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MAXINE: Welcome to another episode of the Talks at Google podcast where great minds meet. I'm Maxine bringing you this latest episode featuring Chess Grandmaster Garry Kasparov. Talks at Google brings the world's most influential thinkers, creators, makers, and doers all to one place. Every episode of this podcast is taken from a video that can be seen at youtube.com/talksatgoogle. In May 1997, the world watched as Garry Kasparov was defeated for the first time by the IBM supercomputer Deep Blue. It was a watershed moment in the history of technology. Machine intelligence had arrived at the point where it could beat human intellect. In his breakthrough book, *Deep Thinking: Where Machine Intelligence Ends and Human Creativity Begins*, Kasparov tells his side of the story of Deep Blue for the first time, what it was like to strategize against an unrelenting, untiring opponent, the mistakes he made, and the reasons the odds were against him.

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Kasparov and DeepMind's CEO Demis Hassabis discussed the book, his match with Deep Blue and his thoughts on the future of AI in the world of chess. Here is Garry Kasparov, *Deep Thinking*. [applause]

DEMIS HASSABIS: Well, thank you everyone for coming. It's a really special privilege and honor for me actually to talk to Garry. In my opinion-- my humble opinion, the greatest chess player of all-time and, you know, I've really enjoyed his book which I reviewed recently and, you know, I was impressed with Garry's understanding of artificial intelligence and the latest advances in that so, you know, it's going to be great to talk about that as well as chess today.

GARRY KASPAROV: Yes.

DEMIS HASSABIS: So welcome to--

GARRY KASPAROV: Thank you very much--

DEMIS HASSABIS: Google and DeepMind.

GARRY KASPAROV: For your review. It offered me all the protection against all the tech guys that tried to criticize me for not being an expert.

DEMIS HASSABIS: Well, I'm glad that that can be of use.

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DEMIS HASSABIS: So before we get talking about, you know, Deep Blue match and-- I'm sure everyone's going to want to hear about your insights on that and also machine learning more generally. And I wanted to begin by asking you, you know, about growing up as a chess champion in Soviet Union. Did you always want to be a chess player-- world champion of chess, did you consider anything else or were you from a very young age decide that this was your path?

GARRY KASPAROV: I learned how to play chess when I was five or six. I'm sorry. I couldn't give you an exact moment. Nobody was there to tweet about it.

DEMIS HASSABIS: [laughs]

GARRY KASPAROV: It was late '68, maybe early '69. Yeah. Watching my parents trying to solve chess problem and I loved the game at first sight. And then ever since, you know, I'm still in awe with the game and I could feel that was a match made in heaven and everybody around also could see that chess was a perfect fit for my mind.

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DEMIS HASSABIS: And skills, yeah.

GARRY KASPAROV: Yeah.

DEMIS HASSABIS: And actually you talked about it in the book about chess informing all of your thinking and the rest of your life, right? Do you-- what do you mean by that? What skills can you see yourself using in the rest of your life that you learned from chess?

GARRY KASPAROV: Naturally, if you are engaged in a competitive sport at such an early age, you see many things just as a reflection of your chess games, your engagement. Because you have to play, you have to win.

DEMIS HASSABIS: Yeah.

GARRY KASPAROV: That means you have change certain habits and certain customs. And what was important for me, that's what I learned from my mother is, that my game was not just about winning.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: It was also about making a difference.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: And that's what helped me to make a transition later on in my life from playing chess, being number one chess player for 20 years to other things that I'm doing now--

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Not pretending that I could be number one and repeat my outstanding achievements in the game of chess but still recognizing that I'm quite useful because I'm trying to bring my chess experience, my-- what I learned from the game of chess, my analytical skills to make the difference elsewhere.

DEMIS HASSABIS: Uh-hmm. So maybe, you know, we should talk about, obviously, the heart of your book which is the Deep Blue match and, you know, I was fascinated to see your take on, you know, having gone through the AlphaGo matches ourselves from the other side your take on it from the player's perspective.

GARRY KASPAROV: It's an interesting story because when we played our first match and I always want to remind people that there were two matches, and I won't the first one.

DEMIS HASSABIS: Yes, exactly. We should make that very clear.

GARRY KASPAROV: Yes, yes, yes. So it's--

DEMIS HASSABIS: I was going to say-- exactly.

GARRY KASPAROV: Now, the first match in Philadelphia, it's just-- it was organized as quite a low-level event. The corporation was not even involved. It was ACM behind it.

DEMIS HASSABIS: Yeah.

