L AST DECEM-BER 5, a group of researchers from the DeepMind project, an artificial intelligence company acquired by Google in 2014, registered in the archives of Cornell University (New York) a report announcing that their AI program "AlphaZero "had managed to defeat, starting from scratch and in just 24 hours of self-learning, the world champion programs in games of go, chess and shogi.

The news quickly spread to the media. The technology page of the BBC website published the following day: "Google's 'super-human' DeepMind AI claims chess crown" and the British newspaper "The Guardian", entitled: "AlphaZero AI beats champion chess program, after teaching itself in four hours."

The media pointed out that the Google program "AlphaZero" (hereinafter AZ), based only on the knowledge of the basic rules of chess, and after training playing with itself a few hours, clearly defeated "Stockfish 8" (hereinafter SF), one of the strongest programs of today, in a match of 100 games, that the self-taught algorithm of the Californian company won with 28 wins, 72 draws and no losses.

GM Miguel Illescas

ALPHAZERO ¿Machines or gods?

Google's Artificial Intelligence learns chess and, in a few hours, defeats Stockfish 8

After playing 44 million games of training for 9 hours, AlphaZero destroyed Stockfish in 13 out of 100 games, 12 of which were forced to play on a specific opening. In the encounter with free openings aloud AlphaZero won +28 = 72 -0

13 March 2016

A few months after having established an absolute superiority over humans in the until recently unattainable game of go, the algorithm of DeepMind surpassed itself, become a new version more powerful and versatile, able to learn and reach superhuman levels in almost any game, completely self-taught, by the procedure of facing against itself. After the success in Go and Chess it was the turn of Shogi (Japanese chess).

FM Mike Klein said on chess.com: —*What do you do if you are a thing that never tires, and you just mastered a 1400-year-old game? You conquer another one. After the Stockfish match, AlphaZero then "trained" for only two hours and then beat the best Shogi-playing computer program "Elmo."*

The original report -pending to be validated in the scientific field- presents the experiment as it follows:

—*"The game of chess is the most widely-studied domain in the history of artificial intelligence. The strongest programs are based on a combination of sophisticated search techniques, domain-specific adaptations, and handcrafted evaluation functions that have been refined by human experts over several decades. In contrast, the AlphaGo Zero program recently achieved superhuman performance in the game of Go, by tabula rasa reinforcement learning from games of self-play. In this paper, we generalise this approach into a single AlphaZero algorithm that can achieve, tabula rasa, superhuman performance in many challenging domains. Starting from random play, and given no domain knowledge except the game rules, AlphaZero achieved within 24 hours a superhuman level of play in the games of chess and shogi (Japanese chess) as well as Go, and convincingly defeated a world-champion program in each case."*

While the attention of the chess world was focused on the London super-tournament, the news about AlphaZero spread like wildfire in the specialized media, and soon the impact was huge. Experts and amateurs wondered how such a feat was possible.

The original report included ten games - all AZ victories - that were soon dissected and analysed endlessly by dozens of YouTubers and teachers of higher or lower level, throughout the Internet. For the most part, the commentators praised the play of AZ to worship. The Spanish GM Paco Vallejo immortalized in a tweet the feelings of the chess community:

We analyze this brilliant game at the end of the article, along with other selected games and fragments.

> *"We've been playing chess for 600 years and apparently it only takes 4 hours. It's scary."*
>
> **V. Anand**

> *"I'm pretty sure not even God could beat Stockfish like this without any odds."*
>
> **H. Nakamura**

It is easy to be impressed by quotes like this one and on the internet, we saw bombastic statements.

In pursuit of objectivity, it is worth asking: was it really that impressive? Are we not exaggerating?

Is AlphaZero so superior to Stockfish?

Some experts criticized the way of carrying out the experiment, questioning the scientific validity of it, and even questioning the announced superiority of AZ over SF.

There were two factors most criticized, and quite rightly in the opinion of this commentator, although this does not diminish brilliance or merit to the impressive feat achieved by AZ.

In the first place, the time control, 1 minute per game, typical of go, seemed very inappropriate for chess.

Members of chess.com interviewed Tord Romstad, one of the creators of SF, who said: — *"The match results by themselves are not particularly meaningful because of the rather strange choice of time controls and Stockfish parameter settings: The games were played at a fixed time of 1 minute/move, which means that Stockfish has no use of its time management heuristics (lot of effort has been put into making Stockfish identify critical points in the game and decide when to spend some extra time on a move; at a fixed time per move, the strength will suffer significantly). The version of Stockfish used is one year old, was playing with far more search threads than has ever received any significant amount of testing and had way too small hash tables for the number of threads. I believe the percentage of draws would have been much higher in a match with more normal conditions."*

Secondly, and not least, SF was deprived of access to the book of openings and the tablebases, integral parts of the program. While AZ benefited from the theoretical knowledge acquired in his training, which, as we shall soon see, was extraordinary, SF fell in the openings in elementary strategic errors, as in the well-known position of the Petrosian's Sacrifice line (7.d5) of the Queen's Indian Defence.

Any opening book will tell us that we must liberate black's play with 11 ... d5, while **11…♗f6?** is a serious mistake, since after **12.♘d6** lBlack is strategically lost, with insuperable difficulties to develop the queenside (*RN: see article of games*).

The bad play of SF in some openings is not an obstacle to recognize the formidable achievement of AZ. To reach a high level in chess in so few hours, and without external help, is really something futuristic. How could it be achieved?

Objective data from the scientific report

For a better understanding of how it was possible, we recommend reading the original report, although it can be a bit tedious, since there are 19 pages with a lot of technical jargon.

It turns out that instead of 100 games between AZ and SF, 1,300 games were actually played, distributed in 13 matches of 100 games each, 12 of them with a thematic opening and the last one with free opening, whose result was the one that transcended to the media.

The 12 thematic positions were chosen by the DeepMind team, based on their frequency in human practice.

> *"I always wondered how it would be if a superior species landed on earth and showed us how they played chess, Now I know."*
>
> **PH. Nielsen**

Diego Rasskin Gutman
Scientist and author of the book "Chess metaphores"

AlphaZero does not know how to play chess. Nor did it know when it began its scarce hours of training playing against itself, nor did it know after beating Stockfish in an extraordinary fashion. What's going on? Creating a generic neural network whose architecture is capable of learning to solve many seemingly complex problems after adequate training, improving the skills of humans and the best expert systems, is an impressive scientific triumph.

There are two things I would like to point out. In the first place, that the architecture of networks, a crude metaphor of the biological functioning of our brain, is very effective when training a problem-solving system from scratch; this constitutes the essence of AI as a science and, until the emergence of deep neural networks, was a matter that simply could not be achieved.

The technical ability helps to prune the tree of possibilities simply by calculating conditioned probabilities. In the second place, the possibility that the problem, playing chess, is not such a complex issue, but that our human way of approaching it makes it look like it; After all, it is based on a few simple rules. I think it would be desirable for the authors of Alpha Zero to release all the games starting off with the first ones, necessarily random, to know how it learned to settle between good and bad play and, above all, what kind of game phases had to go to get to be a chess monster of such calibre.

