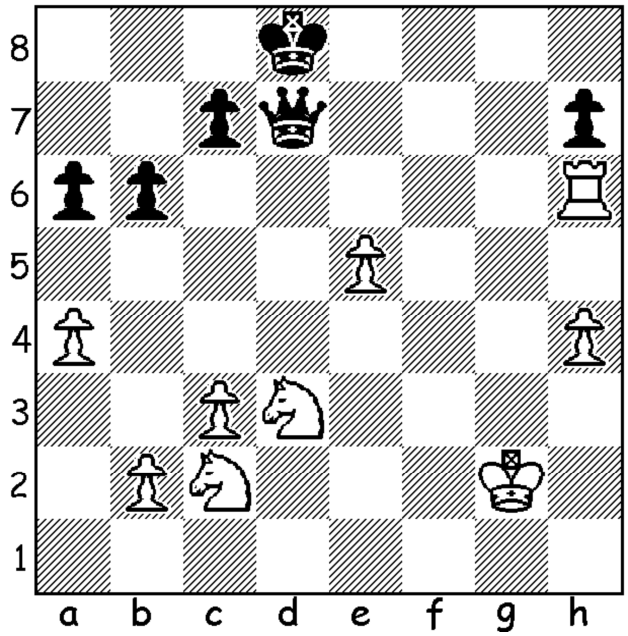
As noted, in order for human chess players to avoid having to calculate excessively large numbers of variations, they have to restrict the possible moves they examine in depth. In order to do this, they have to bracket off groupings of pieces on the board that are less central to their main focus. The player needs to treat some groupings of pieces on the board as semi-permanent units, like complex objects, which have no direct bearing on the task in hand. If the immediate task is, for example, to find a direct sacrifice to expose the opponent's king to a possible mate, then the player may ignore pieces on the other side of the board, at least in a temporary way, while exploring the initial sacrificial possibilities.

An example here will illustrate what I mean, and clearly shows the difference between the way computers "think" or compute in chess, and the way that humans explore the tactical possibilities in positions.

This is from a very interesting endgame study by Mihai Neghina, first posted on the internet in 2009. The position was initially published without a solution, accompanied by the claim that computers were unable to evaluate the position correctly.

D 12 Neghina Endgame Study position (version). White to play and win.



This position is a forced win for White. However, even after some introductory moves, the computer wrongly calculates that Black has a winning advantage:

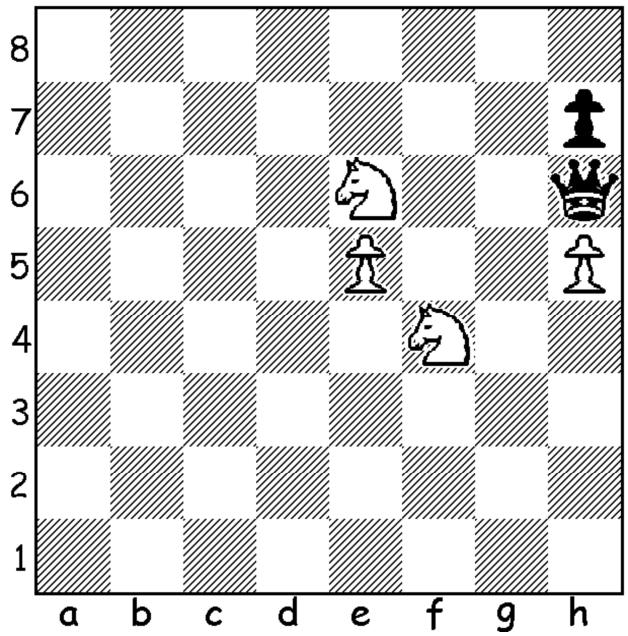
1 Nd4 Qg7ch
2 Kh3 Qxh6
3 Nf4 Kc8
(Because of the threat of a knight fork on e6, if the knight on f4 is captured)
4 Nde6 Kb7
5 h5

Black has a queen for two knights and a pawn, normally a winning advantage for the side with the queen. The computer's verdict on this position is that Black should be able to force a win. But what the computer cannot do is assess the position in the way

that a human can, as involving a piece complex in which the Black queen will be trapped, and out of play - a key idea that the human player can trade on - and hence work out that it is White who has the advantage.