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GARRY KASPAROV: And the team always wanted to challenge me. And I had an experience of playing with-- played against them in 1989 when they had a Deep Thought.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: The prototype from Carnegie Mellon that they brought to IBM and that-- it's turned into a Deep Blue project. And everything has changed after game one with-- by the way, if we are talking about a watershed moment, that was in February 1996 in Philadelphia when I lost game one of that match because the rest is, you may argue, a matter of technique, a matter of time. It was like signing on the wall. If the machine can beat a world champion in one game then--

DEMIS HASSABIS: Eventually.

GARRY KASPAROV: Eventually.

DEMIS HASSABIS: Yeah.

GARRY KASPAROV: I fought back. I won the match. I won game two and game five and game six but it was pretty clear that the rest would be a matter of time. And the first game had some kind of a record following on the internet. I think the numbers they had there were even higher numbers later on in Atlanta that-- when IBM ran the website there.

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And suddenly, the corporation, Lou Gerstner and his team discovered the huge potential at a rather low cost.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: So-- and while the rest of the match was still, you know, played-- it's just about purely chess, then it turned into a big corporate endeavor and I'm-- look, it's water under the bridge, 20 years ago, I lost the match but I think-- and I discussed it in the book, I made many mistakes in preparation. And one of the biggest mistake, and that's quite, you know, that's why I was so upset with myself is that, I didn't treat the IBM, Deep Blue, as just, you know, opponent the way I treated Anatoly Karpov or Vishy Anand or Nigel Short. For me, it was a still-- and it's-- I was still part of a great social and scientific experiment of the end of the 20th Century, something that could help us to understand more about how we humans make decisions, how machines can play with us. It was not just, you know, winning or losing, big mistake.

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DEMIS HASSABIS: Yeah.

GARRY KASPAROV: Yeah. Now, for IBM, it was just about winning or losing.

DEMIS HASSABIS: Yeah.

GARRY KASPAROV: Yeah. And the one of the big mistakes that I made while signing the contract, you always have to read the fine print.

DEMIS HASSABIS: Yeah. And say, hey, that rematch clause is--

GARRY KASPAROV: Yeah. Honestly, and because it's-- when people ask me whether IBM cheated, no. They just bend the rules in their favor. It's-- they followed the letter but not the spirit of the agreement. And for instance, one of the big issues after the match-- after our first match in

Philadelphia for me was, "How can I prepare if I didn't have any games?" This is the normal way to prepare. You look at the games of your opponent. And Deep Blue in Philadelphia was a black box. I had no idea what it was capable of. There were so few games that machine played in other-- against other computers but it was not the machine that faced me. Now, one year-- more than one year-- 15 months between the first match and the second match, and I was under the impression that it will be-- I'll be treated fairly.

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Because after my first victory in Philadelphia, I went to Yorktown Heights, I sat with the team. They had this, you know, similar regimens for all IBM labs around the world. So the atmosphere was very friendly.

DEMIS HASSABIS: Yeah.

GARRY KASPAROV: Uh-huh.

DEMIS HASSABIS: [laughs] And then it changed.

GARRY KASPAROV: And then it's just-- it's the-- when I, you know, it was just--I expected the games to be provided and then they said, "Wait a second, but did you read?" The game's played in official tournaments. And of course, Deep Blue hasn't played a single game outside the lab. So which means that in May 1997, I faced another black box that I knew was much stronger than it was before but still no idea what to expect. I knew they had a professional team so they made a massive preparation and I have to also admit my preparation was quite lousy. Because again, only just before the match-- a week before the match, I realized, you know, that's how difficult the challenge could be. But also the-- one of the key elements of this contract that I totally overlooked was about machines rebooting.

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DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: That's a big issue.

DEMIS HASSABIS: Yeah.

GARRY KASPAROV: You understand what it is? It's-- here, I don't have to explain but general audience doesn't understand it. The moment you reboot the computer, you will never be able to reconstruct the game. So which means that is a whole idea that match is fair and square and you can always go back and to see why Deep Blue did-- made this move or that move. It's over. And also the--

DEMIS HASSABIS: Yeah. Maybe people didn't realize that. I didn't realize it until I read the book that in fact several times that--

GARRY KASPAROV: They rebooted.

DEMIS HASSABIS: The Deep Blue crashed and then they rebooted it.

GARRY KASPAROV: It's the-- we don't know that it crashed.

DEMIS HASSABIS: And then they came up with a different move, right? In a couple of situations.

GARRY KASPAROV: Look, no, no, no. It doesn't matter what the move was, it's just the crash, you know, it's-- if you played a match, anything but the problem was agreed. Crash? You lost the game. Heart attack. Sorry, go to see a doctor.