This process of learning and discovery can make us face the edge of a new paradigm in our poor, human understanding of the game.

GM Garry Kaspárov
(Interview on chess.com)

It is a remarkable achievement, of course that was to be expected after AlphaGo. It brings to chess the "human B" approach, more human, with which Claude Shannon and Alan Turing dreamed, instead of brute force.

We have always taken for granted that chess required too much empirical knowledge for a machine to play so well from scratch, without adding any human knowledge. Of course, I would love to see what we can learn about AlphaZero's chess, because that is the great promise of machine learning in general: that machines decipher rules that humans cannot detect.

Demis Hassabis: *One of AlphaZero's fathers was a chess prodigy. At age 14 he only had Judith Polgar ahead of him, but he retired to start his own videogame company at the age of 16, and then finish his studies in computer science and neuroscience. In 2010 he founded DeepMind, sold to Google in 2014 for 500 million dollars*

Of great interest to readers will be the article "The Openings of AlphaZero", included in this issue, where you can examine the total statistics recorded in each line tested and weigh the amazing conclusions that we have reached. This author understands that the few hours dedicated by AZ to chess can be a revolution in the field of openings, especially if Google releases the 1,300 games played.

On the other hand, talking about 4 hours of training may be misleading. First, because the report actually declares 9 hours, but the most important thing is the enormous power of the hardware made available to AZ.

This allowed AlphaZero to play with itself nothing less than 44 million games! If we take into account that in the Mega2017 database there are barely 7 million, 200,000 of them among masters, we will understand that in a short space of time the Google machines generated an overwhelming knowledge of chess.

How does AlphaZero play?

MF Mike Klein explained it with a sense of humor on chess.com: —""*Oh, and it took AlphaZero only four hours to "learn" chess. Sorry humans, you had a good run. This would be akin to a robot being given access to thousands of metal bits and parts, but no knowledge of a combustion engine, then it experiments numerous times with every combination possible until it builds a Ferrari.*". We will see that it is not exactly like that, but the metaphor is useful to get an idea of the totally different way of thinking used by AZ, which brings out the word "alien", a poetic license, because AZ is a work of the human race.

To shed light on the matter, we will publish in the next issue the complementary article "How does AlphaZero play chess".

There were actually 1,300 games played, divided into 13 matches of 100 games each, 12 of them with a thematic opening and the last one with free opening choice.

We advance a conclusion and a reflection on this. The analysis of the material and the metodological approach described in the report, make possible to ensure that **AZ's way of playing is much more "human" than that of SF or any of the existing programs to date.** In several of the games provided, AZ sacrifices material for a long-term advantage, as masters do. In addition, once the learning process was completed, AZ only needed to consider 80,000 moves per second to beat SF, which could calculate up to 70 million. A selective search based on what was learned, which is very reminiscent of the one applied by humans, particularly Grandmasters.

Is chess that easy?

When we talk about the complexity of chess, the data arises according to which the number of games possible would be approximately 10120, a really immeasurable figure. Of course, that would be moving the pieces randomly. How many games are possible if there is a coherent play? Obviously, many less.

We have already mentioned that all the human chess knowledge accumulated in five centuries can be summed up in 200,000 valuable games. Let's say that there are a million relevant games, with opening books and ending books and all. With an average of 50 moves per game, we would have a total of 100 million positions (in reality, quite less, because of the transpositions). It is a relatively affordable number for modern engines. If we take into consideration that there are only 32 pieces and 64 squares, we will get a manageable number of possible moves. Such an "affordable" magnitude for the silicon entities.

So far no one and nothing had been able to manage such amount of information, but AZ did it with the use of powerful neural networks.

> *AlphaZero trained for 9 hours by playing 44 million games against itself.*

Juan José Gómez Cadenas
Scientist and science fiction author

Perhaps the most interesting thing of the recent and controversial victory of Alpha Zero over Stockfish, is the fact that the same neuronal network that constitutes "the brain" of the new champion can be trained to drive a car (Google Car), diagnose diseases or recognize the natural language (Watson, IBM). AlphaZero not only surpasses us humans (and other machines) playing chess. It is the first step in a world in which artificial intelligences will begin to displace humans in areas that until recently seemed to be untouchable. As in chess, the future that is coming will not be exclusively human, but we will have to share it with our own creations.

Thanks to the learning process, AZ manages to estimate in each moment with great reliability what are the moves with greater probability of scoring.

Maybe chess was not so difficult after all? Maybe our engines will soon overcome any previous expectations and show us how weak we are? Just like what happened a little more than 20 years ago, when I was part of the Deep Blue team that beat Garry Kasparov, I feel that today we are reaching a new milestone, which will end in a scenario with thinking engines and will open an exciting stage of unpredictable consequences for the future of the human race.
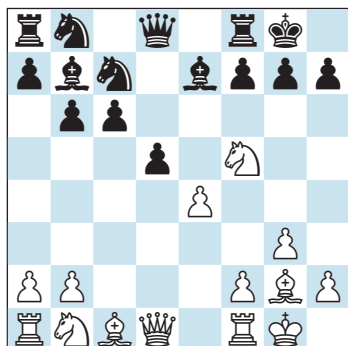
Extra contents in the PDR blog

- *Original report in PDF.*
- *PGN viewer with the 10 commented games.*
- *Video explanations of the key moments.*
- *Links to interviews and relevant articles.*
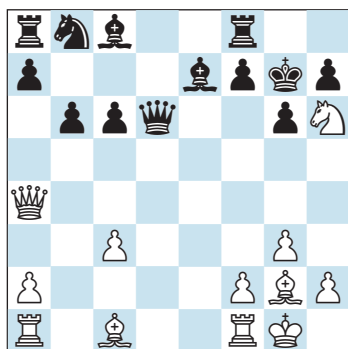
AlphaZero - Stockfish 8

1.♘f3 ♘f6 2.d4 e6 3.c4 b6 4.g3 ♗b7 5.♗g2 ♗e7 6.0–0 0–0 7.d5 exd5 8.♘h4 c6 9.cxd5 ♘xd5 10.♘f5 ♘c7 11.e4 d5

12.exd5!? It could be an important novelty in a position where everybody plays 12.♘c3 or ♖e1.

12...♘xd5 13.♘c3 ♘xc3?! With more time for thinking, analytical modules prefer. 13...♗f6 which transposes a very well-known variant.

14.♕g4! g6 15.♘h6+ ♔g7 16.bxc3 ♗c8 17.♕f4 ♕d6 18.♕a4

White Queen moves are very subtle in this game and would require complex explanations to make them understandable to the common people. Now it follows a bold movement of the black pieces, which objective is to move back the opponent knight.

But AZ will play without respite and will reply by sacrificing a piece similar to Mijail Tal's style, a long term strategy only seen in human intelligence until now.

