

Cowley, M. (2016). Chess masters' hypothesis testing in games of dynamic equilibrium. *Econometrics: Econometric & Statistical Methods – General eJournal*, Jan 13, 2016. See also *Game Theory & Bargaining Theory eJournal*, Jan 13, 2016.

9. I have semi-open file h,
10. which could be leading somewhere,
11. em I can stop f5 by playing Ne7
12. but that could lead to Bb4
13. threatening to,
14. well obviously wanting to get the knight
15. in or planting the bishop on d6,
16. probably need to play c5,
17. which I can do if I have to if...
18. or next... (*time up*)

These segmented protocols were then worked through move by move and segment by segment alongside a chess board to map each move verbalized by a player for a board position. The number of segments for normal board positions ranged between 32 to 74 segments for masters and 27 to 48 segments for novices. The length for random board positions ranged between 30 to 64 segments for masters and 24 to 54 for novices. Problem behaviour graphs were constructed from each protocol indicating the order of moves and move sequences considered with their retrospective evaluations (see Appendix D for a subset of problem behaviour graphs generated).

Scoring

The data was scored in relation to the primary measure, the sorts of hypothesis tests, falsification or confirmation, that players carried out. It was also scored in relation to six search behaviour measures including, (i) first move quality, (ii) number of individual moves, (iii) search depth, (iv) search breadth, (v) and the different sorts of articulated move sequence: complete, skipped moves, base skip move, and ambiguous; (vi) point at which skipped moves occur.

To illustrate the scoring, two problem behaviour graphs are presented, one constructed for a grandmaster and one for a novice for position 1, when it is black to play in Figure 3 and Figure 4. A visual comparison of the grandmaster graph to the novice graph, illustrates their differences. The most obvious difference is the size. The master's graph has more moves than the novice's. These differences will be explored in more detail shortly.

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30. Ok lets start looking at the rook take first
31. so Bxe3
32. Rxc8
33. nothing there with the bishop yet
34. so I have to take back with the R Rxc8.
35. He has moves with the B such as Bxg6
36. but they are not really good
37. because I can always take back on f2
38. or p back on g6 I think...
39. So that's ok.
40. Bxe3
41. Rxc8
42. Rxc8
43. fxe3
44. Qxe3+,
45. Now I've got 2 pawns for the B
46. Rf2 is not good
47. because Ng4.
48. So he has to play Kh1
49. then I can but my Ng4,
50. and that leads to a very unpleasant threat of Nxf2,
51. and if in this position I can win his R for N I'll be a R and 2 pawns up.
52. And even if I drop one of the pawns I'm most likely to be better in the position
53. because he...Bxe3.

S4 Position 3: W

1. So this is from the English opening
2. and the position looks about equal.
3. I would say it looks about equal
4. it's a real even
5. so not much seems to be happening.
6. I have a real problem with the Bb2
7. which seems to be blocked
8. so ideally I would like to play d4 at some point.
9. Simply to improve the B.
10. It may not be possible right now
11. but is definitely a plan.
12. Semi-open file
13. but black is defended that and reasonably well...
14. about playing, I can Nc4
15. whether that is a big improvement is not clear
16. but then I might take back with a piece
17. and then I might take back with a pawn b pawn...
18. slightly but that's not really an improvement
19. because the Nb6 is not doing much as such
20. so, black's position is pretty solid
21. so maybe I don't have any advantage (cough)
22. so, to have to have advantage is not to be sure in this position.
23. Black on the other hand doesn't really have a threat
24. Ne6 but that's not a threat as such,
25. em perhaps one way of playing would be Nf3
26. and then at some point if I can manage I might go for e4.
27. I have to watch out for the d4 pawn...
28. something has to be done with this B (Bh2).
29. Its just sitting there doing really nothing.
30. Now the other idea would be to Nc5 maybe via e4,
31. so I can probably start by playing Ne4

