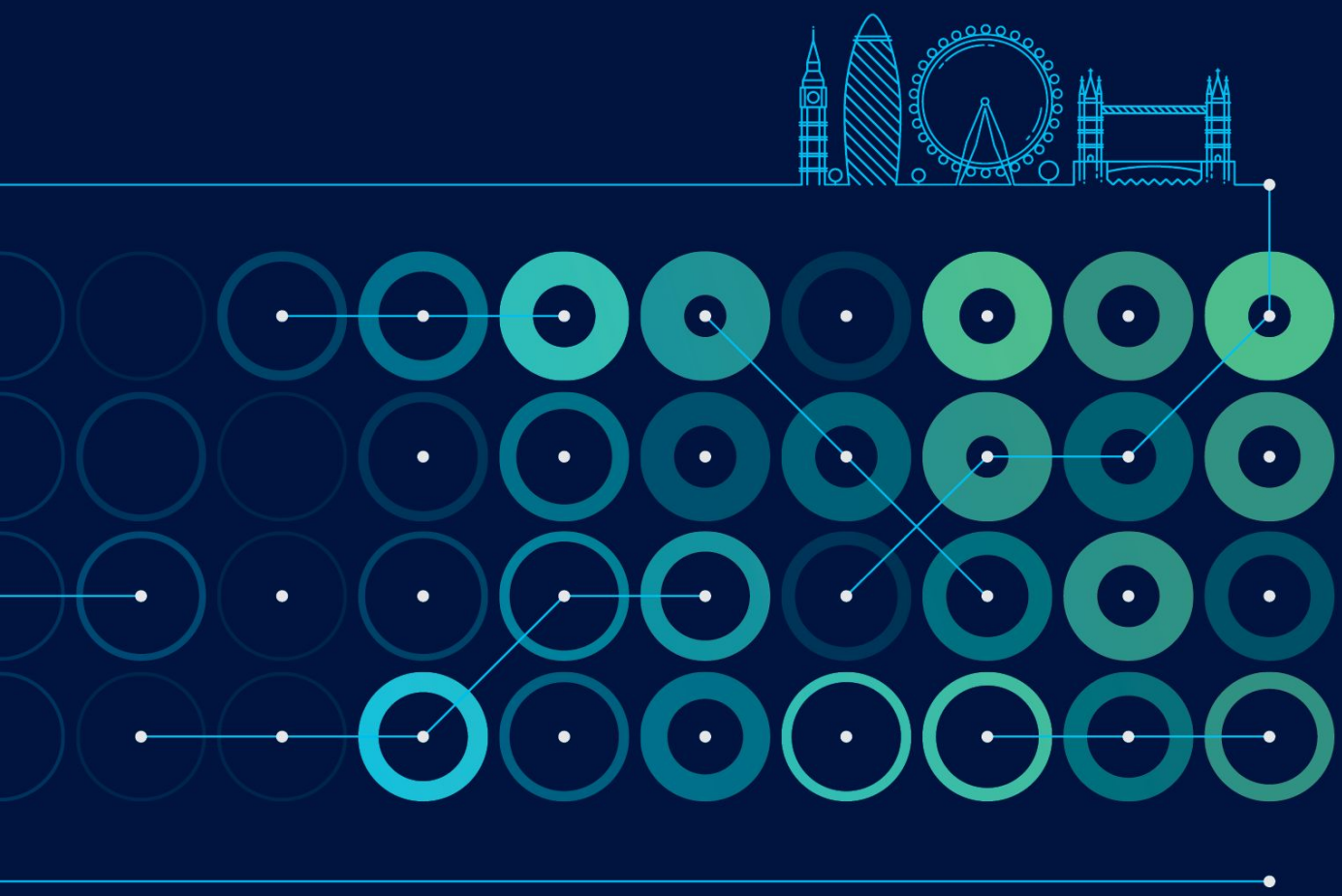
Google DeepMind

Challenge Match

8-15 March 2016



Game 1: “Dawn”

Commentary by Fan Hui

Go expert analysis by Gu Li and Zhou Ruiyang

Translated by Lucas Baker, Thomas Hubert, and Thore Graepel

Dawn

I sometimes suffer from insomnia during important tournaments, but I slept well before the first game of this match. Perhaps it was because I was not the one playing. At breakfast, everyone on the team displayed some tension, but as for me, I was already free of doubts.

I entered the playing room at 12:35, twenty-five minutes before the match was due to start. Some members of the staff were testing the cameras one last time. A make-up artist called me to put powder on my face, to prevent the light from reflecting. Everyone looked very busy, but the real cause of the activity was just to occupy us while we waited.

At 12:40, Lee Sedol entered the room with his wife and daughter, and sat down in front of the Go board. His daughter looked at him inquisitively, as if this was the first time she had accompanied her father to an official match. Lee smiled back at her.

After the staff explained a few details about the live broadcast, Lee exited the room. The minute he left, without knowing why, I felt a strange sense of pressure descending. It was not the pressure of anticipating the outcome, but rather of uncertainty - of not knowing what would transpire when the match began.

The playing room was actually quite sizeable. Apart from the Go board and the referees' table, there was a space for the AlphaGo team and VIPs to experience the game up close, complete with a screen for the commentary. The cameras did not face this section, so the audience would only see the players and the board.

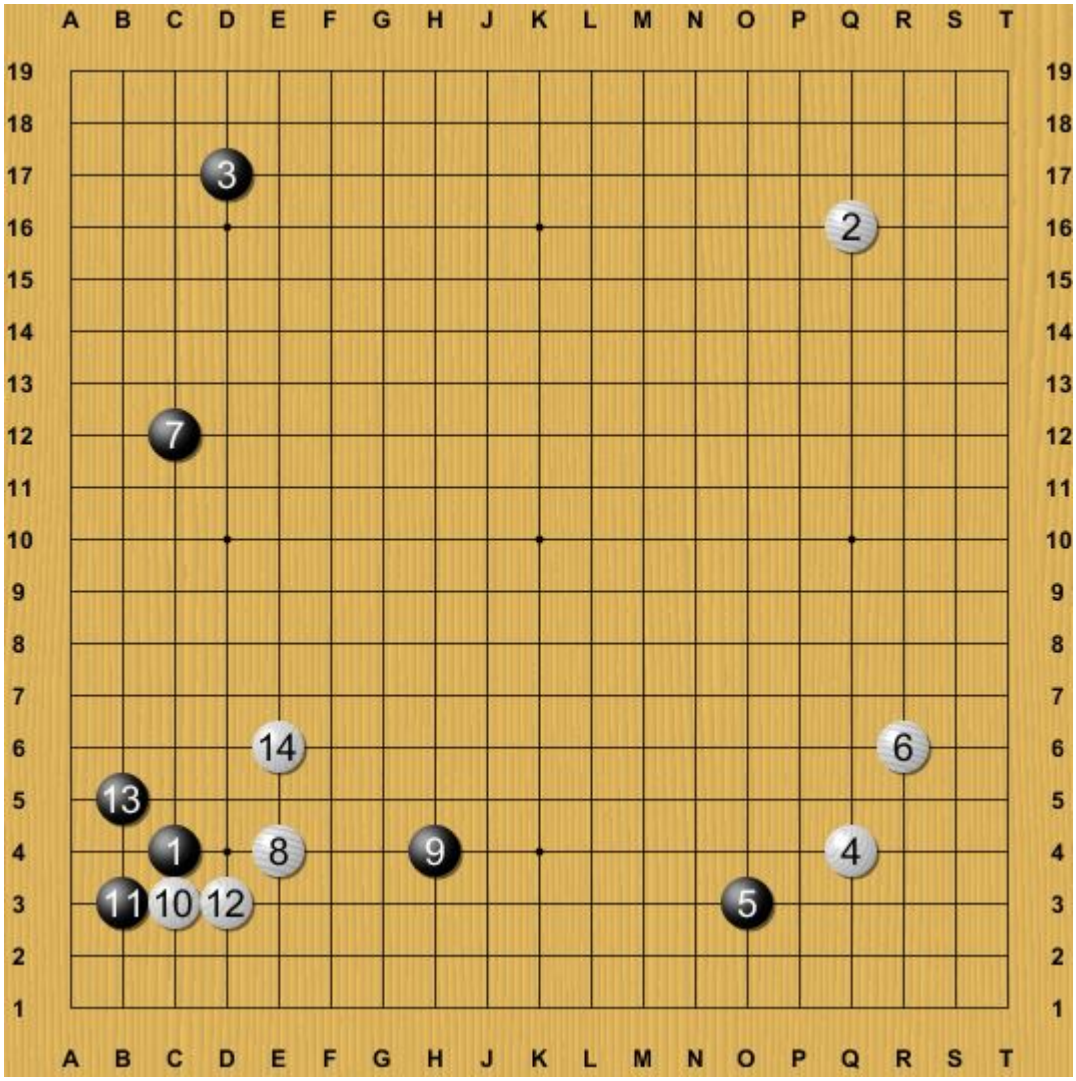
At 12:47, two Korean referees entered the room. One was a professional 8 dan, whose main role would be to announce the beginning of the game and the final result. A different professional would take on this role each day. The other was a woman, reportedly an amateur player, who would be in charge of reading out the seconds during byo-yomi. Like me, she would be here for every game. Myself, I had only one role: to count the final score if the game reached an end and neither player had resigned. Due to the language barrier, the other referees and I could only communicate by nodding our heads, but I could still see in their eyes their absolute confidence in Lee Sedol's victory.