18...g5 19.♖e1!! ♔xh6 20.h4! It calls people attention that, from now on, some computing programs, like Komodo 11, see the white advantage after a reasonable time of thinking. Which is not the case of SF which considers the position as balanced. **20...f6 21.♗e3 ♗f5 22.♖ad1 ♕a3 23.♕c4 b5 24.hxg5+ fxg5 25.♕h4+ ♔g6 26.♕h1!**
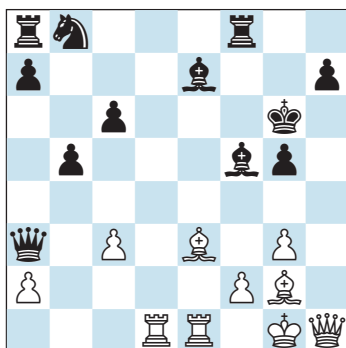
This manoeuvre is the one that draw Vallejo's attention. White pieces keep playing calmly despite having one piece less, and will reject, one after the other, the possibility of playing for a tie.

26...♔g7 27.♗e4 ♗g6 28.♗xg6 hxg6 29.♕h3 ♗f6 30.♔g2 ♕xa2 31.♖h1 ♕g8 Black pieces defend themselves tenaciously, and enjoy from a big material advantage, with one knight and two pawns more. But, any GM will say that black pieces are bound to lose, hence they have one rook less and the King very exposed. Next AZ's move is from another world, but easy to explain. It is about limiting the activity of the black Queen through the diagonal g8–a2 and open, even more attack lines against the opponent King.
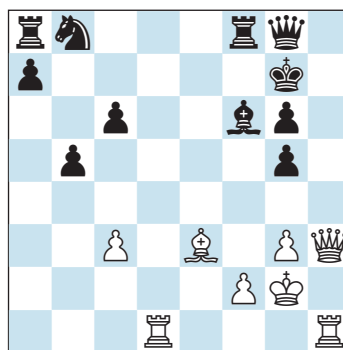
32.c4!! ♖e8 32...bxc4 follows 33.f4! and the white attack is decisive. **33.♗d4 ♗xd4 34.♖xd4 ♖d8 35.♖xd8 ♕xd8 36.♕e6!** Nobody said that the victory would be easy. White pieces keep dominating the game while pressing hard the siege over the opponent King. Confronted to the deadly check in e5, SF has no other option that give pieces back. **36...♘d7 37.♖d1 ♘c5 38.♖xd8 ♖xe6 39.♖xa8 ♔f6 40.cxb5 cxb5** And the victory of the white pieces is a matter of (good) technique execution. **41.♔f3! ♘d4+ 42.♔e4 ♘c6 43.♖c8 ♘e7 44.♖b8 ♘f5 45.g4 ♘h6 46.f3 ♘f7 47.♖a8 ♘d6+ 48.♔d5 ♘c4 49.♖xa7 ♘e3+ 50.♔e4 ♘c4 51.♖a6+ ♔g7 52.♖c6 ♔f7 53.♖c5 ♔e6 54.♖xg5 ♔f6 55.♖c5 g5 56.♔d4 1–0**

AlphaZero - Stockfish 8

1.♘f3 ♘f6 2.c4 b6 3.d4 e6 4.g3 ♗a6 5.♕c2 c5 6.d5 exd5 7.cxd5 ♗b7 8.♗g2 ♘xd5 9.0–0 ♘c6 10.♖d1 ♗e7
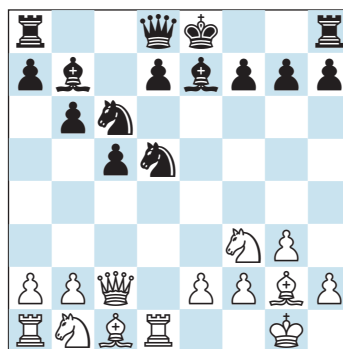
**11.♕f5** Elite players gave away this one and prefer here 11.♕a4 but it is very likely that after this game, things could change. **11…♘f6 12.e4 g6 13.♕f4 0–0 14.e5 ♘h5 15.♕g4 ♖e8** The issue is 15...♕b8 which leads to huge complications, such as: 16.♘c3 ♘xe5 17.♘xe5 ♗xg2 18.♘xd7 ♕b7 19.♘xf8 ♘f6! 20.♕h4 ♗h1 21.f3 ♗xf3 22.♖d2 c4 23.♘d7 ♖e8 24.♖f2 ♗c5 25.♗e3 ♗xe3 26.♘xf6+ ♔f8 27.♕h6+!? ♗xh6 28.♖xf3 ♗xf3 29.♘xe8 ♔xe8=

16.♘c3 ♕b8 17.♘d5 ♗f8 18.♗f4 ♕c8 19.h3 To avoid 19...d6.

19…♘e7 19...d6 20.exd6! ♕xg4 21.hxg4 ♘xf4 22.gxf4 ♖ed8 23.d7! ♗g7 24.♗d2 ♗f8 25.♘c7 ♖ab8 26.♖e1!

20.♘e3 ♗c6 21.♖d6 ♘g7 22.♖f6 ♕b7 23.♗h6 ♘d5 24.♘xd5 ♗xd5 25.♖d1 ♘e6 26.♗xf8 ♖xf8 27.♕h4 ♗c6 28.♕h6 ♖ae8 29.♖d6 ♗xf3 30.♗xf3 ♗a6 31.h4 ♕a5 32.♖d1 c4 33.♖d5 ♕e1+ 34.♔g2 c3 35.bxc3 ♕xc3 36.h5 ♖e7 37.♗d1 ♕e1 38.♗b3
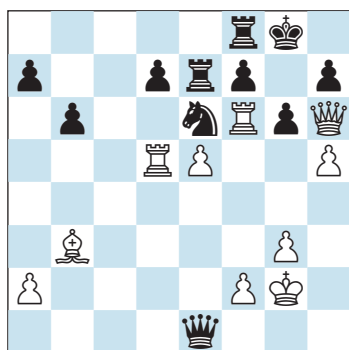
38…♖d8?!
Was better 38...♕e4+! 39.♖f3 *(39.♔h2 ♖fe8 40.♕d2 ♕g4 41.♗d1 ♕e4 42.h6 ♖c8)* 39...♖c8! 40.♕d2 g5 41.♖xd7 g4 42.♖xe7 gxf3+ 43.♔h2 ♕e2 44.♕d7 ♕xf2+ 45.♔h3 ♕f1+ 46.♔g4 ♖c4+ 47.♗xc4 ♕xc4+ 48.♔xf3 ♕f1+=

Nor is it worth 38...♖c8? 39.♖xd7 ♖xd7 40.hxg6 ♕e4+ 41.♔h2 hxg6 42.♗xe6.

39.♖f3 ♕e4 40.♕d2 ♕g4 40...g5? 41.♗c2! ♕g4 42.♗d1! ♕e4 43.♔h2.

41.♗d1 ♕e4 42.h6 ♘c7 43.♖d6 ♘e6 43...♕xe5? 44.♖e3 ♕g5 45.f4.

44.♗b3 ♕xe5 45.♖d5 ♕h8 45...♕a1 46.♖c3 and the black Queen has problems. Or 45...♕c7 46.♖fd3 ♘c5 47.♕c3! ♘e6 48.♕f6, winning.

