c) proliferation . . blighted
- (d) destruction . . disputed
- (e) disappearance . . frustrated

(source: itunes.apple.com)

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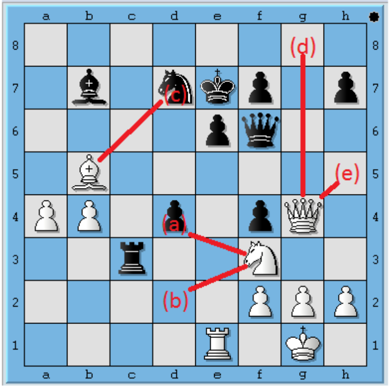

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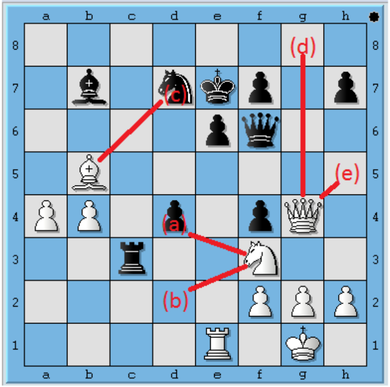

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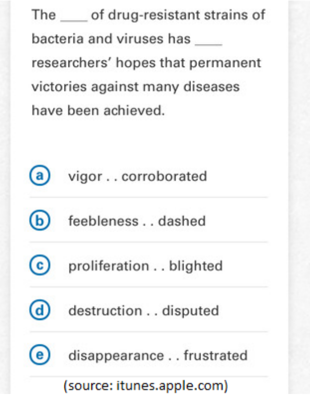

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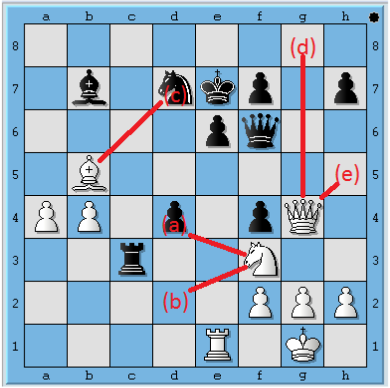

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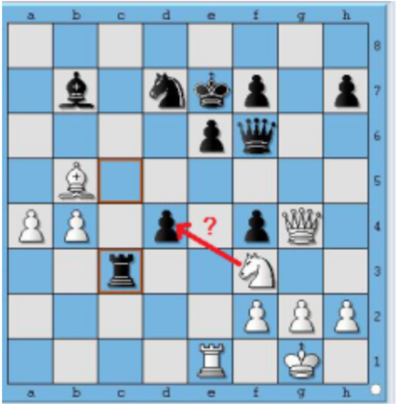
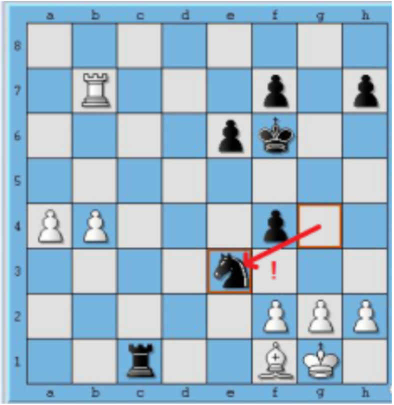
A Difficult Trap (Kramnik-Anand, 2008 WC)





Depths... Values by Stockfish 6

Move	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Nd2	103	093	087	093	027	028	000	000	056	-007	039	028	037	020	014	017	000	006	000
Bxd7	048	034	-033	-033	-013	-042	-039	-050	-025	-010	001	000	-009	-027	-018	000	000	000	000
Qg8	114	114	-037	-037	-014	-014	-022	-068	-008	-056	-042	-004	-032	000	-014	-025	-045	-045	-050
...			...			...			...			...			...			...	
Nxd4	-056	-056	-113	-071	-071	-145	-020	-006	077	052	066	040	050	051	-181	-181	-181	-213	-213

Aptitude—Via Elo Grades (calculator)