DEMIS HASSABIS: [laughs]

GARRY KASPAROV: Yes.

DEMIS HASSABIS: Should have just been a loss.

GARRY KASPAROV: Yeah. It's a-- yeah. It's-- no, but it's the-- they have Ken Thompson, you know, that's the great computer expert, just-- you know, just-- who was there in Philadelphia helping me. He was also in front of the screen.

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But on the screen, you could see the Deep Blue's communication back to the programmer. But you didn't see whether they said anything--

DEMIS HASSABIS: The other way.

GARRY KASPAROV: The other way. Again, I don't know but it's definitely created a lot of tension in the match. And, you know, after losing game two, which that's another story of its own, I was very upset and I demanded logs. And by the way, if they wanted to play a fair game, all they had to do is produce the log-- the logs and to prove that my suspicions were not well-founded. They didn't do it.

DEMIS HASSABIS: Yeah.

GARRY KASPAROV: They just wanted me just to be inflamed. Because they realized that while Deep Blue was not that strong at that time, I still think I was stronger objectively.

DEMIS HASSABIS: Yeah. You were definitely stronger, I would have said too.

GARRY KASPAROV: Now, 20 years later, you can look at the games. You know, you can take a chess engine on your laptop, and you'll find out that many mistakes were made from both sides. I mean, one of the most amazing-- not even game two, but game five-- the end game, reaching the end game, I was slightly better. And everybody at that time in 1997 believed that was a brilliant escape by Deep Blue.

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Now, in thirty seconds to one minute, depends on the strengths of your-- of the speed of your computer, chess engines like Stockfish or Komodo will tell you that the end game was a draw. Deep Blue made a bad mistake, and then I missed a win. Which nobody saw in 1997, it's including Deep Blue. So that tells you that's the draw of the strengths. And I think that if we played the short match, the rubber match, I still had a good chance of winning. Again, it wouldn't change the sort of long-term outcome. But at that--

DEMIS HASSABIS: How long do you think you could have held them off for if you're at your full potential?

GARRY KASPAROV: Maybe two, three years.

DEMIS HASSABIS: Yeah. That's what I would have guessed too.

GARRY KASPAROV: Deep Blue, maximum two, three years. I played two more matches with Deep Fritz and Deep Junior in 2003, both ended in a draw. So that was a balance in the next five years. But in 1997, they realized that if putting pressure on only one human player in a match, they could achieve the result. If you cannot make your player stronger, you can definitely, you know, inflame the other player and took him off the balance.

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DEMIS HASSABIS: So what-- so sort of moving more to the present day now, you know, how do you-- do you think-- how have chess computers changed chess? Do you think it's for the better? It's just different? What do you think about that evolution?

GARRY KASPAROV: It's something that you said that, you know, just-- it's quite striking because you said is it for better or worse. It's happening, period. It's just the technology is neither good nor bad. It's agnostic. You know, you can do many great things with your mobile phone. But you can also create a terrorist network. So it's happening and we just have to adjust. And as for the game of chess, it's different because the young generation of chess players, they learn very differently from us. I remember I had books. And not so many books you can-- new books you can buy in the Soviet Union. Every book was cherished. And I had my notebooks. So this is-- and when I went to the top and played world championship matches, I had also notebooks and just all my-- recorded my analysis.

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DEMIS HASSABIS: Absolutely nuts. Yeah.

GARRY KASPAROV: And I treasured them. I remember, just you know, I had couple of quite thick notebooks with analysis. And they were, you know, just top secret. And I believed in 1985, in 1986, 1987, that was real treasure. That was a powerful weapon. It's like, you know, the magic sword of Merlin. Now, when you look at this analysis with computer, you understand it was a broken knife. But also, when you look at young chess players, and under the umbrella of Kasparov Chess Foundation, I have been involved in working with them. And I'm talking about kids of international masters, grandmaster level. It's such a difference in the way they approach the game, the way they look at the pieces. It happened time and again where you're reaching a certain position analyzing the game, and they say, "Bad move. I made a mistake here." I said, "Fine. Why?" Oh. And then it's a long line.

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So the machine show-- I said, "I understand. I can see the screen. But why you think this move is wrong?" And they don't understand the question. Because the machine said so. Because it's on the screen. So it's somehow their mind's being hijacked by the power of the machine. And one of the reasons Magnus Carlsen was so successful and still a dominant force in the world of chess, and I remember after working with him in 2009, 2010, for more than a year, he never looked at the machine as an ultimate source of wisdom. For him, it was more like a calculator to verify his own understanding and evaluation of the position. This is a big challenge. But I believe it's not only chess. It's elsewhere. Many people just are staring at the computers, eyes are just being, you know, being caught by the screen expecting just to find a solution there. Just--

DEMIS HASSABIS: Instead of thinking for themselves? Yeah, you know--

GARRY KASPAROV: Exactly. So that's why I always bring, as a piece of wisdom, the classical phrase from Pablo Picasso that computers are useless because they can only give you answers.