46.♕b4 ♘c5
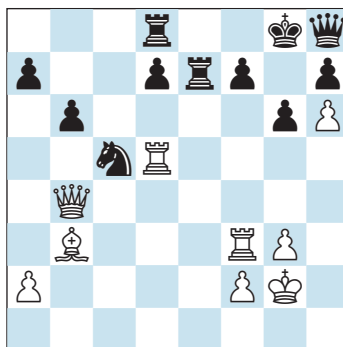
47.♖xc5! bxc5 48.♕h4 ♖de8 49.♖f6 ♖f8 50.♕f4 a5 51.g4 d5 52.♗xd5 ♖d7 53.♗c4 a4 54.g5
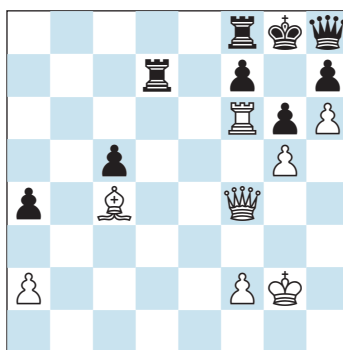
The plight of the black Queen is the living image of AZ's strategic triumph.

54…a3 55.♕f3 ♖c7 56.♕xa3 ♕xf6 57.gxf6 ♖fc8 58.♕d3 ♖f8 59.♕d6 ♖fc8 60.a4 1–0

1.♘f3 ♘f6 2.c4 b6 3.d4 e6 4.g3 ♗b7 5.♗g2 ♗e7 6.0–0 0–0 7.d5 exd5 8.♘h4 c6 9.cxd5 ♘xd5 10.♘f5 ♘c7 11.e4 ♗f6? 12.♘d6± ♗a6 13.♖e1 ♘e8 14.e5 ♘xd6 15.exf6 ♕xf6 16.♘c3 ♘b7 17.♘e4 ♕g6 18.h4 h6 19.h5 ♕h7 20.♕g4 ♔h8
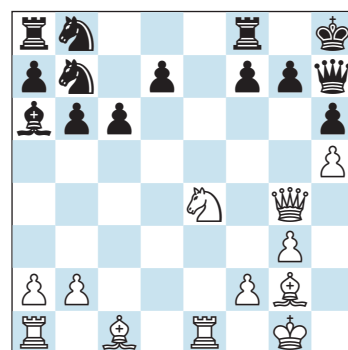
21.♗g5! It has been long praised this move, but 21.b4 d5 22.♗b2 gives a big advantage too or even the calm 21.♘c3 d5 22.b4.

21…f5 21...hxg5 22.♘xg5 ♕g8 23.♕h4 with the idea of 23...-- 24.h6. **22.♕f4 ♘c5** 22...hxg5 23.♘xg5 ♕xh5 24.g4! ♕h6 25.♖e8! **23.♗e7 ♘d3 24.♕d6 ♘xe1 25.♖xe1 fxe4 26.♗xe4 ♖f5 27.♗h4 ♗c4 28.g4 ♖d5 29.♗xd5 ♗xd5 30.♖e8+ ♗g8 31.♗g3 c5 32.♕d5 d6 33.♕xa8+− ♘d7 34.♕e4 ♘f6 35.♕xh7+ ♔xh7 36.♖e7 ♘xg4 37.♖xa7 ♘f6 38.♗xd6 1–0 (117)**
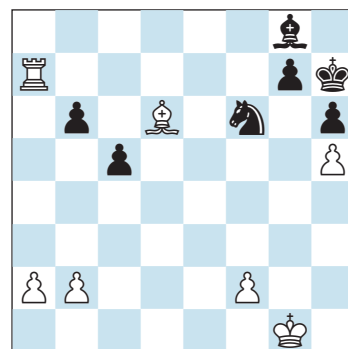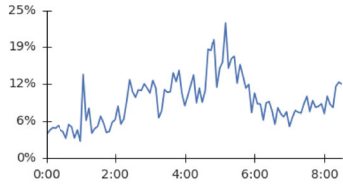

Although SF resisted until move 117, the white advantage is decisive and AZ imposed its technique.

LEARNING STATISTICS IN THE 12 SELECTED POSITIONS (SOURCE: Google DeepMind)
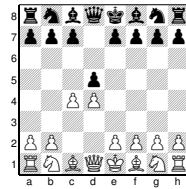
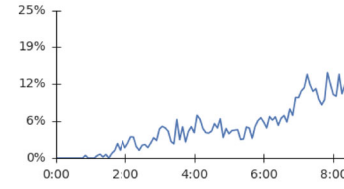### A10: English Opening
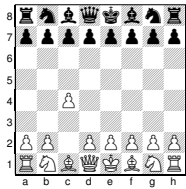
w 20/30/0, b 8/40/2

1...e5 g3 d5 cxd5 ♘f6 ♗g2 ♘xd5 ♘f3
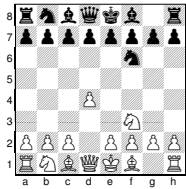
D06: Queens Gambit
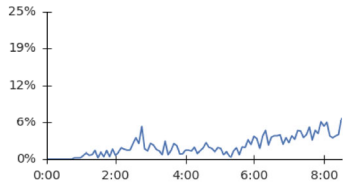
w 16/34/0, b 1/47/2

2...c6 ♘c3 ♘f6 ♘f3 a6 g3 c4 a4
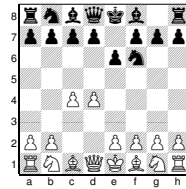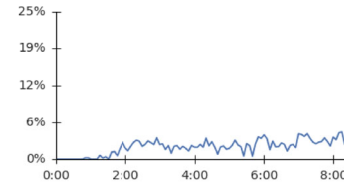
A46: Queens Pawn Game

w 24/26/0, b 3/47/0

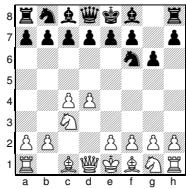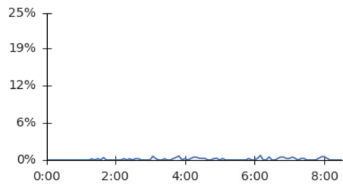2...d5 c4 e6 ♘c3 ♗e7 ♗f4 O-O e3

E00: Queens Pawn Game

w 17/33/0, b 5/44/1

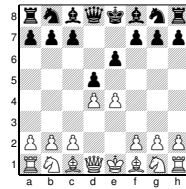3.♘f3 d5 ♘c3 ♗b4 ♗g5 h6 ♕a4 ♘c6

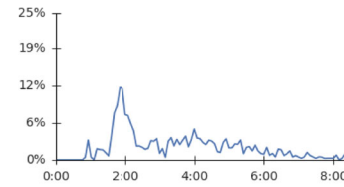### E61: Kings Indian Defence

w 16/34/0, b 0/48/2

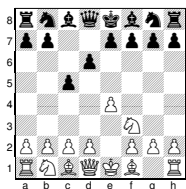3...d5 cxd5 ♘xd5 e4 ♘xc3 bxc3 ♗g7 ♗e3

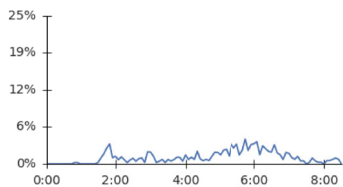### C00: French Defence

w 39/11/0, b 4/46/0

3.♘c3 ♘f6 e5 ♘d7 f4 c5 ♘f3 ♗e7
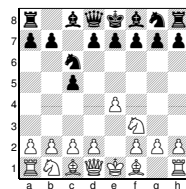
B50: Sicilian Defence
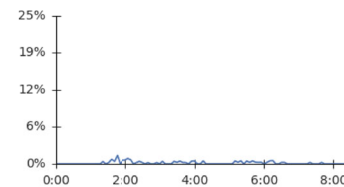
w 17/32/1, b 4/43/3