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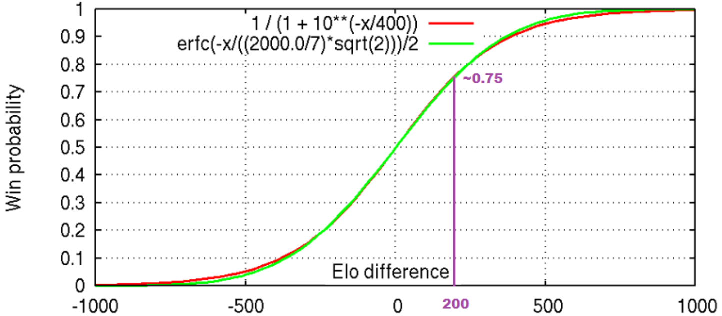
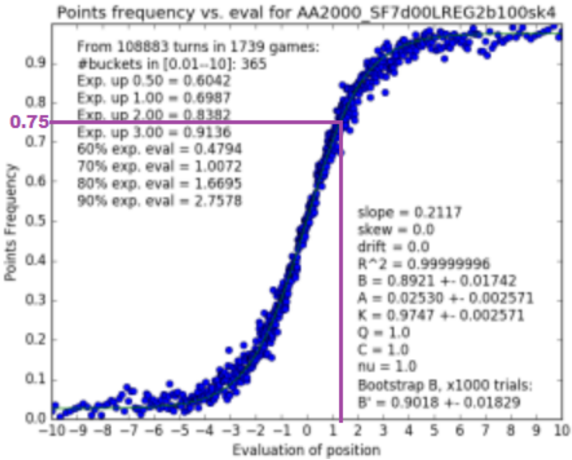
- Expectation $e = \frac{1}{1+\exp(c(R_P - R_O))}$ depends only on difference to opponent's rating R_O. With $c = (\ln 10)/400$ the curve is:



Position Value $\longleftrightarrow$ Expectation (2000 vs. 2000)



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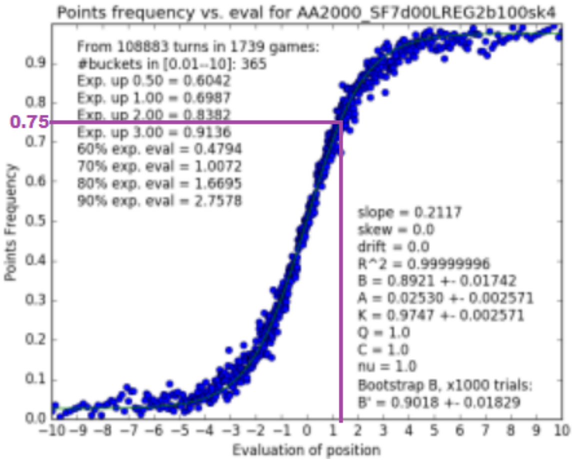

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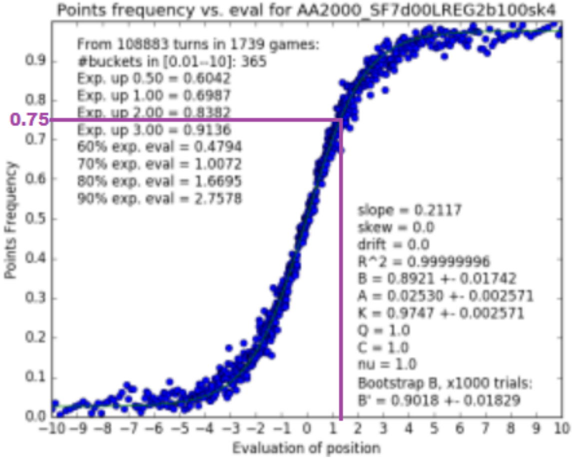

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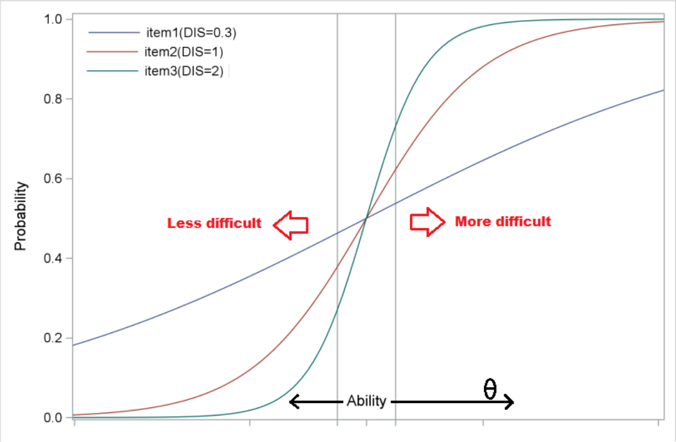
- Complication: dependence on rating itself.