Because this was the first game of the match, everyone looked a bit tense. No event of this scale had ever taken place in the history of Go. Although Google had no prior experience in organizing Go competitions, they had conscientiously seen to every detail: the camera angles, the timings, the order in which the players should enter, the setup of the postgame press conference, and everything else. Even we Go players can learn from the professionalism, enthusiasm, and sincerity they displayed in organizing this match.

As the countdown on the screen hit zero, Lee Sedol and Aja Huang entered the room and took their seats. Following the nigiri, Lee Sedol chose Black. Interestingly, even if the difference is minute, it is clear from AlphaGo's data that it prefers White.

After thinking for just thirty seconds, Lee placed the first black stone. The historic battle had begun!

Moves 1-14



Lee Sedol quickly played the two 3-4 points, followed by Black 5, another very common move. Next, after a minute of reflection, Lee played at 7! A new fuseki, perhaps? Or was it a strategic ploy? If Lee thought that AlphaGo's knowledge was based on pattern recognition from existing games, then playing a move no professional had played before might confuse it. In reality, Lee had underestimated AlphaGo.

Faced with a strange move like 7, a human player would no doubt take some time to think, as the first impression would be that the opponent is laying a trap. Imagine two kung fu masters locked in battle. If one makes an unusual move, the other would surely react with caution to avoid being caught out. However, there is no concept of "fear" in AlphaGo's dictionary. It knows only one strategy: constantly adapting to the present situation.

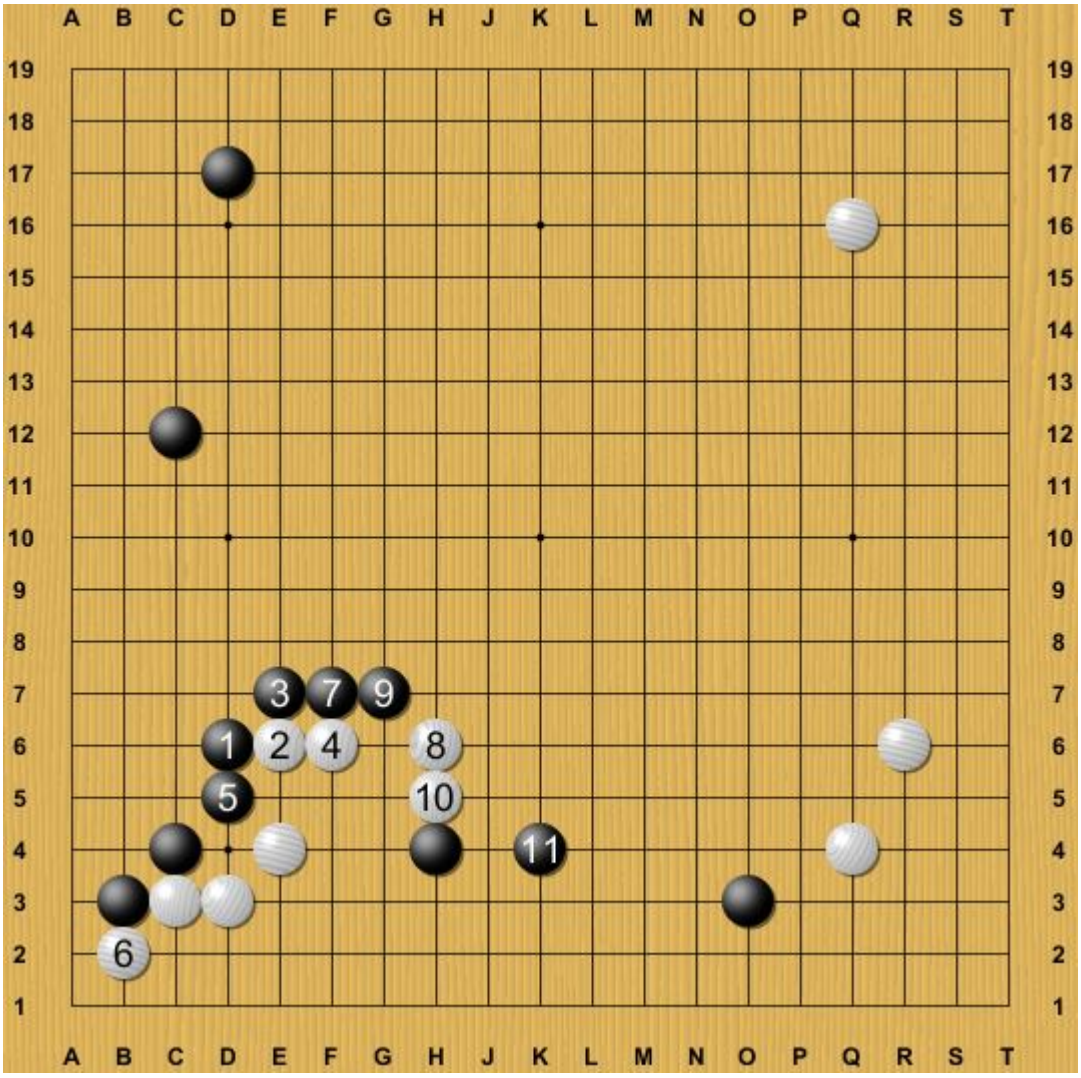
Against White's approach at 8, Lee quickly pincered at 9, as if he had prepared this response. When White attached in the corner at 10, Lee instantly blocked at 11. The classic thinking is that this way of playing is very heavy for White, not only strengthening Black's corner, but turning 9 into the perfect attacking move. Could it be that AlphaGo did not know the joseki? When the players in the commentary room saw White 10 and 12, everybody thought Lee had exposed a problem in AlphaGo's opening. After all, our first impulse when passing judgment is to look within the scope of our existing knowledge. However, this can

sometimes distract us from the essence of the problem. Were the black stones on the left side truly working well together?

When White jumped at 14, the feeling in the room suddenly changed. The black stones on the left were too low, and Black's formation was nothing to be proud of after all!