3.d4 cxd4 ♘xd4 ♘f6 ♘c3 a6 f3 e5

B30: Sicilian Defence

w 11/39/0, b 3/46/1

3.♗b5 e6 O-O ♘e7 ♖e1 a6 ♗f1 d5

B40: Sicilian Defence
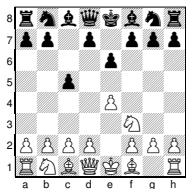
w 17/31/2, b 3/40/7
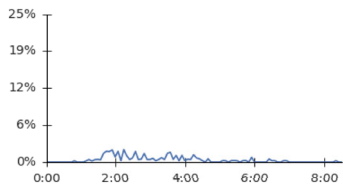
3.d4 cxd4 ♘xd4 ♘c6 ♘c3 ♕c7 ♗e3 a6

C60: Ruy Lopez (Spanish Opening)

w 27/22/1, b 6/44/0

4.♗a4 ♗e7 O-O ♘f6 ♖e1 b5 ♗b3 O-O

B10: Caro-Kann Defence

w 25/25/0, b 4/45/1

2.d4 d5 e5 ♗f5 ♘f3 e6 ♗e2 a6

A05: Reti Opening

w 13/36/1, b 7/43/0

2.c4 e6 d4 d5 ♘c3 ♗e7 ♗f4 O-O

Total games: w 242/353/5, b 48/533/19   Overall percentage: w 40.3/58.8/0.8, b 8.0/88.8/3.2

Alphazero's openings

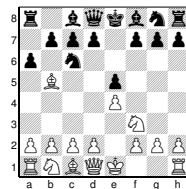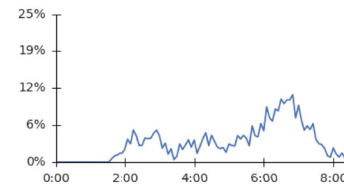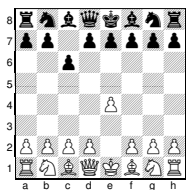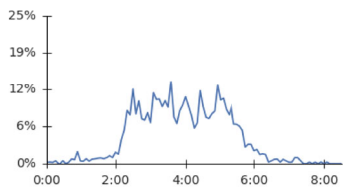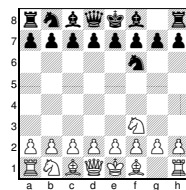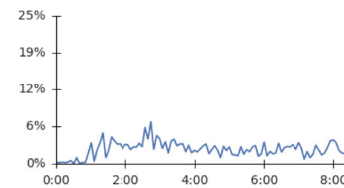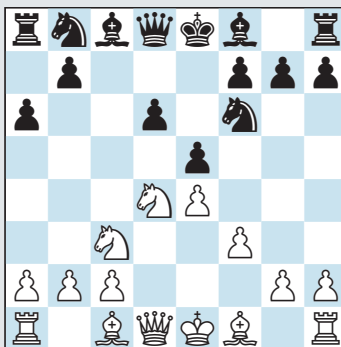**GM Miguel Illescas**

The results of the training session: 9 hours and 44 million games

WE WILL START OFF by analysing the graphics showing the preference of AZ on each of the opening lines examined. In each graphic, the horizontal is the line of time (from 0 to 9 hours of training) and the vertical is the frequency of appearance of the position in the diagram. Although AZ must have played many other openings Only statistics on these 12 selected positions have been released.

The first thing I want to point out -That many commentators seem not to have understood- is that the fact that a position appearing more or less times depends so much on the preferences of AZ with black as well as with white. If queen's pawn is played you cannot play the Sicilian!

Right from the start, there is a clear predominance of closed openings, which brings us to the conclusion that AZ understood that 1.e4 wasn't giving any good results. This thesis coincides with the fact that in the set of ten games provided there are only two e4 openings, and they are AZ victories playing with Black.

After 44 million games, these are some of the conclusions of AZ.

Sicilian Defence

AZ never liked the Sicilian too much. Only during the sixth hour of training AZ showed some willingness to play the Sicilian with 2 ... d6 (Najdorf). These are its favourite lines:

- **1.e4 c5 2.♘f3 d6 3.d4 cxd4 4.♘xd4 ♘f6 5.♘c3 a6 6.f3 e5**

- **1.e4 c5 2.♘f3 ♘c6 3.♗b5 e6 4.0–0 ♘ge7 5.♖e1 a6 6.♗f1 d5**

- **1.e4 c5 2.♘f3 e6 3.d4 cxd4 4.♘xd4 ♘c6 5.♘c3 ♕c7 6.♗e3 a6**

It draws the attention and it is almost frightening that an intelligent entity has discovered the strength of the English Attack and the Rossolimo on its own, with absolutely contemporary lines.

More calmly, a detailed analysis can be done, and it arises many questions: why AZ prefers **3.♗b5** to **3.d4.** Is it because of the Pelikan?

French and Caro-Kann Defences

On the contrary, the other main semi-open defences were of AZ taste. At two hours of training AZ liked the French, which was replaced for the Caro-Kann, from the second to the sixth hour.

AZ must have played several millions of games with these defences, becoming an expert in handling them, which was revealed later in the match against SF. Little by little, as it was leaving the king's pawn opening, the Semi-open openings were being less and less practiced. These were the AZ's favourite lines in each defence:

- **1.e4 e6 2.d4 d5 3.♘c3 ♘f6 4.e5 ♘fd7 5.f4 c5 6.♘f3 ♗e7**

- **1.e4 c6 2.d4 d5 3.e5 ♗f5 4.♘f3 e6 5.♗e2 a6**

We must insist on the enormous theoretical value that these lines have. After millions of games, these are the moves that AZ considers to be the best for each Side. Interestingly, the engine is not afraid to close the game with **e4-e5,** leading to closed positions, something that normal programs handle really badly.

> *After some hours of training, AZ understood that 1.e4 was not giving any good results.*

Spanish opening

The Ruy López was the winner among the answers to 1.e4, and the graphic tells us that AZ liked it from the sixth hour, replacing the Caro-Kann. However, the statistics provided correspond only to the classical line with 3 ... a6, leaving out important lines like the Italian, the Scottish, etc. as well as the Berlin Defence that was finally chosen as the best by AZ, wich was used in the free choice opening match against SF with great success, I might say, because it leads to strategic positions where the long-term vision of AZ is better than SF"s.

In the classical Spanish there was nothing New. AZ ended up finding the main line, almost trying the Marshall Attack, because it castled in the seventh move, instead of playing **7…d6.**

- **1.e4 e5 2.♘f3 ♘c6 3.♗b5 a6 4.♗a4 ♗e7 5.0–0 ♘f6 6.♖e1 b5 7.♗b3 0–0**

It draws the attention the order of the moves with ♗e7 before ♘f6, although it does not really matter.