Item-Response Theory (IRT source)



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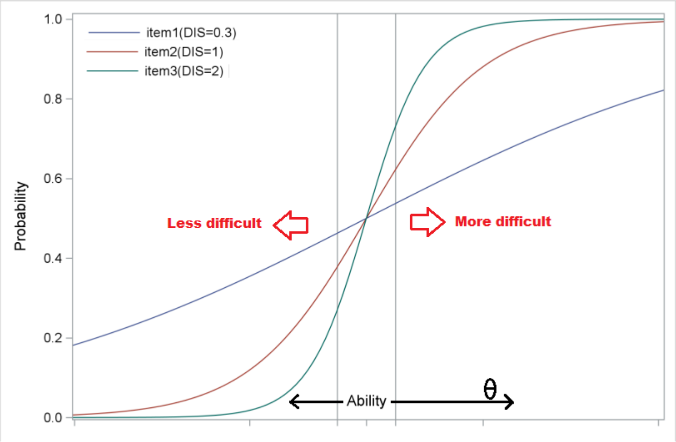

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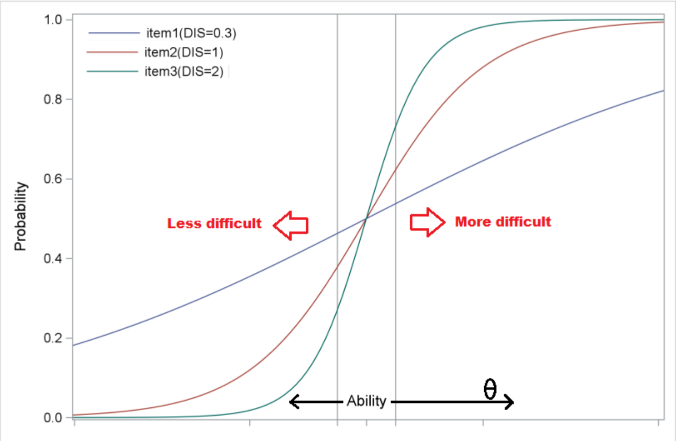

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- Slope at $y = 0.5$ *correctness rate* is the **discrimination** factor.

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- How well does hazard—normalized over aptitude—work as a measure of difficulty?

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Model and Metrics

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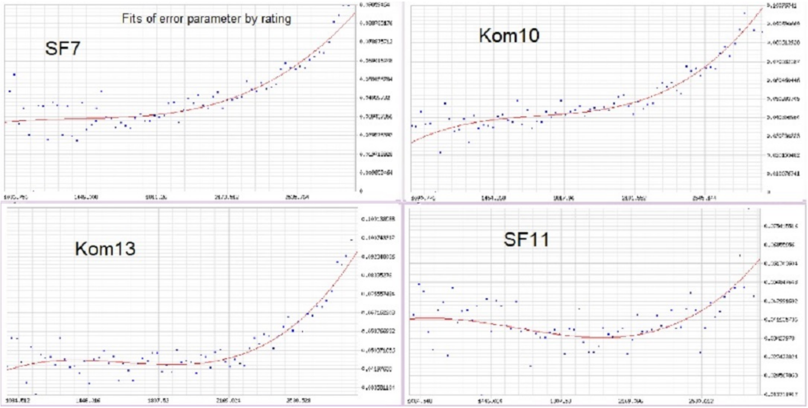
Internal evidence that it gives $\approx (1+\epsilon)$ relative error with $\epsilon \approx 0.04$ for most rating levels. Means it supports betting on chess moves with only 5% "vig" to avoid *arbitrage*. (Except for bets against clear-best moves.)



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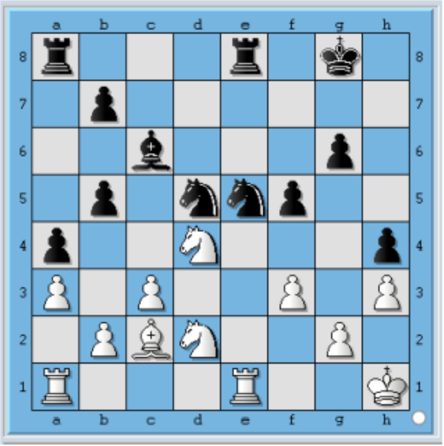
- Low-hazard positions either have an obvious best move or many good moves.

Example: Niemann-Shankland, USA Ch. 2023



Depths	1	2	3	...	18	19	20	21	22	23
Rad1	+041	+035	+029		-067	-068	-070	-070	-071	-071
Rab1	+016	+009	+021		-061	-067	-070	-070	-071	-071
Ne2	-048	-091	-040	...	-070	-070	-070	-071	-071	-071
Reb1	-030	-052	-010		-068	-070	-070	-071	-071	-071
Ra2	-003	-029	-010		-068	-070	-070	-071	-071	-071
Rf1	-029	-080	-010		-067	-070	-070	-071	-071	-071
Red1	-006	-057	-010		-067	-069	-070	-071	-071	-071
Nf1	+017	-029	-062		-080	-069	-070	-071	-071	-071
Rac1	+018	+012	+021		-067	-070	-070	-071	-071	-071
Rec1	-029	-052	-010	...	-067	-070	-071	-071	-071	-071
Rg1	-030	-044	-008		-067	-070	-071	-071	-071	-071
Re2	+008	+022	+035		-067	-069	-071	-071	-071	-071
Kg1	+021	+022	+028		-067	-069	-071	-071	-071	-071
Kh2	+022	+022	+013		-066	-069	-071	-071	-071	-071
Nxc6	-044	-044	-030		-088	-094	-086	-095	-089	-097
b3	-076	-076	-062	...	-101	-132	-120	-104	-118	-113
...										