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8. em better look at the material 2-4-6, 1-4-6 (counting pawns),
9. equal material
10. but that's not very important in this position.
11. God and I'm expected to come up with a move.
12. Oh, ok so how do you get at the king?
13. Hmm, Rf4
14. doesn't work
15. Bc1 can take that.
16. Nb3 covers a5.
17. It's a tricky position.
18. So ok the Rc7 not protected.
19. What can we do there?
20. Em I'm supposed to talk all the time.
21. I prefer to think in this position (laughs).
22. Ok can't find a sensible move.
23. Glad I'm not in time trouble.
24. Ok so its, if I look just logically here...
25. Rd1 any sensible move,
26. trying to get rid of that Bc1
27. then Rf4.
28. But after Rd1
29. Be3
30. hasn't really achieved anything.
31. On the other hand, ok is black really in danger of being in mate here?
32. Could be, hmm.
33. Ok if I come up with a move its because I have to not because I really like this position.
34. Em these are not my type of positions.
35. Ok Nc6
36. that would also be something
37. so Qd8
38. no
39. then Rd7
40. sacking the exchange.
41. Qa5 is covered
42. hmm very difficult em you will probably tell me that my time is up soon.
43. Ok, Rf5 is also a possibility,
44. don't ask me why,
45. hmm probably Rd1 looks most sensible
46. Be3 than Re1
47. but it doesn't really do anything.
48. At least it covers b5 with the bf4.

S1 Position 4: W

1. Well, first this position strikes me as being eh, composition straight off
2. or eh a random position
3. due to the placement of all the pawns everywhere.
4. The f pawns the 'Irish pawn centre'.
5. Also the eh...the way eh the pieces the pawns are all just the white pawns are all just atypically spread.
6. The actual position to assess, phew em quite tricky
7. because the placement of the pieces suggest that both teams are in danger,
8. they actually look quite vulnerable
9. it seems to me that the white king is in more danger...
10. eh than the black so to speak.
11. Em obviously eh obviously eh white would, white would like to play Rc5 at some point
12. eh taking advantage of the queen and king unfortunate alignment of the queen.
13. The black pieces seem more well placed.
14. The material here in the position is quite irrelevant actually

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15. from eh looking at it its actually...equal.
16. Eh the knight of course would be more useful in this kind of position
17. bishop should,
18. tends to have a more limited role.
19. So the bishop when you scale it sown essentially worth nothing
20. protected the Re6,
21. now , plans in this position might be eh...moves like f5.
22. it is white to play.
23. I need to support, to assess the kind of threats black has
24. as I said I don't see any immediate eh chances of there being eh an advantage for white.
25. That being said the Ng1 could spring into action at some point,
26. the Rf2 seems to gain control,
27. covering it as regards seeing what eh white should do in this position its quite tricky to say the least ... (keep on talking)
28. essentially its going to be difficult for white by
29. I don't see eh the winning path for black either
30. but eh all the activity suggests there maybe moves like h5
31. gxh5
32. then gxh6
33. which immediately might just win the house straight out. That eh...

S2 Position 4: W

1. Well this looks like what I would call a hairy position.
2. The king is out on the edge of the board (Kh3).
3. Risky position indeed.
4. And the black pawns are at very advanced position.
5. So, I , I'm looking in consequence at the black king
6. and I see that he is also in a very dangerous position
7. because he can't actually move the king anywhere (Kg5)
8. and he will be checked because on every square he could move to he would be walking into check.
9. So, if I could force the issue like swinging the Rc5
10. planting it in front of the queen.
11. Unfortunately its covered by the bishop (Bf8).
12. So it would be Bxc5.
13. the other alternative would be to play Nxf3+,
14. getting the queen out of the way first,
15. but unfortunately that would give black the game
16. because Qxf3 mate.
17. So, very delicately poised...
18. em another possibility would be to try bringing the rook over.
19. That doesn't seem to work.
20. So what would I move, I ... the key lies somewhere in shifting the queen off the file...
21. off the rank in front of the king
22. so I get the check in with the rook.
23. So, can I take the bishop first? (E: keep on talking)
24. ok, its all hinging around there so maybe if I could ... no move.
25. So, supposing I play my rook in front of queen...

S20 Position 4: B

1. This is certainly a most unusual position for both white and black with both kings. The position their in their absolutely the game is wild.
2. I couldn't describe it as anything else.
3. Eh: Black has queen and rook on a file (rank)
4. and a very far advanced pawn
5. which I don't think will be tenable for some time.

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6. The black king and the white king are in most disastrous looking positions.
7. So, what would I do as black.
8. Well I think obviously.
9. One is going to be attempting to force the position onto the white king.
10. Now the difficulty, again even the Rd3 is defended by the Bf1.
11. So white or black with the move at the moment could I think immediately play Qd8. now that looks like the most immediate response.
12. It threatens the rook from c7.
13. the white rook which has really eh, no where to go.
14. The white pawns of course can be advancing .
15. But I think this is the move, now play that and eh.
16. The Rb7 in which,
17. ah there's a knight up there too
18. which makes life rather difficult
19. because there was a lovely move with the queen,
20. but however, Qa5
21. would have been very nice
22. except there's a knight there so you can't do that.
23. Its very hard to see how one makes progress in this position.
24. But I think maybe on second thoughts the Qe8 might be better than Qd8
25. now this threatens the pawn
26. if there is a way of shifting something there
27. but where its going to shift to I just do not know.
28. Is there anything else in this at all... a most confusing position.