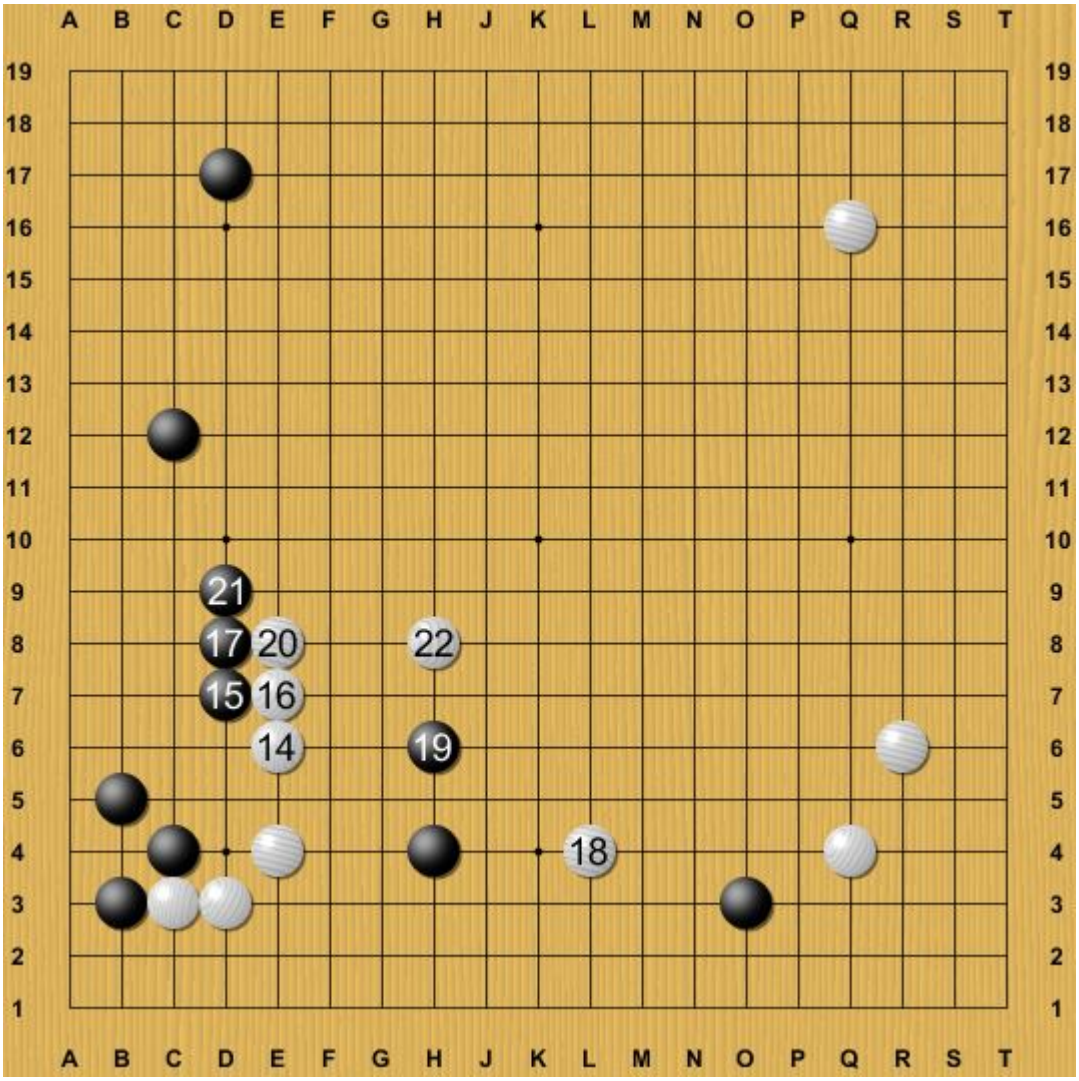
In fact, at this moment, AlphaGo already felt that the game had begun to favor White. According to its analysis, the problem lay in the tiger's mouth at Black 13, and Black should have chosen Diagram 1.

Diagram 1



If Black plays the knight's move at 1, White will attach at 2 to avoid being enclosed, and Black can continue to press with 3, 7, and 9. Through 11, Black's formation on the left is clearly better than the game.

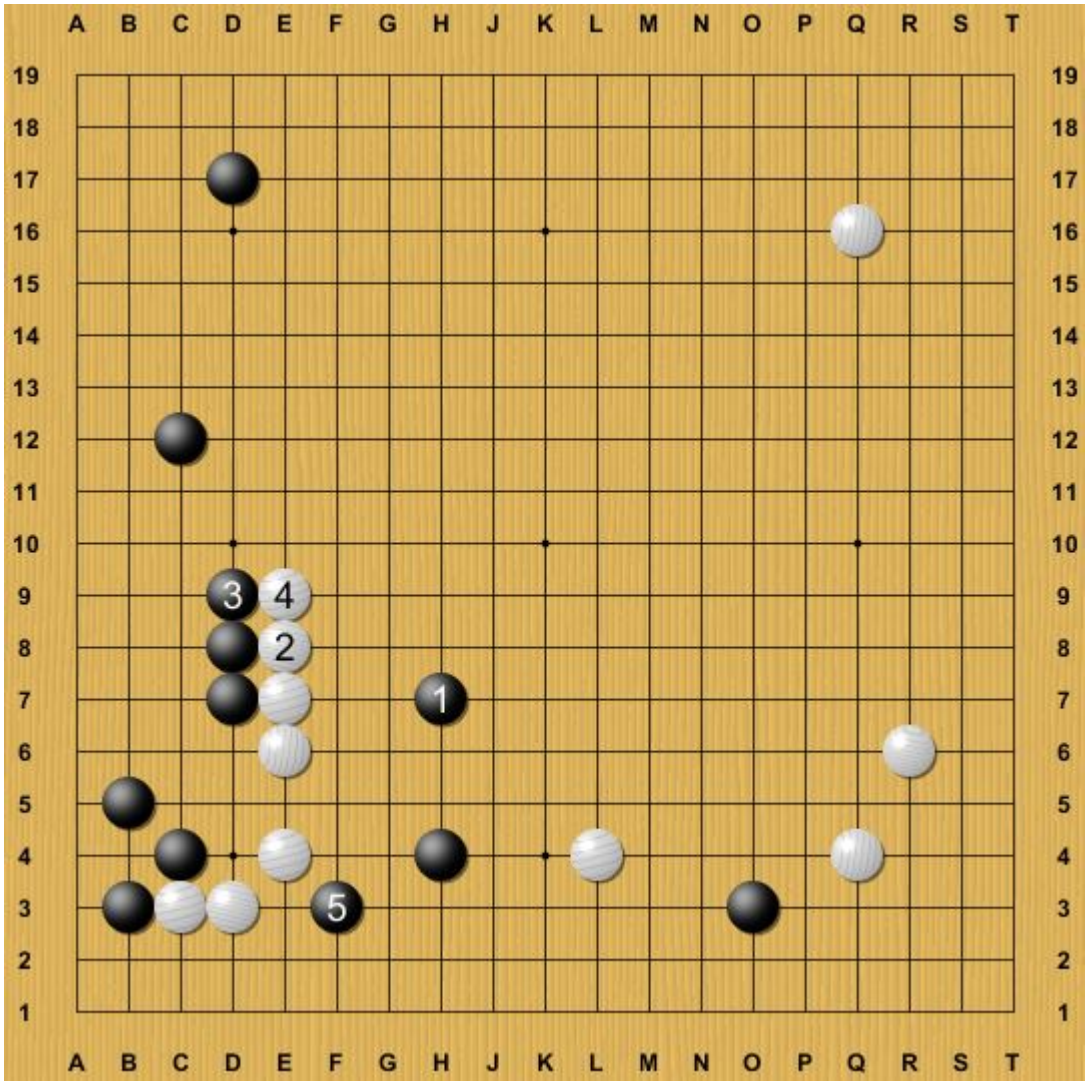
Moves 14-22



Although many professionals already thought the result was unfavorable for Black, Lee still looked confident, and played 15 and 17 almost instantly. When White played 18, however, Lee hesitated. For the first time since the game began, his hand left the bowl of stones. He pressed his left index finger to his upper lip, and started tapping the right one against his leg. He seemed to realize things weren't going as well as expected. Of course, when circumstances take a sudden turn for the worse, the pressure can be difficult to handle.