Queen's Gambit

As we have indicated, the preference of AZ for the queen↗s pawn opening was growing as it was getting better at the game. So one question arises: **What is the better answer against 1.d4?**

The graphics do not leave room for doubts: the symmetric **1…d5.** Just as with the king's pawn opening, the symmetric response is the choice of AZ after several hours of study.

In the case of the Queen's Gambit it was love at first sight and it didn't change, because the use of this opening kept growing. It is however surprising the line played by AZ: The Slav with **4…a6,** to which it answers in modern fashion with **5.g3,** sacrificing a pawn for a long-term compensation as it does in so many other lines.

- **1.d4 d5 2.c4 c6 3.♘c3 ♘f6 4.♘f3 a6 5.g3 dxc4 6.a4**
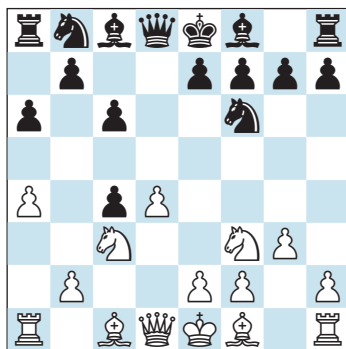
This position barely has one hundred games in the database. If I was still a professional player I would immediately go study it, with both colours.

Indian defences with g6

The report mistakenly gives the name King's Indian Defence to the position that occurs after the fianchetto with g6, which can let to both the King's Indian and the Grünfeld, or different types of Benoni or Old Indians.

The fact is that at any time of the learning phase AZ shows great interest in these structures, which we assume must consider inferior.

The main line is a well-known Grünfeld:

> *The Berlin Defence was chosen as the best one by AZ.*

- **1.d4 ♘f6 2.c4 g6 3.♘c3 d5 4.cxd5 ♘xd5 5.e4 ♘xc3 6.bxc3 ♗g7 7.♗e3**

Indian Defences with e6, Queen's Pawn Opening and the Réti Opening

AZ considers that the defences starting with 2...e6 are better, although putting a pawn on d5 as soon as possible, and in fact the main line that it plays is a transposition of the Orthodox Defence of Queen's Gambit Declined. The same thing happens with other move orders, wrongly called in the report as Reti, etc.

The Orthodox occupies an important place in the AZ's repertoire, which seems to give preference, especially with black, to very solid defences. So we figure that AZ does not allow the Nimzoindian, and in several games responded to the Queen's Indian Defence played by SF with the 4.g3 fianchetto, playing aggressive with white.

- **1.d4 ♘f6 2.c4 e6 3.♘f3 d5 4.♘c3 ♗b4 5.♗g5 h6 6.♕a4+ ♘c6**

- **1.♘f3 ♘f6 2.c4 e6 3.d4 d5 4.♘c3 ♗e7 5.♗f4 0–0**

- **1.d4 ♘f6 2.♘f3 d5 3.c4 e6 4.♘c3 ♗e7 5.♗f4 0–0 6.e3**

It is surprising in one of the move orders, the preference for the Ragozin with a ♗b4, a very trendy and dynamic line, played nowadays by the elite.

The English Opening

It is quite a surprise the AZ's choice of the English opening with white, that became very noticeable in the fifth hour of training.

In the recommended line, the open classical - which leads to a Sicilian with colours reversed-, it draws the attention the move order used to break on d5, on the second move, not on the third as it is usual.

▪ **1.c4 e5 2.g3 d5 3.cxd5 ♘f6 4.♗g2 ♘xd5 5.♘f3**

THEMATIC MATCH ALPHAZERO VS. STOCKFISH

We now show the table of results of the twelve matches played between AZ and SF, in each of the positions selected by the DeepMind team. For comparative purposes we have added the statistics of the updated MegaBase, selecting 181,500 games in which both players have an Elo of at least 2500.

1,200 games Thematic Opening	AZ with white				AZ with black				MegaBase Elo > 2500			
	+	=	−	%	+	=	−	%	1-0	1/2	0-1	%
English 1.c4	20	30	0	70%	8	40	2	56%	29	53	18	55%
Queen's Gambit 2.c4	16	34	0	66%	1	47	2	49%	27	56	17	55%
1.d4 ♘f6 2.♘f3	24	26	0	74%	3	47	0	53%	26	55	18	54%
Indians 2.c4 e6	17	33	0	67%	5	44	1	54%	27	57	16	56%
Indians 2.c4 g6 3.♘c3	16	34	0	66%	0	48	2	48%	31	49	20	56%
French 2.d4 d5	39	11	0	89%	4	46	0	54%	31	51	18	57%
Caro-Kann 1…c6	25	25	0	75%	4	45	1	53%	28	54	18	55%
Sicilian 2…d6	17	32	1	66%	4	43	3	51%	31	48	21	55%
Sicilian 2…♘c6	11	39	0	61%	3	46	1	52%	30	51	19	55%
Sicilian 2…e6	17	31	2	65%	3	40	7	46%	32	48	19	57%
Spanish 3…a6	27	22	1	76%	6	44	0	56%	28	56	16	56%
Reti 1.♘f3 ♘f6	13	36	1	62%	7	43	0	57%	26	57	17	55%
TOTALS	242	353	5	70%	48	533	19	52%	29	53	18	55%

Several very significant facts are observed. The result of AZ with white is huge, achieving 70% of the points at stake and winning with authority the 12 games. It is amazing that of the 600 games played (plus 50 of the free session) AZ only loses 5 with this colour. However, when AZ plays with black there are lots of draws; even so, AZ wins 9 of the 12 games. Human statistics are much more homogeneous, which seems to indicate that SF suffers a serious imbalance in its play because of not having the opening book, especially with black.

The reader can examine each line of the table, to draw interesting conclusions, but I will share some of mine, which I have taken in a first examination of the data.

The defence with the worst result for SF is the French, especially with black. This might be for several reasons:

1 The French Defence is bad. This also happens with statistics between humans, where this defences gets the worst results, along with the Sicilian Paulsen / Tajmanov (2 …e6), but that does not seem to justify a score so huge.

2 StockFish plays the French poorly with no Opening book. This may be true, as many blocked positions raise from those openings that the traditional programs do not handle so well.

3 AlphaZero plays the French very well. This seems to be a compelling reason. As we have said earlier, AZ devoted a lot time to this defence while it was learning the game, and it can be deduced that it has become an expert of the highest level.

Probably, the reason for that high percentage in white's favour, as it happens in the Caro-Kann or the Spanish, could be a mixture of the three reasons, although the third is the most impressive. **Can these intelligent systems be so good at something after such a short time?**

THE 10 GAMES OF THE ALPHAZERO-STOCKFISH MATCH (Grouped by openings)

Berlin Defence (ST vs AZ)

1.e4 e5 2.♘f3 ♘c6 3.♗b5 ♘f6 4.d3 ♗c5 5.♗xc6 dxc6 6.0–0 Elite players are holding up castling with 6.♘bd2!? Too subtle for a SF without a book of Openings.