S11 Position 4: W

1. Well the first thing that occurs to me when I look at this is that it is a mirror image of the position,
2. eh, take me a moment or two to realise what colour I am.
3. I think I'm white (laughs) (E: yes that's right).
4. Em ok, I em, well first thing is my king is in a very exposed position
5. but em maybe eh black has some threats against that,
6. em my Re3 is defended by bishop at moment.
7. Maybe black could generate threats against that
8. eh by playing Rh1
9. and maybe getting the rook over,
10. well Rh1
11. threatens RxB
12. the QxR.
13. Also maybe trying something, his rook over to the em h-file
14. his king is his king is in his way but I don't see the ,
15. any immediate yes, does it? There's a threat there.
16. I'd better do something about it. I could, I'd like to be able to play Rf4 (c5)
17. that would win the queen
18. but I can't at the moment because of Bf8...
19. em, I don't see any maybe if I played em, if I play Re1 (Re8)
20. the double threat of swiping off the Bf8
21. and then playing Rf4,
22. that's a major threat,
23. so what happens if I play Re1 (Re8),
24. eh well, if bishop moves to g7...

S12 Position 4: B

1. Ok, I'm black in this position,
2. piece count 2-5-6 pawns.
3. White has six pawns two bishops, two knights (for black),

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4. so material level.
5. White has rook on seventh (Rc7).
6. Two passed pawns.
7. White's kings exposed on b4,
8. can't really move so have the potential in there for checkmate playing something like Nxc6+
9. but that loses to Qxc6++ eh,
10. I can pin the queen by playing Rf4
11. that wins the queen as
12. QxR
13. QxQ+
14. and must lead to mate.
15. Pawn up Qxp,
16. Nd4
17. to block it
18. and then the something
19. there must be a potential mate in there.
20. Em just spotted the Bc1 there on
21. and that screws up the Rf4 move.
22. Em to way of getting that in there, play something like Rxc3
23. KxR,
24. doesn't really get me very far.
25. Bishop back into play.
26. My pawn on h4 is attacked,
27. doubly attacked by queen and rook
28. so I might advance my queen pawn to g5.
29. what can white play in terms of getting me in trouble
30. with Rxa7
31. Kxa7
32. pc7
33. Na6,
34. should be paying probably more attention to my k-side defence rather than my q-side defence.
35. Em very double edged position here.
36. Looking at bishop moves.
37. My Bf8 has to be a way of taking advantage of the fact that white has no squares for his king.
38. Eh, rook move
39. Rd3
40. can I hit the queen can I move the bishop?

S13 Position 4: W

1. Em, I looked at Nxf3 immediately
2. but that's no good because that leads to mate (Qxf3++).
3. I see black's king is in a spot of bother
4. and if I can play h4
5. with h5 protected
6. its mate.
7. I'm looking at a way to em, move my king from the square
8. because he's precariously placed at the minute as well.
9. I'm thinking about Qe1
10. but I think Bc5
11. defends rook adequately,
12. I think black has the possibility of creating a passed d-pawn
13. 'cause em, the pawn is quite advanced.
14. Apply more pressure
15. and I see a threat is Bb4
16. with a skewer with the rook through d-pawn.
17. So, something I'd have to be aware of.
18. Em, so now I'm looking for a counter to that move.

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19. But perhaps I play Kb1
20. if Bb4
21. Rxd3
22. eh I think Rxd3...
23. perhaps em, I think I well ok 'cause the Qxa5
24. and I think my d2 pawn's a gonner.
25. So I don't think that leading to any particular advantage.
26. Em consider playing Bd7
27. just to defend my c-pawn
28. and the bishop
29. and consequently the rook in the long-term
30. but that's not give me any threats
31. and its also easy to play Bb4.
32. I'd look briefly at Ne2
33. but that just gets taken.
34. I can't see a good way of removing the rook..
35. especially as its on dark square
36. as I don't have a dark squared bishop.
37. I think the Rf2
38. my pawn on as is attacked twice at the minute.
39. Em I'm thinking about sacking my rook on f6.
40. I'm, also bit doubtful how that works.
41. Also possible to play Rc5
42. but its only briefly
43. because its covered by the bishop.
44. Em, I don't see any checks.
45. I like the idea of playing Qb1
46. Bd4
47. Rxb1
48. Qxa5 '
49. cause now I realise I can play Rd5
50. no I can't.
51. trying to get my queen onto the light squares
52. maybe thinking about checkmate eventually
53. on f5 with my queen there.
54. Now I'm trying to think of a way to do that now. Em, perhaps I could...