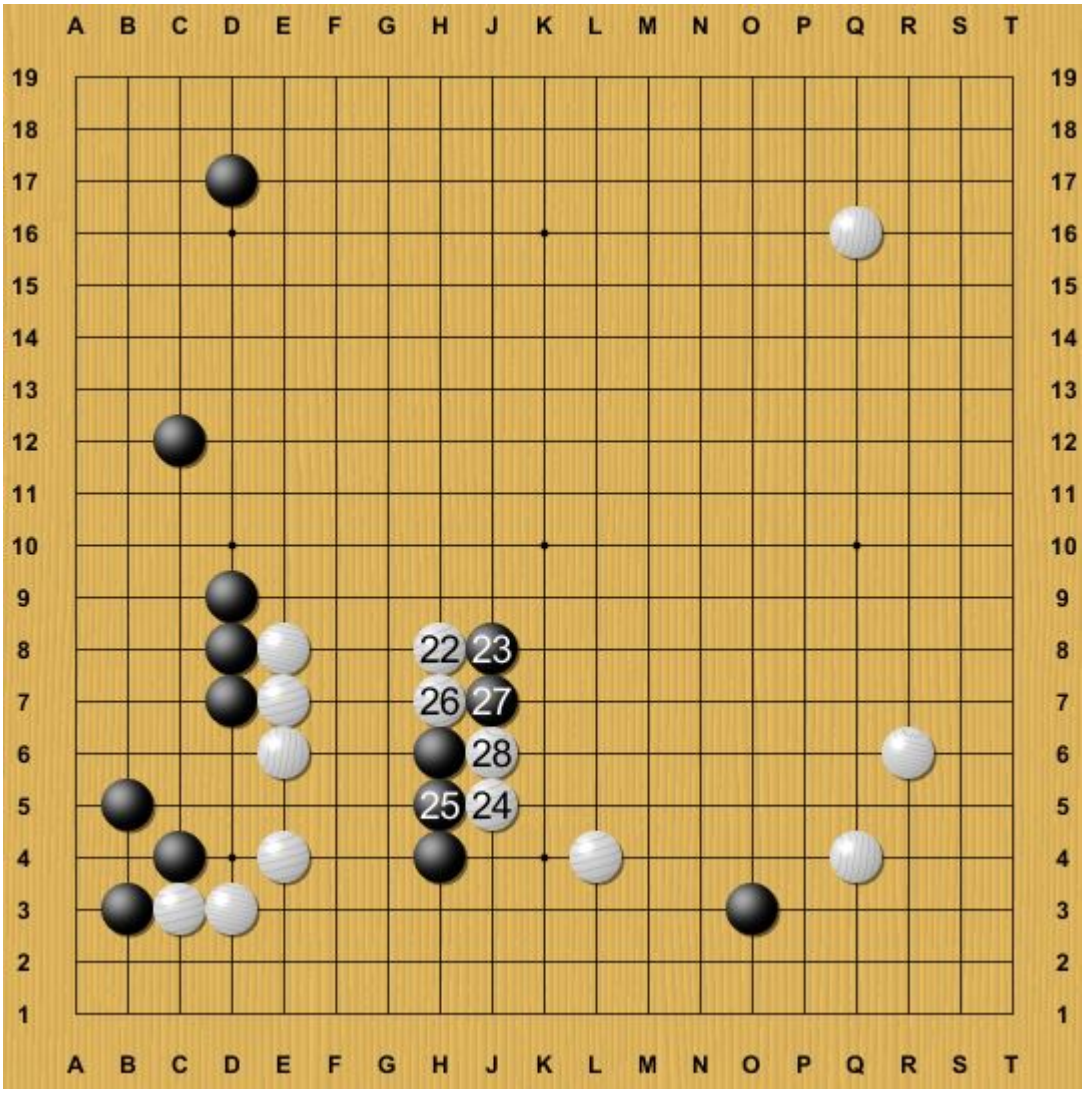
Lee responded steadily with the jump at 19, and after exchanging 20 for 21, AlphaGo capped at 22. In AlphaGo's judgment, Black's jump had been too slow and White had already taken the lead, with a win rate of 54%. See diagram 2 for an alternative.

Diagram 2



The two-space jump at 1 looks more dynamic. White pushes with 2 and 4, and Black destroys White's eye shape with 5. This variation will lead to a complicated fight.

Moves 22-28



In response to white 22, Lee quickly attached at 23. Subconsciously, he may have believed that AlphaGo would be unwilling to initiate a fight. At the same time, 23 was very much his style, a move brimming with fighting spirit.

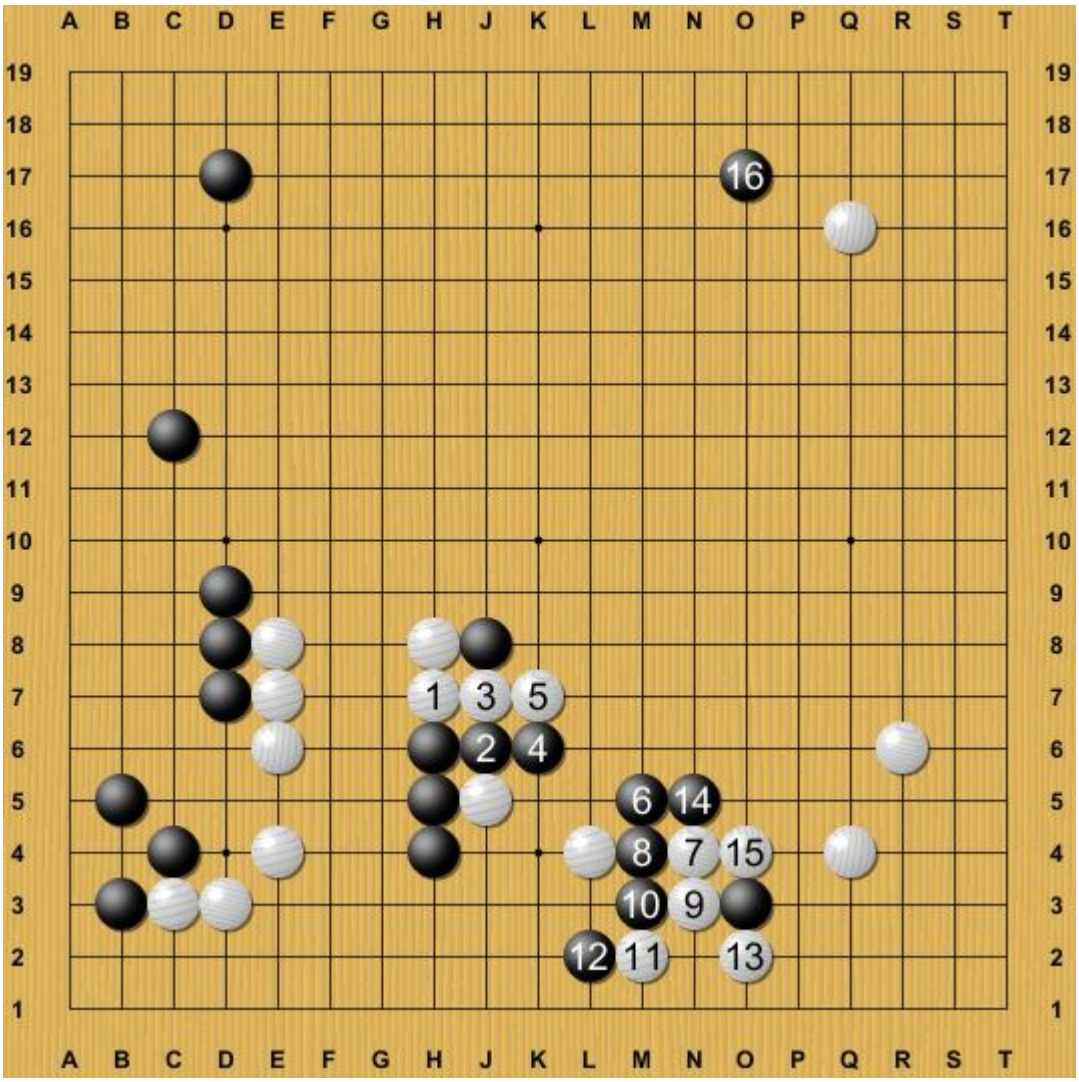
After the game, many commentators questioned Black 23, but this was AlphaGo's suggestion as well. In this case, it seems great minds thought alike.