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DEMIS HASSABIS: Uh-hmm. Yeah.

GARRY KASPAROV: But everything begins with a question.

DEMIS HASSABIS: I mean, you know, since you're talking about Magnus Carlsen, you say that interestingly, although he's grown up in the computer chess era, he's one of the most human, I think you called it, or intuitive players around. Right? So it's kind of interesting.

GARRY KASPAROV: He's consistent. It's a-- yes, it's human. Because at the end of the day-- 20 years after my match with Deep Blue, more people playing chess than ever before. And chess is still very popular, because at the end of the day, it's a fight between two individuals. And what has changed is not just the game itself, but the way people are watching it. Twenty years ago, or thirty years ago, forty years ago, the world championship match was kind of an event of absolute quality. Even Karpov and Kasparov played the game, and one-- made a terrible blunder. It could take time in the precedent of the grandmasters to--

DEMIS HASSABIS: To find out.

GARRY KASPAROV: To whisper it, mistake.

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And it's like, you know, it's something that you should worship. Today, you know, when I'm watching the games by Magnus Carlsen, Caruana, and you have thousands of amateurs from all over the world watching it. Because they're screaming, "Ah, mistake, mistake!" Because the machine shows immediately-- it says, evaluation, drop. So see, some kind of respect has disappeared.

DEMIS HASSABIS: Yes, from that. It's a real shame.

[laughter]

GARRY KASPAROV: But also, it added interest, because people can follow. They just, you know, they have access to their computer and they don't have to be strong players to understand what is happening. And--

DEMIS HASSABIS: One of the interesting things you said actually about the chess computers and I wonder if it's going to happen with Go as well. In the countries that are not traditionally good at chess or Go, because they have access to these machines, maybe kids in those countries can now get very strong, right? Like, Magnus in Norway or-- I don't know whether that's, you know--

GARRY KASPAROV: I'm not sure Magnus' rise, meteoric rise was due to computers.

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And maybe, it's because, you know, you-- in this environment, you don't have to spend so much time learning from other players.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: So, the process of maturing for the chess player is much shorter.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: You have grandmasters at 14, 15 today that know much more than Bobby Fischer knew 40 years ago, just because they've played many games, they could travel around, they could watch the games. So, chess is a perfect match for internet, because you can follow the games, you can learn, you can analyze. So, there are many things you can do that dramatically increase the pace of learning and getting to the top.

DEMIS HASSABIS: Uh-hmm. So, you invented, I think, the concept of advanced chess, right? Man and computer.

GARRY KASPAROV: Human.

DEMIS HASSABIS: Human and computer.

GARRY KASPAROV: Sure.

DEMIS HASSABIS: Human and computer versus computer. Are you still stronger-- have you tried that recently with the latest chess engines? Are you-- is that still--

GARRY KASPAROV: Now--

DEMIS HASSABIS: True now?

GARRY KASPAROV: Oh, yes. Yeah, while licking my wounds after Deep Blue match, you know, I thought, how about bringing it together, just out of curiosity?

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Because I thought, "Wait a second, if I just can play with who is a machine, just against another player, so maybe we can play a perfect chess."

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: Now, the interesting thing is when we played this match with Veselin Topalov, another top player in 1998, I can tell you the quality was not very high because it was limited amount of time and we-- it was so new for us, how to use the machine. And eventually, I realized-- and we had many events, they're so-called freestyle events on the internet, that proved that it sounds quite ironic, but you don't need a very strong player to get the best result of human plus machine combination. It could sound like a heresy now but I would say that you don't want a strong player.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: You need a good operator, a decent player, but someone who will follow the machine as you guide the machine, but not to use the machine to back up his or her own ideas.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: Because instinctively, if I team up with a computer, I'll try to make my own moves.

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DEMIS HASSABIS: Yeah.

GARRY KASPAROV: You don't have to.

DEMIS HASSABIS: Yeah.

GARRY KASPAROV: All you need is just to maximize the effect of machine's play, because machines are so strong now all you need-- all you have to do is just to guide them. Sometimes, you can feel-- no, just, you know, a slight correction, move here, move there. So, it's something that requires very different kind of qualities. It's more about interface. So, you don't need a great knowledge of the game. It may help but it's-- but on the other side, it may preclude you from, sort of, using machine's power because you'll try to play your own game, which could be detrimental.