S17 Position 5: B

1. (laughing). Complicated.
2. Count pieces 1-2-3-4-5-6, 1-2-3-4-5-6.
3. Actually kind of initially like certain aspects of my position here.
4. My king is very safe.
5. Em white has a lot of weak pawns eh on the queenside
6. whereas my pawns are safe.
7. I'd be wondering what happened earlier on in the game to get tripled e-pawns.
8. But eh and actually I'm not too happy with my Na7.
9. ok so ways for me to improve my position here.
10. Em well I'd like to get my Bg6 into the game,
11. my Na7 into the game.
12. Getting the Na7 sorry Na8 into the fame,
13. the only way to do that is via c7
14. and there are particular problems with that
15. because if I play Qb7
16. which is the way to do it
17. eh then eh white plays the move that white wants to play which is Rb3.
18. So I'd like to discourage Rb3
19. or how would I do it

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20. so not eh Bh7
21. is a potential move
22. because that rook hasn't actually
23. Bh7 yea.
24. I kind of like that idea
25. because the white king is vulnerable
26. although white pieces around it n' stuff
27. so Bh7
28. when followed by kg7
29. followed by Rh6
30. followed by Qg6
31. followed by Qg5
32. looks extremely strong.
33. Actually that could be just winning.
34. Bh7 rook somewhere along the back rank.
35. Is there a particular problem with that?
36. There's certainly a problem.
37. Ah there's a problem with the whole idea
38. because eh pawn e5 will be un pres when I carry out that manoeuvre.
39. I'd have to look at precisely where the rook actually goes after Bh7
40. em it'd go to d8
41. because all the other squares whether allow me to,
42. are covered by
43. I gain tempos em now
44. I'd probably just pursue.
45. Oh the king can go to f5.
46. Perhaps a nicer way of doing it.
47. Potentially nicer anyway,
48. and black ok em wow there in this position.
49. I think Bh7 would definitely by my move.
50. 100% of the time
51. and after Rd8
52. I would definitely play either Kf5
53. or Kf(g)7.
54. Kf5
55. might have the ...to allow Rd5
56. and which could give some kind of counter play against the d5 pawn.

S4 Position 5: W

1. Gosh, what is this?
2. Lets something...its completely random.
3. Phew, I'm white so I guess I should make a move.
4. My, all my pieces are weird.
5. The only good thing I can see is my e6 pawn.
6. I think I can queen that pawn.
7. I don't think there are particularly dangerous threats which black has, now ...
8. one idea is to, a central idea is Rxf7
9. K x followed by
10. Kxc7
11. get Queen up,
12. eh probably wouldn't work at the moment,
13. now the other thing I might consider is Rf7
14. then with the same idea of playing e7.
15. Em, Rf7
16. Rx and
17. pxf7 my pawn is blocked,
18. but the good thing I might take the pawn on f5

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19. (Qxf5).
20. Still my Re7 is probably a good one so I may not do it.
21. Now if I can move my pieces somewhere closer that should help
22. but I don't think I can move them,
23. ok so I should really find something...now so.
24. The material is level that's a good thing.
25. Oh well all my pieces should be probably better,
26. I have equally bad pieces
27. but I have at least a passed pe6.
28. em, centre Re8 and then
29. e7 perhaps,
30. now that's that's it. Am I finished? I am finished now phew.