However, when White peeped at 24, Lee slowed down. He sighed, as if realizing he was in for a hard game.

Black had to connect at 25, but White continued severely with 26! This move challenged Lee to make the game's first crucial choice: War, or peace? It is impossible to calculate every variation fully, so how to choose? For most players, the decision is a combination of personal style and a feeling for shape. At the same time, it is important to consider the opponent's intentions. For instance, did White pause before playing 26? Did White look pleased or dissatisfied with the previous position? Normally, reading the opponent is one of Lee's strong points. Thanks to his exquisite perception, he can pick whichever way of playing gives him the greatest advantage.

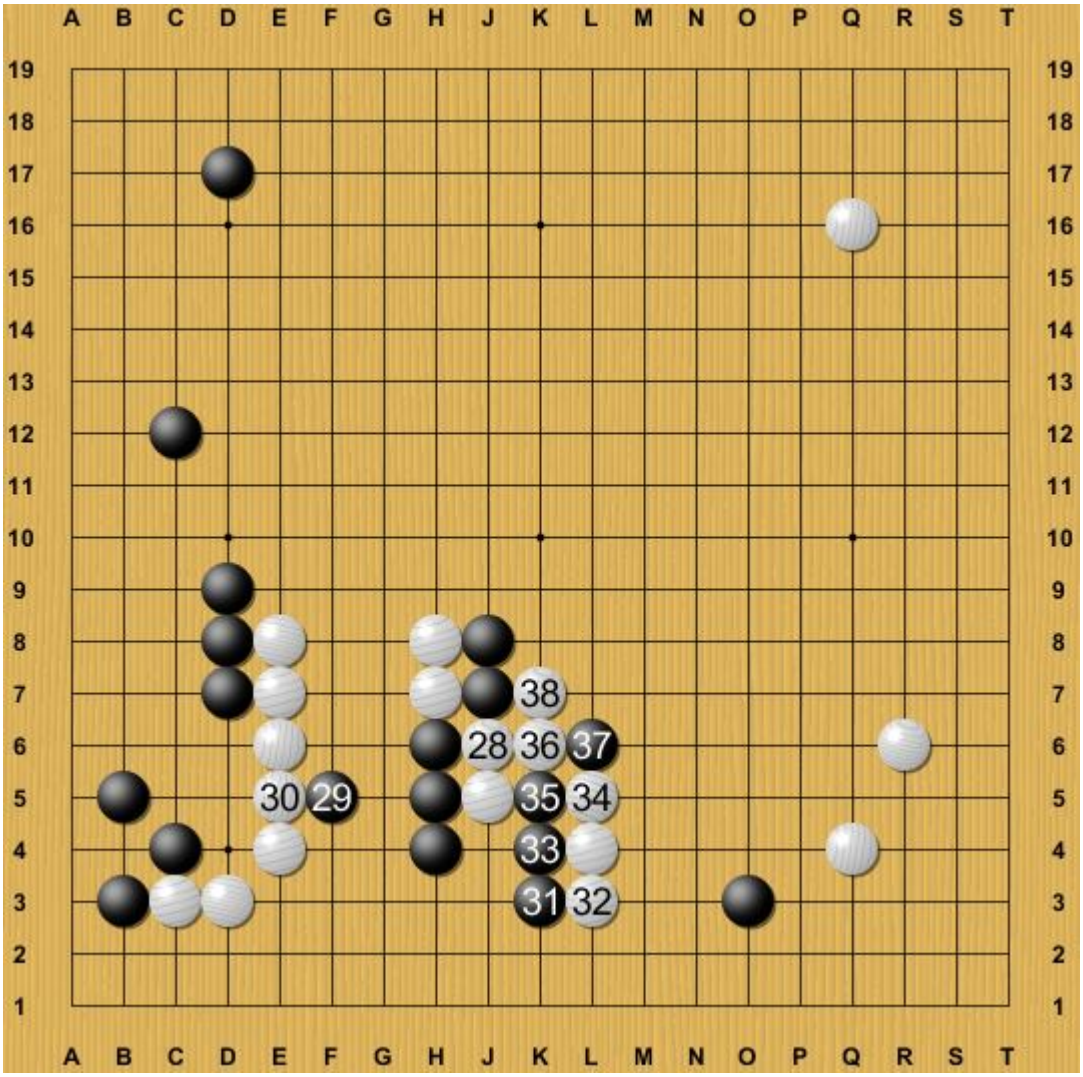
This time, however, he hesitated. Since the start of the game, AlphaGo had played at a constant rhythm, with no sign of doubt or confusion. It felt as if every move were inevitable. This was the first time in the match that Lee found himself at a crossroads, and he had no intention of backing down before a machine. So, after three minutes of thought, Lee resolutely blocked at 27, and White cut at 28. At this point, AlphaGo's win rate rose to 56%. In AlphaGo's judgment, Black should have followed diagram 3 and turned at 28 after all.

Diagram 3



AlphaGo thinks Black should turn at 2. Although the tesuji at 7 gives White a local advantage, Black comes out with sente to approach the upper right with 16. Globally, Black is by no means behind.