DEMIS HASSABIS: So it's something that-- you know, I think you touched on it on a few places, it's become known as Kasparov's law now, right? Something like it's--

GARRY KASPAROV: It's--

DEMIS HASSABIS: With the process it's actually more important. Do you want to explain what that is?

GARRY KASPAROV: And again, I just-- I relied on results of the freestyle tournaments. And what's happened there, that as predicted, a human plus machine beat supercomputer quite handily.

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But the most unexpected story was that, it's-- as I described, a relatively weak human or a group of humans plus machine or machines plus--

GARRY KASPAROV: Better process.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: They-- of course, they beat a supercomputer more remarkably, they beat a strong human plus a machine plus inferior process.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: So, that's led me to the conclusion that it's all about interface.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: There's so many ways of empowering machines with our creativity.

DEMIS HASSABIS: Yeah.

GARRY KASPAROV: So, not our creativity was the machine's brute force of calculation. Actually, you do it other way around and then the result is-- it could be phenomenal.

DEMIS HASSABIS: Uh-hmm. So, it strikes me, in the whole book, you're very optimistic about technology in general with-- you know, in terms of, like, what it might be able to do. What-- is-- this kind of process, is that a kind of blueprint for, you know, an advanced chess of how you see things going forwards in other areas of life with machines and humans working together in a complementary way?

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GARRY KASPAROV: I believe the future is a self-fulfilling prophecy. And I cannot stand all this, you know, doom and gloom predictions. It's-- it was quite amazing when you just look at the change of the trend in science fiction from '50s to the '60s, where it was all about optimism, us teaming up with computers, robots, cyborgs, flying to other-- not just to other planets but to other star systems. And then it's-- it changed to a very dystopian vision of The Terminator, and The Matrix.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: Oh, and by the way, just speaking about The Terminator, you know, I just-- it's-- I just-- recently, I just got an idea of just having a lecture in Dallas, Texas earlier this month. I looked at The Terminator, I said, "You know what, guys, I can tell you, that's another proof of what you call Kasparov's law, because we all watched the first one, human versus machine.

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GARRY KASPAROV: But if you follow the number two and number three, that was exactly what I said.

[laughter]

GARRY KASPAROV: Human plus machine plus a better process beats the supercomputer.

DEMIS HASSABIS: Beats computer machine.

[laughter]

DEMIS HASSABIS: That's very true.

GARRY KASPAROV: So, it's the-- yeah. And I think it's this-- what we learned from chess is that there are many ways of us, sort of, getting something new, something positive out of the cooperation. And by the way, these things are going to happen anyway.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: So, actually, what's the point of trying to slow down which is a natural cycle that we have technology replacing certain elements of human activities. For centuries, technology was there. Machines had been replacing blue collar jobs. Now, the difference is now machines are threatening people with college degree, political influence, and Twitter accounts.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: That's why we hear all these stories about it, but that's actually normal. I think that's called progress. And it's-- if machine's take over certain, you know, certain menial parts of our-- elements or aspects of recognition, that's not the end of the world.

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GARRY KASPAROV: It's-- there's still many things that humans can do. All we need is just to look for new challenges and for new frontiers.

DEMIS HASSABIS: Uh-hmm. So, we just come back from China for the AlphaGo match against Ke Jie. And one thing that happens in Go, which is slightly different than chess, is in Go, there's a [inaudible] of players thinking about how far off from optimal play are they, in theoretical God play or optimal play. So, how far do you think even the top chess computers are from optimal chess? I mean, what do you think the top Elo rating would be possible to play chess at is? Do you have an idea?

GARRY KASPAROV: No, I don't have an idea because as we briefly discussed, you know, at lunch is that when you look at the endgame databases, and now we have all seven pieces, that's, you know, 100 terabytes or whatever. And so every position is being calculated from-- you know, to the very end. And in many cases, you just-- you know, you have a position that says made in 492 moves.

[laughter]

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And I bet you that in the first 450 moves, you will not see the difference. So, I could see probably it's 420 moves, yes. But it's just-- now, I don't know what it tells about the game we play because the average human game is 50 moves. Now, when you look at average machine games, it's maybe 80, 90 moves. It doesn't mean that the game should be too long or-- what we know that, you know, the game of chess is-- the ultimate endgame is 32 pieces, so that's why I don't see any chance in any future that machine will play E2-E4 and will announce made in 16,755 moves.