S8 Position 5: B

1. Hmm, really wonder what this test is about? (laughs).
2. Ok an unusual position
3. and, more sensible than the last one,
4. black to move
5. although black looks like he's got a good pawn.
6. King is in a cage
7. but doesn't seem to be in danger immediately.
8. Pawn d3 looks very promising.
9. How do you get at it that is the question.
10. Ok, eh what's the plan?
11. Ok white, hmm ok Qb7
12. could be an idea try to get in on the second rank
13. and once the rook has moved
14. just play d2
15. followed by d1!
16. Does white have any threats?
17. Not really.
18. Pawns are weak, not going anywhere.
19. Ok the Ne/a8 not doing anything either.
20. Qb7 might be sensible
21. any way to get at the king,
22. h-file yea but that takes a long time.
23. Get rook out,
24. bishop out Kf5
25. looks quite safe.
26. Could get the king maybe,
27. the queen to h-file
28. and then try to mate with Qh4
29. but there are too many pieces in the way.
30. A more prophylactic approach is probably to play Qb7
31. Qb1/b2
32. then Rd1
33. just to get rid of knight on c1
34. and then queen the pawn.
35. Alternatively Kf5
36. followed by Qb1
37. d1
38. Qg4
39. could also be a good idea.
40. em yea, yea Qb7 looks like the move that I would play in this position.

S1 Position 5: W

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1. Ah, ok here we have another extremely unclear position
2. which is actually possible to occur....
3. Well likely... well anyway the actual position as I see it.
4. Once again the kings are in very compromised positions.
5. Black is more active than white,
6. white seems to have more immediate position plusses.
7. The Rd7-e7 em
8. what white needs to do there is to somehow... untangle his forces on the kingside seems to be maybe to do...
9. the actual opportunity where for instance where eh... moves such as Kc4
10. followed by c3
11. is not immediately observable
12. should actually... perhaps with the idea of b5
13. followed by Kb4
14. em would be interesting
15. as em the R +
16. the queen then would come into the play on the third rank.
17. And while the king is on b4
18. c4 would be possible
19. followed by c5+
20. em king forced a7
21. and after a move like Rd8...
22. em mate
23. or check on the a-file
24. it would be mate...
25. even b6 +
26. px
27. px
28. Kx eh
29. Rc3
30. followed by Rc6+
31. sacrificing rook
32. bring the queen in in some lines,
33. but that being said... instance Kb5
34. c4
35. c5+
36. Rxc7
37. right were black as black do anything to counteract this?
38. Ideally, if playing b5
39. black could...
40. why I like the idea of playing b5
41. is black had looked to take advantage of the weakness on the dark squares...
42. by just opened up such as eh eh by playing Qa8 to a5+
43. with the queen misplaced on the other side of the board,
44. and it doesn't look like its going anywhere fast...
45. but there is the threat of the h-pawn
46. em but perhaps key to blacks defence of this position is actually after b5
47. to play a move like Ka5
48. to stopping the idea of Ka4
49. it looks quite absurd...
50. but maybe it is not as stupid it looks...
51. unless if white was to take on b5...
52. then Rxc7
53. would surely give a big advantage to white
54. followed by Rc4...
55. Rb4+
56. and just eh...
57. Bc4+ clearly be,

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26. I can then re- deploy my Re6 to em h6...

S12 Position 5: W

1. Ok, very complicated position here.
2. Lots of pawns 1-2-3-4-5-6, white six pawns.
3. White Nh1 Qh3.
4. Rook stuck up there on e7.
5. Eh black has Rb1.
6. King exposed although maybe not that bad.
7. This position here does not look good.
8. Black has pawns on f-file.
9. Ok they're doubled
10. but they're eh fairly clean run through to promotion.
11. Same could be said about my pe6
12. eh what how can I advance that.
13. Rook supporting it.
14. Immediate danger is from my perspective bishop moves
15. Bxd4+,
16. ... Rxe6
17. pxN,
18. black isn't going to play that,
19. bishop into play
20. Rook Bishop out to get his bishop active
21. drop that...
22. potential moves for white
23. Rf7
24. RxR
25. pxR
26. no and queen just wins that back
27. em, Rf3 attack pawn
28. what against it can be done.
29. Rf3
30. Nf2
31. knight active,
32. Ra1
33. Bxd4
34. RxB
35. back pawn up pf3
36. white's Nf8 is fairly inactive...
37. Ng6 to hit my rook.
38. Where does my rook got then, Rxc7...

S13 Position 5: W

1. Em, ok I see I've got tripled pawns on the d-file.
2. I see I've got a protected e-pawn on e6.
3. I would consider playing Rxf2 (c7)
4. I'm also considering playing Ba4
5. at some stage.
6. Ba4 em,
7. ... just think that's a good square for the bishop.
8. I'm thinking about playing Ba2 em,
9. perhaps that's a little pointless.
10. I think about playing Kc4
11. with the idea of Rc3
12. and then Kd3.