Here is the key trapping position, reduced to its bare elements.

D 13



The Black queen can make 8 moves in all, but they will all lead to her capture. It is very difficult to programme a computer to disregard this complex - at each move the computer will calculate these 8 possibilities, and their further ramifications, including over twenty possible replies by the White knights and the king. The possible variations multiply up to such an extent that they exceed even the computer's capacity for calculating billions of different positions.

The human player thinks differently. He, or she, can conceptualise the array on the right-hand side of the board as a semi-permanent object. The trapping piece-complex is treated as a stable unit. It can be imagined as a separate object, one that does not affect the play.

If the complex is treated in this way, it then becomes easier to ignore it when calculating the main lines, and analysing the best play for both sides. This results in White winning a crucial pawn on the queen side, so as to reach a won ending. The central variation continues: 5...c5 6 Kg4 c4 7 Kf5 Kc6 8 Ke4 b5 9 axb5ch axb5 10 Kd4 Kb6 11 Kd5 Ka5 12 Kc5 Ka6 13 Kc6 Ka5 14 Kb7 b4 15 Kc6 bxc3 16 bxc3 Ka4 17 Kc5 Kb3 Kd4 Kc2 19 Kxc4 and wins. It is only near the final stages, after around 10 or so moves, that the computer begins to assess the position correctly, as a win for White.[12]

There are two morals to be drawn from this example. Firstly, with respect to the differences between the way that humans and computers think, the fact that humans

[12] For discussion of this endgame study, see Josten (2010).

are able set aside piece-complexes, treating them as irrelevant to the immediate focus of play, shows something important about their imaginative resources.[13] Here the imagination works in a negative manner, by restricting the assessment of future possibilities, and by treating the trapping position as a fixed unit, removed from the immediate scene of action. The future possible moves within the piece complex are, as it were, "suspended" and removed from consideration by the player, at least on a temporary basis.

Secondly, it is a phenomenologically important fact that the structure which is treated by the player as a relatively stable object is a complex spatial structure. This structure can be interpreted as a high-level property of the chess game, and illustrated by a concrete arrangement of pieces on a board, but its essence is nevertheless something abstract and formal.

9 Implications and Applications

To summarise what I have argued so far:

1) The imagination is exercised in different ways in chess. At the basic level, each piece is understood in terms of its spatial role. Players also exercise the imagination in further ways, in thinking through tactical sequences and assessing strategical possibilities, and in recognising larger structures, piece groupings that have different degrees of permanence and complexity.

2) A player's grasp of a chess position is based upon an implicit or explicit awareness of the potential moves open to each piece: players envisage the different transformations of the position that will result from possible legal moves, generating different spatial arrangements of pieces.

3) In thinking about a given position the player is *guided* by the representation of the position, either through seeing the qualitative aspects of the pieces on the board, or in imagining the positions of pieces when playing blindfold.

4) In a stricter sense, what the chess player grasps is an abstract model, a purely formal structure devoid of any intrinsic qualitative aspects, which is distinct from any concrete representation of the position reached in the game. In playing chess the player is dealing with what is at one level something purely mathematical: an abstract spatial structure governed by formally specifiable rules. Such structures are represented, for greater convenience, by arbitrarily chosen shapes on a board with a certain spatial configuration.

5) Yet the manner in which a good player responds to a chess position extends far beyond a grasp of its abstract spatial character. The arrangements of pieces on the board have phenomenological significance, and carry emotional charge. Although its essential aspects are purely formal, a chess position is seen as being richly meaningful.

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[13] I am ignoring other differences between humans and machines that relate to the content and interpretation of chess moves, and the like. It is, of course, arguable that this constitutes a further dimension in which humans and computers differ.