Moves 28-38

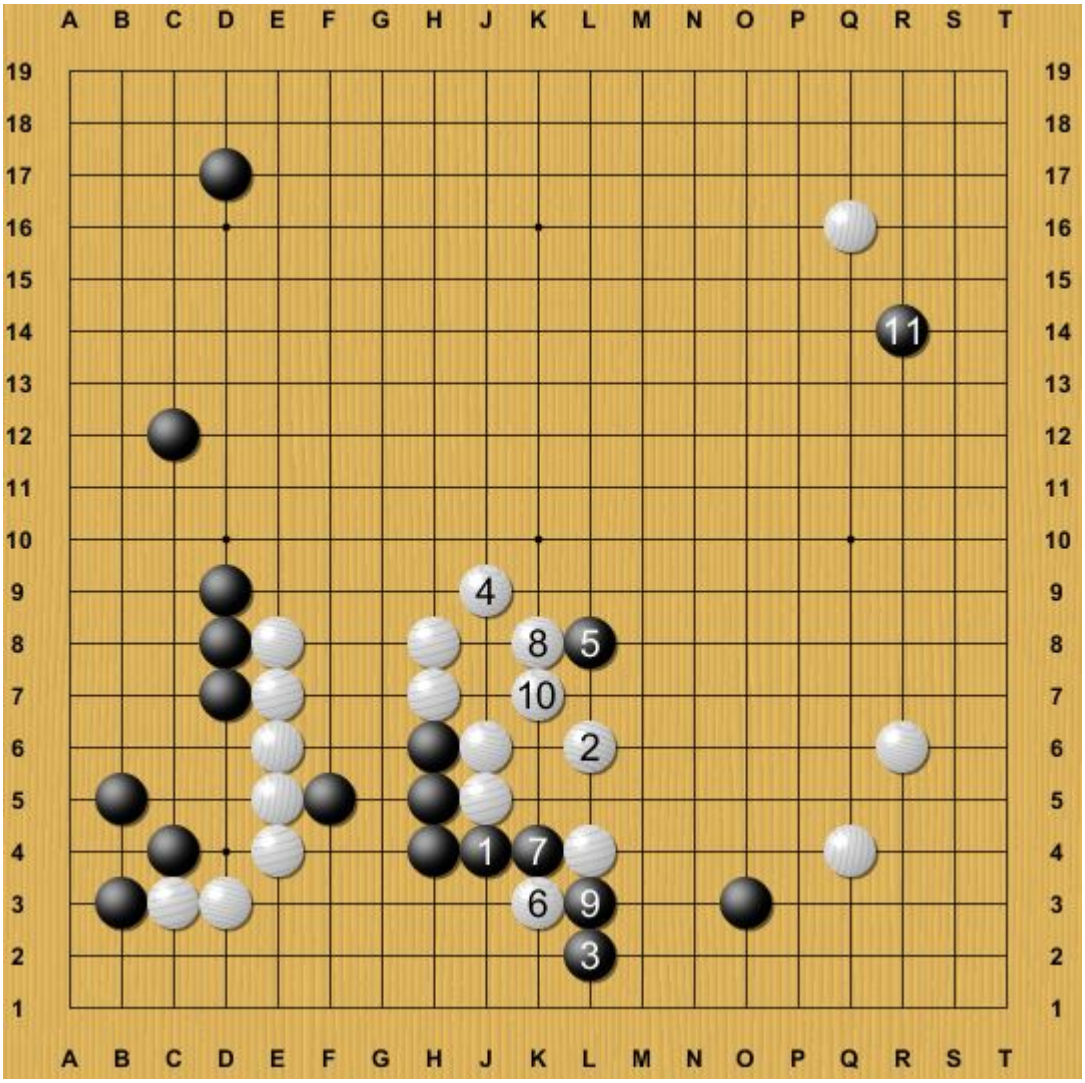


Black peeped at 29 and White connected at 30. At this point, Lee Sedol had 1 hour and 43 minutes remaining, AlphaGo 1 hour and 44 minutes.

Black 31 continued to probe White's intentions. Lee was asking AlphaGo, “Dare you block?” Without hesitation, AlphaGo did. The curtain rose on the first major battle, and the moves to 38 were a one-way street. However, AlphaGo only grew more and more confident, its win rate reaching 58%. According to AlphaGo, Black should follow diagram 4, but when I showed this variation to Gu Li and Zhou Ruiyang, their faces paled. "If you show this to Lee Sedol, he'll think you're joking!" they exclaimed. Many people have asked me what AlphaGo's style is - it would at least be fair to say that its sense of global and local differs dramatically from human evaluations.

After move 33, Lee had 1 hour and 40 minutes, AlphaGo 1 hour and 43 minutes.

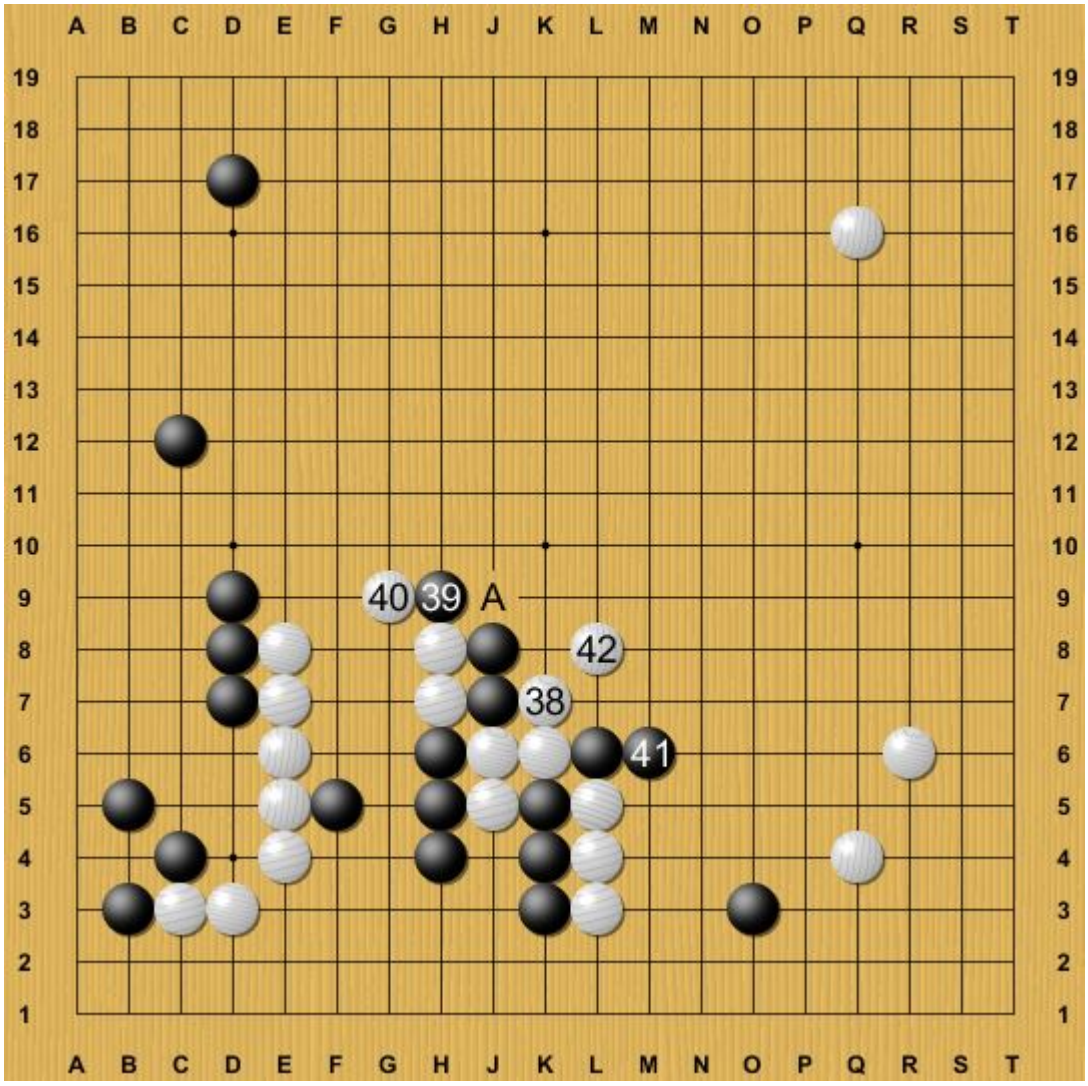
Diagram 4



AlphaGo suggests this alternative to Black 31. Black's aim with 1 and 3 is easy enough to understand, but the price of this connection is sacrificing two critical stones in the center! I fear there is no professional in the world today who would consider this variation. The theory says "a ponnuki is worth 30 points," and here Black has sacrificed not one stone but two! Moreover, the stone at 5 is now utterly useless.

It is important to understand that AlphaGo never thought this result was favorable for Black, only that this way of compromising loses the least. AlphaGo does not debate whether a result is "acceptable" or "unacceptable." In its view, each moment is unique, and the only objective is to seek the highest win rate in every position.