[laughter]

It's not going to happen. The number of legal moves in the game of chess, 10^{45} , that's enough to feel safe. But it's not about solving the game, it's about winning the game. And I think, there's still, you know, some improvement. Machines could get better and better. It's the-- I mean, basically, the sky is the limit. And today, I still think Magnus, who was White in his good day, would probably secure a draw against the machine.

DEMIS HASSABIS: Uh-hmm.

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GARRY KASPAROV: But winning against a computer today, it's virtually impossible. It's-- the level of precision that is required, the level of vigilance, it's just-- it's impossible. So, it's-- we're not used to play with such attention.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: So, machines will get better. And by the way, we see an improvement all the time. I remember this as well by writing my books, My Great Predecessors, and then my matches against Karpov, and then my own-- my best games. And some of the games, the same games, analyzed two, three years later was just new version of the same engine. And just-- I could see that, you know, there's-- Some of the moves that I treated as great in, say 2009, in 2012, was power-- More powerful computer. I had my doubts.

DEMIS HASSABIS: Yeah, very cool. So, look, I've got so many more questions but I know I should give some time and time is moving forward, so I don't know. I should let the audience ask any questions. If you put your hand up high so I can see?

00:26:12

PERSON: I want to ask you, I was too young when the Deep Blue match happened, so I don't have any personal memories of it.

GARRY KASPAROV: You're too young, yes. I can see.

[laughter]

PERSON: But when I read stories of it, it kind of struck me that the match seemed like everyone was-- it had great publicity. But people really wanted to see whether-- well, to put it blunt, whether you would lose against the machine. And I found this really-- my question is, basically, do you feel like this was the case or do you feel it actually felt like a normal chess match, where people would see who would win? Or rather, do you feel like you had support on your side as well?

GARRY KASPAROV: Oh, yeah. I had plenty of support. I can tell you that. Most people who wanted me to lose, they were actually in the world of chess. Now, because I was the world champion for 12 years, and that was the first event I ever lost. So, that's-- naturally, a lot of people wanted me to lose one day, and since I was unbeatable in human chess, so they had their hopes in a machine.

[laughter]

[applause]

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GARRY KASPAROV: But the atmosphere there was phenomenal. And it's the-- it's-- it was a reflection of the famous cover of the Newsweek, The Brain's Last Stand. And I remember when I won game one of the match, it was a big celebration. I can even remember CNN, they talked, the two presenters, they talked about it and said, "Look, it's a Russian playing an American machine, but I'm rooting for the Russian."

[laughter]

DEMIS HASSABIS: Any other questions?

PERSON: [inaudible] from the AlphaGo team. Humans seem to be more efficient in playing both chess and Go, probably, and that they evaluate much fewer variations and positions than computers do, I mean, by many orders of magnitude probably. Can you give us an intuition of how this difference can come about? What are humans actually so good at in chess that they can do this so efficiently, and that they only need to examine so few variations as compared to computers?

00:28:23

GARRY KASPAROV: Now, we can talk about general rules, but also, you should remember that there are different playing styles because the way Karpov or myself will look at the same positions can be very different. Because I will maybe look for an opportunity to break through, just to sharpen

the game, to create complication, and Karpov will be looking for, sort of, long-term strategic advantage that could manifest in the endgame. It's-- those are the differences. What brings us together is that, as you just said, we didn't have to analyze millions of lines. We couldn't. So, we can look for one or two options. How do we know that those two options are the best? I don't know. I just simply I know that's what it is. But, again, it's the-- then, we had another subtle difference. I will probably try to go as deep as I can calculating, Karpov will try to look for an option where he doesn't have to calculate at all, so relying on his understanding because there are many patterns.

00:29:28

You can recognize patterns. And then bringing patterns together, you can have a picture, big picture. That's what humans are unique at. And that's why, for instance, if you team up with a computer, sometimes if you start calculating, it's-- that's-- I wouldn't go there. It's-- and then, it's quite interesting, like, to check whether machine's calculation proves it. But in many cases, I think it will be right, and-- especially at a time when a machine goes very deep and then reaches its horizon. And then, you also should look at the position and say-- it smells. There's something wrong. I don't know exactly what is wrong but something is wrong. There are also situations where you have to calculate when you sacrifice something. You sacrifice material and it's take it or break it, so you cannot afford to be-- to use your common sense because you have material down. So, my game with Veselin Topalov, another one, I played in 1999, that's my longest combination.