6…♘d7! To take the pawn to f6 according to the structure of pawns (white bishop, black pawns) and recycling the knight: a very human concept.
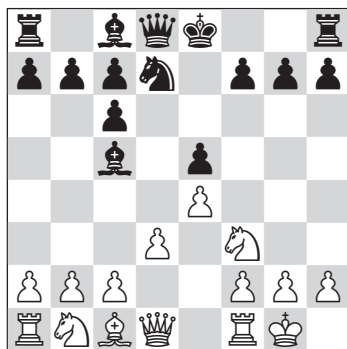
7.c3?! 7.♘bd2 0–0 8.♕e1?! *(8.♘c4=)* 8…f6 9.♘c4 ♖f7 10.a4 ♗f8 11.♔h1 ♘c5 12.a5 ♘e6 13.♘cxe5 fxe5 14.♘xe5 ♖f6 15.♘g4 ♖f7 16.♘e5 ♖e7∓ 17.a6 c5 18.f4 ♕e8 19.axb7 ♗xb7 20.♕a5 ♘d4 21.♕c3 ♘e6 22.♗e3 ♖b6 23.♘c4 ♖b4 24.b3 a5 25.♖xa5 ♖xa5 26.♕xa5 ♗a6 27.♗xd4 ♖xd4 28.♘c4 ♖d8 29.g3 h6 30.♕a5 ♗c8 31.♕xc7 ♗h3 32.♖g1 ♖d7 33.♕e5 ♕xe5 34.♘xe5 ♖a7∓ 35.♘c4 g5 36.♖c1 ♗g7 37.♘e5 ♖a8 38.♘f3 ♗b2 39.♖b1 ♗c3 40.♘g1 ♗d7 41.♘e2 ♗d2 42.♖d1 ♗e3 43.♔g2 ♗g4 44.♖e1 ♗d2 45.♖f1 ♖a2–+ (0–1 in 67 moves).

7…0–0 8.d4 ♗d6 9.♗g5 ♕e8 10.♖e1 f6 11.♗h4 ♕f7 12.♘bd2 a5 13.♗g3 ♖e8 14.♕c2 ♘f8 15.c4 c5 16.d5 b6 17.♘h4 g6 18.♘hf3 ♗d7 19.♖ad1 ♖e7∓ 20.h3 ♕g7 21.♕c3 ♖ae8 22.a3 h6 23.♗h4 ♖f7 24.♗g3 ♖fe7 25.♗h4 ♖f7 26.♗g3 a4 27.♔h1 ♖fe7 28.♗h4 ♖f7 29.♗g3
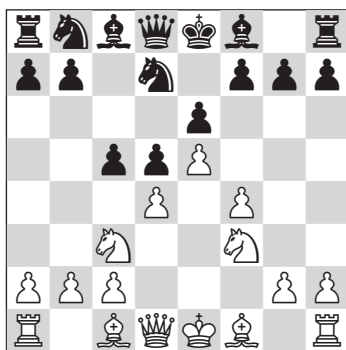
♖fe7 30.♗h4 g5 31.♗g3 ♘g6 32.♘f1 ♖f7 33.♘e3 ♘e7 34.♕d3 h5 35.h4 ♘c8 36.♖e2 g4 37.♘d2 ♕h7 38.♔g1 ♗f8 39.♘b1 ♘d6 40.♘c3 ♗h6∓
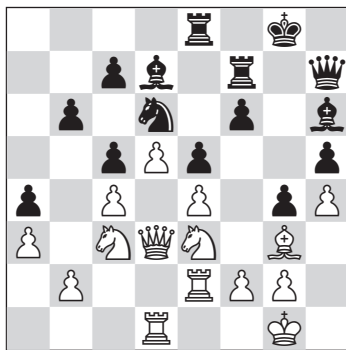
41.♖f1 ♖a8 42.♔h2 ♔f8 43.♔g1 ♕g6 44.f4 gxf3 45.♖xf3 ♗e3+ 46.♖fxe3 ♔e7 47.♗e1 ♕h7 48.♖g3 ♖g7 49.♖xg7+ ♕xg7 50.♖e3 ♖g8 51.♖g3 ♕h8 52.♘b1 ♖xg3 53.♗xg3 ♕h6 54.♘d2 ♗g4 55.♔h2 ♔d7 56.b3 axb3 57.♘xb3 ♕g6 58.♘d2 ♗d1 59.♘f3 ♗a4 60.♘d2 ♔e7 61.♗f2 ♕g4 62.♕f3 ♗d1 63.♕xg4 ♗xg4 64.a4 ♘b7 65.♘b1 ♘a5 66.♗e3 ♘xc4–+ (0–1 in 87 moves]

French Defence (AZ vs ST)

1.d4 e6 2.♘c3 ♘f6 3.e4 d5 4.e5 ♘fd7 5.f4 c5 6.♘f3

6…cxd4?! It seems too early to take 6…♘c6 7.♗e3 ♗e7 8.♕d2 a6 9.♗d3 c4?! SF does not know how to play this without a book. *(Best considered move is 9…b5)* 10.♗e2 b5 11.a3 ♖b8 12.0–0 0–0 13.f5! a5

14.fxe6 fxe6 15.♗d1! b4 16.axb4 axb4 17.♘e2 c3 18.bxc3 ♘b6 19.♕e1 ♘c4 20.♗c1 bxc3 21.♕xc3± (1–0 in 95 moves).

7.♘b5!? An idea relatively new and very promising. 7…♗b4+ 8.♗d2 ♗c5 9.b4 ♗e7 10.♘bxd4 ♘c6 11.c3 a5 12.b5 ♘xd4 13.cxd4± ♘b6 14.a4 ♘c4 15.♗d3 ♘xd2 16.♔xd2 ♗d7 17.♔e3 b6 18.g4 h5 19.♕g1 hxg4 20.♕xg4 ♗f8 21.h4 ♕e7 22.♖hc1 g6 23.♖c2 ♔d8 24.♖ac1 ♕e8 25.♖c7 ♖c8 26.♖xc8+ ♗xc8 27.♖c6 ♗b7 28.♖c2 ♔d7 29.♘g5 ♗e7 30.♗xg6!
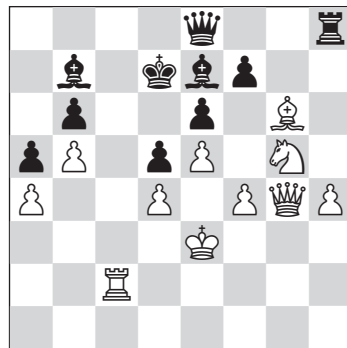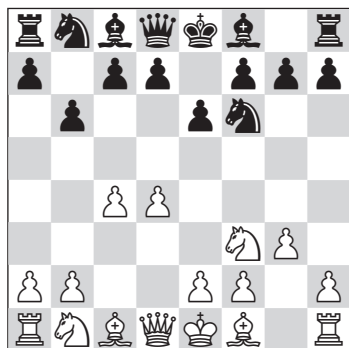