Moves 38-42

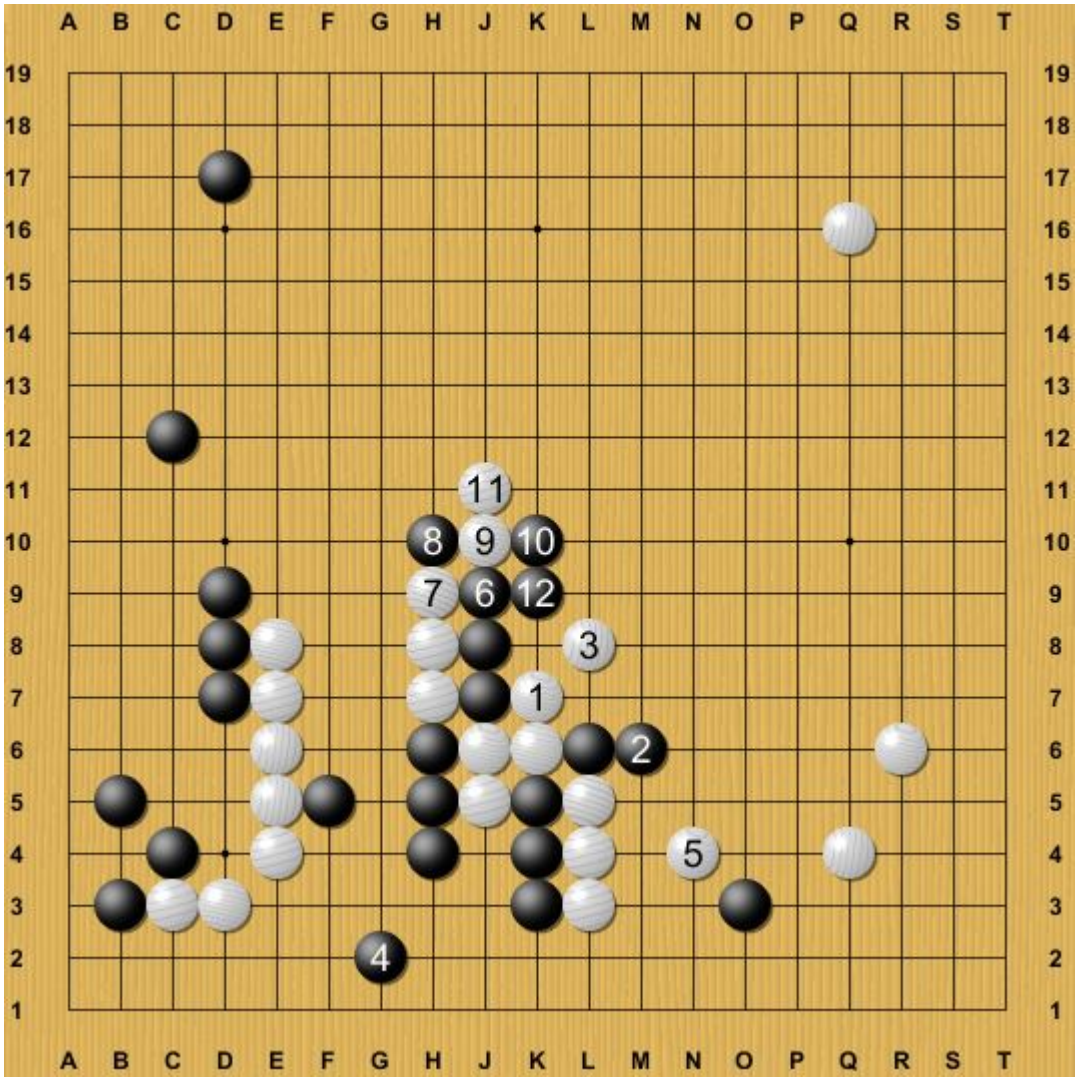


White turned at 38, and AlphaGo's win rate continued rising to 59%.

Many commentators asked why White chose 42 instead of A. In fact, when White played 42, AlphaGo's win rate had already reached 64%, and AlphaGo thought exchanging 39 for 40 was unnecessary. In any case, White is not particularly eager to capture the two stones. See diagrams 5 and 6.

At move 39, Lee had 1 hour and 34 minutes, AlphaGo 1 hour and 39 minutes.

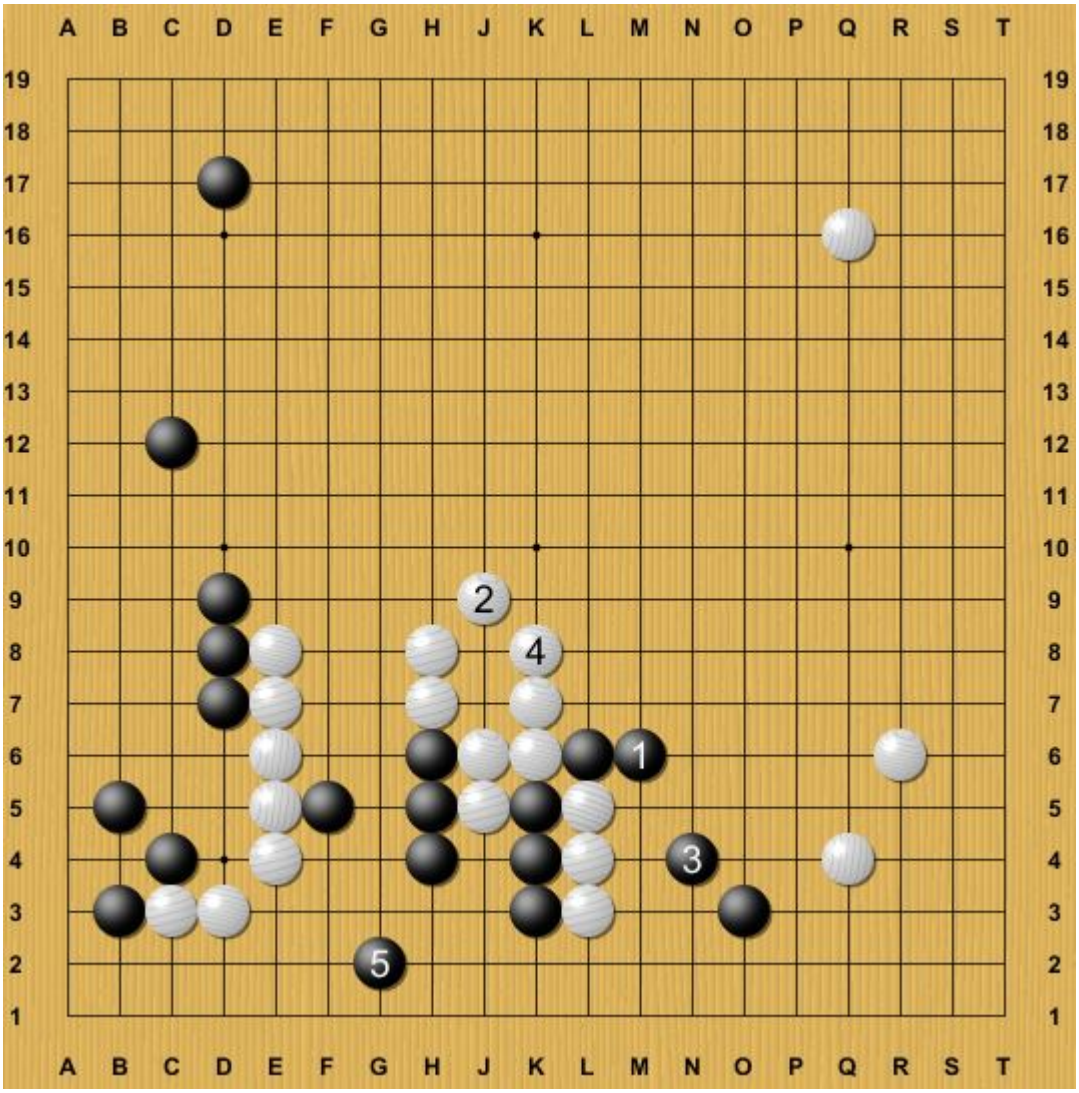
Diagram 5



AlphaGo thinks Black should extend directly with 2. White will not capture the two stones in a ladder immediately, since it would lead to the result in diagram 6.

When White saves the three stones at 5, Black can go back to extend at 6, and the shape is clearly better than the game. Gu Li and Zhou Ruiyang approved of this sequence.