00:30:30

So, I cannot tell you that I saw every line there. It would not be true. But the combination, the final position that I saw is like, you know, lightning, just very quickly what will happen at the end, included the-- it's a [inaudible] lengths, 54 moves. So, that's-- ironically, that-- because I saw this, the final position, later the machine proved that I could win earlier. And Topalov missed the chance to-- not to escape, but to have the endgame that he could probably defend. But otherwise, it's just-- it's what you described, it's just another proof of the Moravec paradox.

PERSON: Yeah.

GARRY KASPAROV: That's the--

DEMIS HASSABIS: I was going to bring that up. You should explain what this is, because you talk about that a lot in the--

GARRY KASPAROV: Yeah, exactly. That is the--

DEMIS HASSABIS: In the book.

GARRY KASPAROV: That's-- machines are very good at what humans are not so good and the other way around. So, it's-- chess is-- it's interesting. Chess was, probably because Go and shogi, they were just played elsewhere.

00:31:32

But for the Western science, chess was an ultimate test for artificial intelligence. And that was another result of 1997 match, that the expectations of the founding fathers of computer science, like Alan Turing, Claude Shannon, Norbert Wiener, that machine beating strong chess player and, of course, the world champion, would be it. This is the moment for AI. I have to say they were wrong. So, there was these people who was as intelligent as your alarm clock.

DEMIS HASSABIS: Yeah.

[laughter]

GARRY KASPAROV: Technically don't go along but--

DEMIS HASSABIS: I actually have a theory about the Moravec's paradox, is the-- an explanation for that. If you have hand-built systems, like Deep Blue was, then as the programmers, you have to understand clearly enough what you're trying to codify explicitly, so you can codify it in the rules or heuristics like Deep Blue was. And the problem is is that for many things that we take for granted as humans, like vision or riding a bike, all these things we do implicitly, we don't explicitly understand well enough how we do those things so we can't codify it.

00:32:35

And that-- that's why I think that learning systems, the [inaudible] the AlphaGo might end up being more powerful because they could learn how-- from experience how to do those things like humans do.

GARRY KASPAROV: Well, it's-- one of the rules that I learned, you know, from my experience is that anything that we do and we know how we do, machines will do better because we can communicate it. So, it's, one way or another, to codify.

DEMIS HASSABIS: Yeah.

GARRY KASPAROV: So, the big question is now whether machines can ever do [inaudible]

DEMIS HASSABIS: The intuitive, implicit things--

GARRY KASPAROV: Things that we do without knowing how we do them.

DEMIS HASSABIS: Yeah, yeah. No, exactly. That's the big question, right? I mean, I think you say in your book, up to now, anybody who attempted learning systems, including your great teacher, Botvinnik, fell short against the--

GARRY KASPAROV: Oh, yeah. They--

DEMIS HASSABIS: Against the-- especially the hand-coded systems.

GARRY KASPAROV: Fifty years ago, forty years ago.

DEMIS HASSABIS: Yeah.

GARRY KASPAROV: Because it's-- in the beginning, there was a big debate.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: And I think that it's-- I mean, Turing, people know, by the way, that he wrote the first program. In 1952, there was a chess program and the trick was that there was no computer.

[laughter]

00:33:37

DEMIS HASSABIS: Yeah.

GARRY KASPAROV: It's the only game that the Turing program--

DEMIS HASSABIS: Executed by hand.

GARRY KASPAROV: Yes, exactly. Just-- you know, just-- he put it on a piece of paper and calculated the moves, and when I spoke at the centenary, so I asked my friends from Germany, they actually reconstructed it and put it in a computer.

DEMIS HASSABIS: How cool.

GARRY KASPAROV: You can actually play a Turing machine.

[laughter]

GARRY KASPAROV: Pretty weak but it's from 1952.

DEMIS HASSABIS: Yeah.

GARRY KASPAROV: So-- but they believe-- and that's interesting. They believe that the way to make machines playing chess, it's not brute force, but understanding. But it's-- it failed-- this concept failed very quickly because brute force kept coming and just, you know, it's what like-- it was like avalanche. They couldn't stand a chance. So, that's why the old attempts, including one of my great teachers, Mikhail Botvinnik, to come up with this parallel concept of learning, failed. And by the end of the '60s, early '70s, it was just-- it was-- it-- the story was over. Now, it seems that we are just like in seasons, we're going back to this notion and maybe it will prove to be superior.

00:34:37

DEMIS HASSABIS: Well, hopefully, AlphaGo will make Botvinnik happy, then. You know, it's his sort of a learning system, right? So, it turns out that Go needed to happen. What do you think the difference is between Go and chess that required Go to have-- you know, have to have this other approach? You know, that they couldn't do with the handcrafted approach.