30…♗xg5 31.♕xg5 fxg6 32.f5! ♖g8 33.♕h6 ♕f7 34.f6 ♔d8 35.♔d2 ♔d7 36.♖c1 ♔d8 37.♕e3 ♕f8 38.♕c3 ♕b4 39.♕xb4 axb4 40.♖g1 b3 41.♔c3 ♗c8 42.♔xb3 ♗d7 43.♔b4 ♗e8 44.♖a1 ♔c7 45.a5 ♗d7 46.axb6+ ♔xb6 47.♖a6+ ♔b7 48.♔c5 ♖d8 49.♖a2 ♖c8+ 50.♔d6 ♗e8 51.♔e7 g5 52.hxg5 1–0
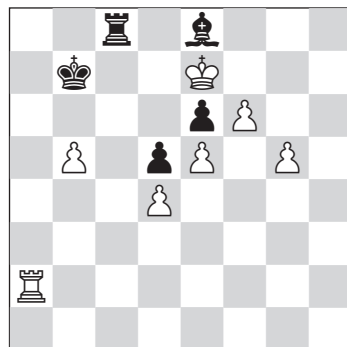
THE 10 GAMES OF THE ALPHAZERO-STOCKFISH MATCH (Grouped by openings)

## Queen's Indian (AZ vs ST)

1.♘f3 ♞f6 2.c4 b6 3.d4 e6 4.g3

4...♗b7 4...♗a6 *(1–0 in 60 moves)* see commented match. **5.♗g2 ♗e7** 5...♗b4+ 6.♗d2 ♗e7 *(6...♗xd2+ 7.♕xd2 d5 8.0–0 0–0 9.cxd5 exd5 10.♘c3 ♞bd7 11.b4 c6 12.♕b2 a5 13.b5 c5 14.♖ac1 ♕e7 15.♞a4 ♖ab8 16.♖fd1 c4 17.♞e5 ♕e6 18.f4 ♖fd8 19.♕d2 ♞f8 20.♞c3± 1–0 in 100 moves).* 7.♞c3 c6 8.e4 d5 9.e5!? ♞e4 10.0–0 ♗a6 11.b3 ♞xc3 12.♗xc3 dxc4 13.b4 b5 14.♞d2 0–0 15.♞e4 ♗b7 16.♕g4 ♞d7 17.♞c5 ♞xc5 18.dxc5 a5 19.a3 axb4 20.axb4 ♖xa1 21.♖xa1 ♕d3 22.♖c1 ♖a8 23.h4 ♕d8 24.♗e4± ♔c8 25.♔g2 ♕c7 26.♕h5 g6 27.♕g4 ♗f8 28.h5

28...♖d8 29.♕h4 ♕e7 30.♕f6 ♕e8 31.♖h1 ♖d7 32.hxg6 fxg6 33.♕h4 ♕e7 34.♕g4 ♖d8 35.♗b2 ♗f7 36.♗c1 c3 37.♗e3 ♗e7 38.♕e2 ♗f8 39.♕c2 ♗g7 40.♕xc3 ♕d7 41.♖c1 ♕c7 42.♗g5 ♖f8 43.f4 h6 44.♗f6 ♗xf6 45.exf6 ♕f7 46.♖a1 ♕xf6 47.♕xf6 ♖xf6 48.♖a7 ♖f7 49.♗xg6 ♖d7 50.♔f2 ♔f8 51.g4 ♗c8 52.♖a8 ♖c7 53.♔e3 h5 54.gxh5 *(1–0 in 68 moves).*

6.0–0 0–0 7.d5 exd5 8.♞h4 c6 9.cxd5 ♞xd5 10.♞f5 ♞c7 11.e4 ♗f6? The game with 11...d5 *(1–0 in 56 moves)* see commented match. **12.♞d6± ♗a6 13.♖e1 ♞e8 14.e5 ♞xd6 15.exf6 ♕xf6 16.♞c3 ♗c4** The game with 16 ...♞b7 *(1–0 in 117 games),* can be seen in the commented match
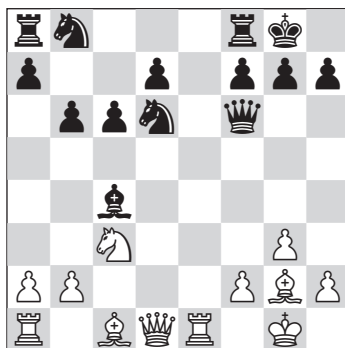
17.h4 h6 18.b3 ♕xc3 19.♗f4 ♞b7 20.bxc4 ♕f6 21.♗e4 ♞a6 22.♗e5 ♕e6 23.♗d3 f6 24.♗d4 ♕f7 25.♕g4 ♖fd8 26.♖e3 ♞ac5 27.♗g6 ♕f8 28.♖d1 ♖ab8 29.♔g2±
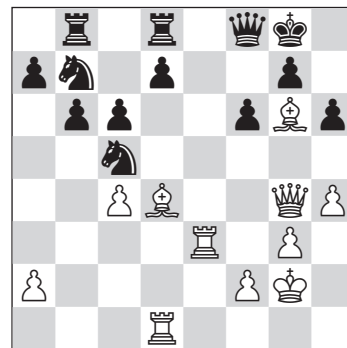
♞e6 30.♗c3 ♞bc5 31.♖de1 ♞a4 32.♗d2 ♔h8 33.f4 ♕d6 34.♗c1 ♞d4 35.♖e7 f5 36.♗xf5 ♞xf5 37.♕xf5 ♖f8 38.♖xd7 ♖xf5 39.♖xd6 ♖f7 40.g4 ♔g8 41.g5 hxg5 42.hxg5 ♞c5 43.♔f3 ♞b7 44.♖dd1 ♞a5 45.♖e4 c5 46.♗b2 ♞c6 47.g6 ♖c7 48.♔g4 ♞d4 49.♖d2 ♖f8 50.♗xd4 cxd4 51.♖dxd4 1–0 (70)

ALPHAZERO'S STYLE

Alphazero plays in a universal and balanced way, having both, the best of the humans and the computers. AZ's tactical strength is overwhelming, but it comes together with a deep strategic knowledge, only seen until now exclusively with humans, as you can see in the game using the Berliner Defence, which wins in 87 movements. AZ plays very well in blocked positions, as shown during the two games played with the French Defence too. AZ's openings are amazing: it has discovered and even overcome five centuries of human effort in hardly two hours of training. When AZ plays with black pieces, it shows a very solid position and rapidly occupies the center in a symmetrical way, like Karpov's style. When playing with white pieces, AZ likes to start with the Queen, but in an aggressive way, like Kasparov's style. AZ loves to give away pieces in the long term, with tactical sacrifices such as Tal's and other positional ones who could be signed by Petrosian.

The way AZ plays against the Queens Indian Defence is sublime, from another galaxy, with outstanding ideas such as the sacrifice of the pawn in c4 during the match that wind in 68 movements. It is also impressive AZ's relentless execution of its positional advantage in some of the matches where AZ plays in inferiority, as it is its faultless technic in the final positions. We could easily say, without a risk of making a mistake, that, from the analysis of the 10 games, AZ plays close to perfection.

REFLECTION

If any elite chess player would have access to the 1,300 games played by AZ or to the complete statistics of the 44 million of training matches, he or she would have enjoyed a competitive advantage versus his or her colleagues. It is all in Google's hands: if they share this information or keep AZ playing chess, our game will give an exciting leap forward over the time.