Low-hazard because crisis is far off, but difficult in real chess terms. Low E_L, high entropy H. (Niemann lost.)

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   - Carow and Witzig [CW, Feb. 2024] consider all the above, but strive for human-chess based measures.

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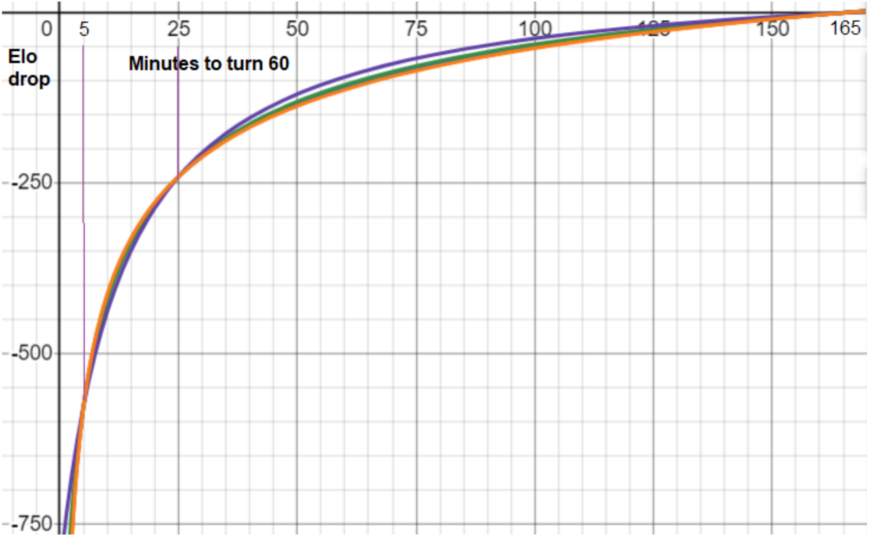
Time-Quality Curves (whole graph)



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- Vivid reproduction of [SZS 2022] (and also Anderson et al., 2016 thru now for online blitz).

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Switching to Komodo 13.3 in place of Stockfish 11 as analyzing engine:

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- Overall IPR of Elo 2000-to-2200 players: **2175 +- 35**.

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- Much more work to do...

Discussion and Q & A

[And Thanks]

[Possible extra slides for Q & A follow...optional, of course...]

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5. ...reproducibility is doubtful and arduous.

The *chess angle* is to trade 1 against wealth of 2,3,4,5: lots of players and games, real competition, clear goals and metrics (Elo ratings), and not only reproducible but conducive to abundant falsifiable predictions.

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- How can we distinguish *uncovering genuine cognitive phenomena* from *artifacts of the model*?

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7. How To Manage Time Budget (basically, follow V. Anand!).

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- **Now suppose the factual positivity rate is 20%.** Can we do this in our heads?

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- *Sensitivity and soundness generally remain separate criteria.*
- This is relevant insofar as I often get a lot of 3.00–4.00 range results.

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- Does not account for the *difficulty* of games. That is the job of the full model.

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- Show this GLL article including example of Ms. Velpula Sarayu.

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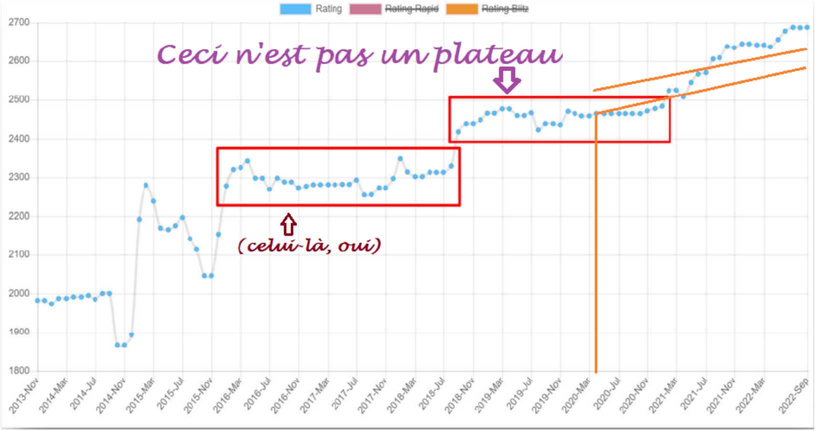
- I will now discuss some other applications that these solid foundations enable.

Hans Niemann: Platform or Plateau?



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- Picture emerging from recent youth events...?