GARRY KASPAROV: You know, it's a tough question because I have nearly absolute knowledge of the game of chess and almost zero knowledge of the game of Go.

DEMIS HASSABIS: Yeah.

[laughter]

GARRY KASPAROV: Yeah. So-- but from what I know is that it's-- the Go doesn't have the same tactical configuration. So, you have to-- it's all about strategy. It's just, you know, it's a long-term and that's why it's far more difficult for machines to learn how to do that. But also, if machines could do it at a certain level, then they could be deadly for humans because it's-- they suddenly become superior. So, my-- and, again, I'm not sure since I'm speaking to a great expert.

00:35:37

I still think that relatively it's-- if you compare the strengths, I think the chess playing engines are relatively stronger than AlphaGo.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: It's in absolute ratings.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: Now-- but then you look at it is-- but then the gap between-- it's-- just because the mistakes made by human players in Go, they are deadlier. They are just-- you know, they could offer more openings for the machine. So, in chess, the human game is always unstable.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: So, it's not as steady as the machine. But I think, in Go, the depths of the mistake could be far more significant than in chess.

DEMIS HASSABIS: I guess we'll have to put that to the test by teaching AlphaGo chess to play chess, right?

[laughter]

And then we will have-- we will see.

GARRY KASPAROV: I see. That's-- that will be interesting, you know.

DEMIS HASSABIS: Yeah.

GARRY KASPAROV: So, how soon AlphaGo can crush the strongest chess engines.

DEMIS HASSABIS: Uh-hmm. Uh-hmm.

GARRY KASPAROV: Again, it's what I said, it's not about AlphaGo but it's about the nature of the game Go and chess. But, you know-- So--

DEMIS HASSABIS: So, would you be pretty surprised if a learning system could beat the hand-crafted system ever in chess?

00:36:39

GARRY KASPAROV: It's-- look, it's-- there's this-- that will be another level of experiment because the current systems, they-- it's not primitive brute force anymore now.

DEMIS HASSABIS: Uh-hmm.

GARRY KASPAROV: It's-- that's why I said, it's-- today, any-- and by the way, that's-- the moment I say it, people will just, you know, look at me in disbelief from nonprofessional audiences. I say the free chess app on your mobile phone is stronger than Deep Blue. They'll say, "Ah, no, no, no." "You are sore loser." Yes, I'm a sore loser.

[laughter]

It doesn't change. You know, this is the fact. This is the--

DEMIS HASSABIS: Absolutely, absolutely.

GARRY KASPAROV: Yeah. It's the--

DEMIS HASSABIS: No, very good. So, I don't know if there's a last question from the audience. We have time for one or two more. Yes, from the lady at the front.

GARRY KASPAROV: Wow.

[laughter]

PERSON: If you could, would you play Deep Blue again?

GARRY KASPAROV: Oh. Oh, God.

[laughter]

Yeah. There's-- the-- there are a couple of problems. One, I'm retired and I don't play professional chess. Two, Deep Blue is dead.

[laughter]

00:37:36

Yeah. I wanted to play in 1998 and I wish I had a chance but that's it. You know, that's old history. It's spilled milk, water under the bridge, you name it. But I-- you know, I played other computers. And as long as I was an active chess player, I never ducked a challenge. And that's why, you know, there's this-- the-- this book begins with the story of me playing 32 chess computers in 1985, a simultaneous exhibition. I'm not sure, but anyone owns-- still owns the chess machine that's from-- antique chess machines? Anybody here?

DEMIS HASSABIS: Yeah, I still have one. I still have one.

GARRY KASPAROV: You still have one?

DEMIS HASSABIS: Yeah, I might have one called Kasparov's version. Yes.

GARRY KASPAROV: Okay. Okay. Yeah. This is it. So, I played. It's 32 machines. And there were four manufacturers, eight machines each.

00:38:36

And I won all the games, most amazing thing that nobody was surprised. And I can tell you the progress. It's just from that match in 1985, just-- I played in June, just a few months before I won the title beating Karpov to my match with Deep Blue, just 12 years. It tells you that something is happening. And-- but I couldn't help but reminding people about this match in 1985 because I say that was the golden age. Yeah, machines were weak. My hair was strong.

[laughter]

DEMIS HASSABIS: Yes. We're entering another very exciting, I think, interesting era. Look, I think-- let's all thank Garry for an amazing discussion and--

GARRY KASPAROV: Thank you.

[applause]

DEMIS HASSABIS: Thank you, Garry.

GARRY KASPAROV: Thank you. Thank you.

DEMIS HASSABIS: Thank you very much.

[mellow music]

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[mellow music]