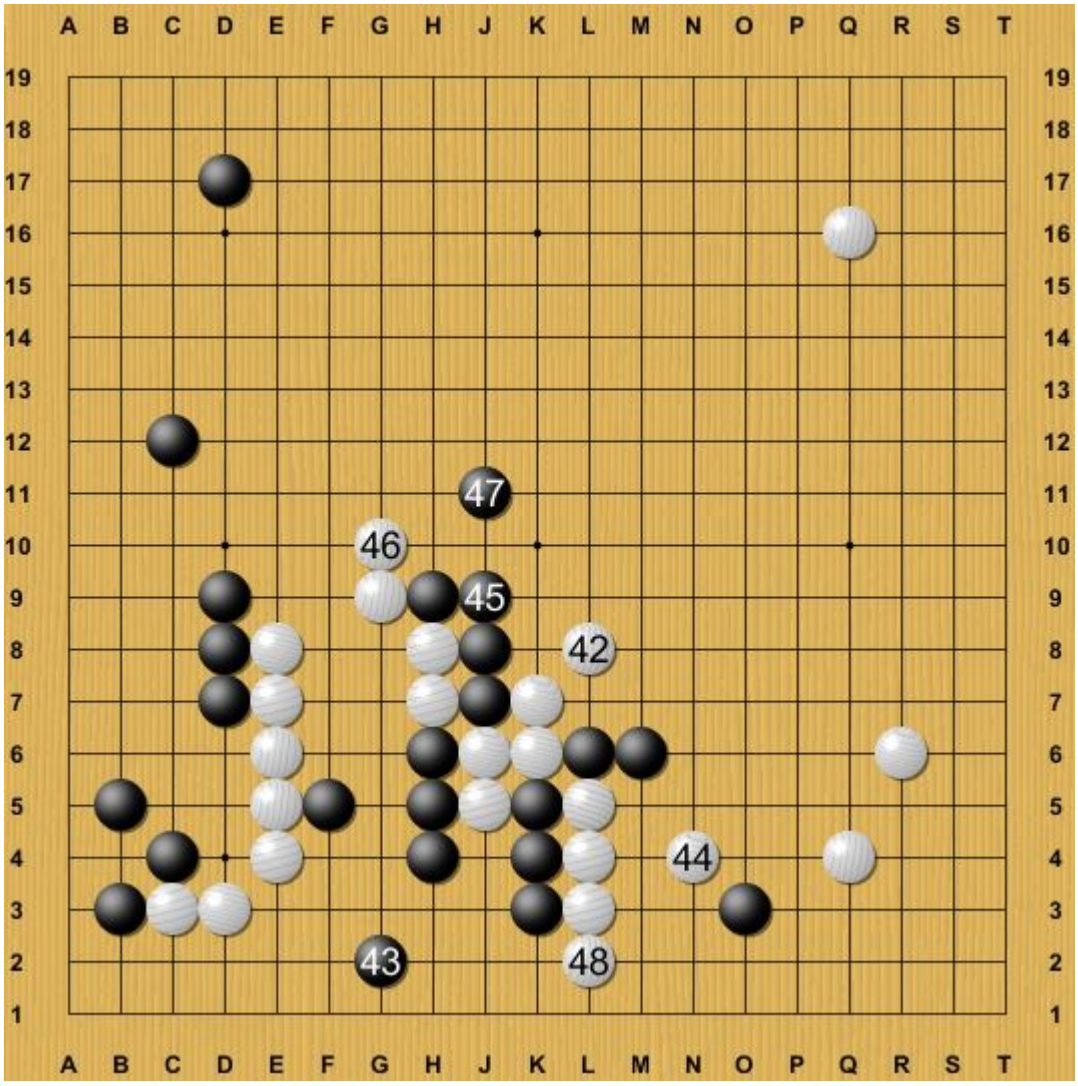
Diagram 6



Of course, White can capture the two black stones in a ladder, but Black simply swallows up the three White stones with 3. The difference between this and diagram 4 is obvious, as Black's territory here is clearly superior.

Since it is so ingrained that letting White capture this way would be unacceptable, Lee may well not have considered sacrificing the two stones, which would explain Black's passive play during this fight.

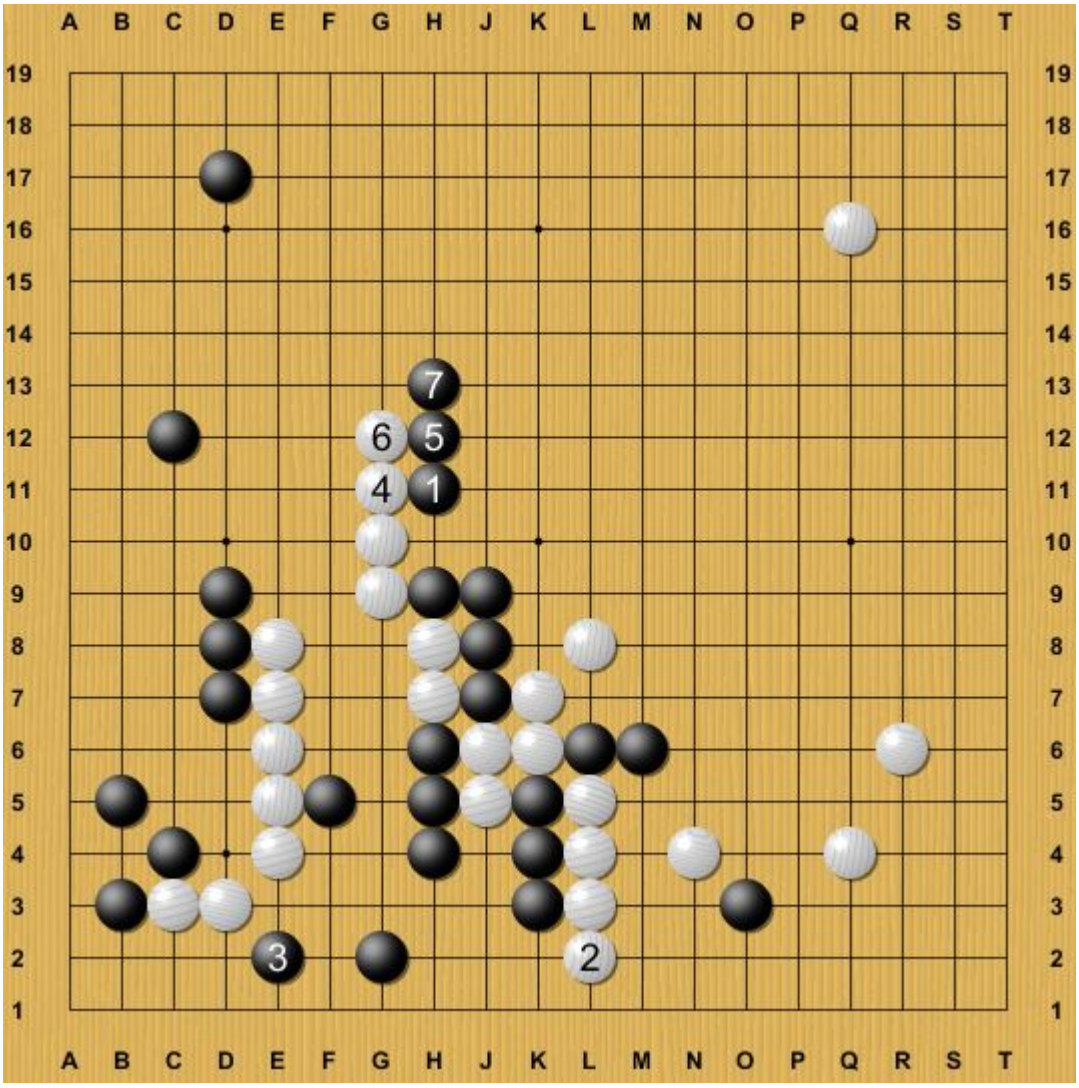
Moves 42-48



At this point, Lee was pausing to think after each move, no longer laying down stones one after another as he had in the opening.

White 44 was mandatory. After the kosumi at 42, the value of the center two stones had decreased markedly. When Black jumped at 47, White descended at 48 to trigger a series of forcing exchanges. Many commentators thought this unnecessary, but from AlphaGo's perspective, the win rate continued climbing to reach 66%. Did AlphaGo think Lee had made another mistake? See diagrams 7 and 8.

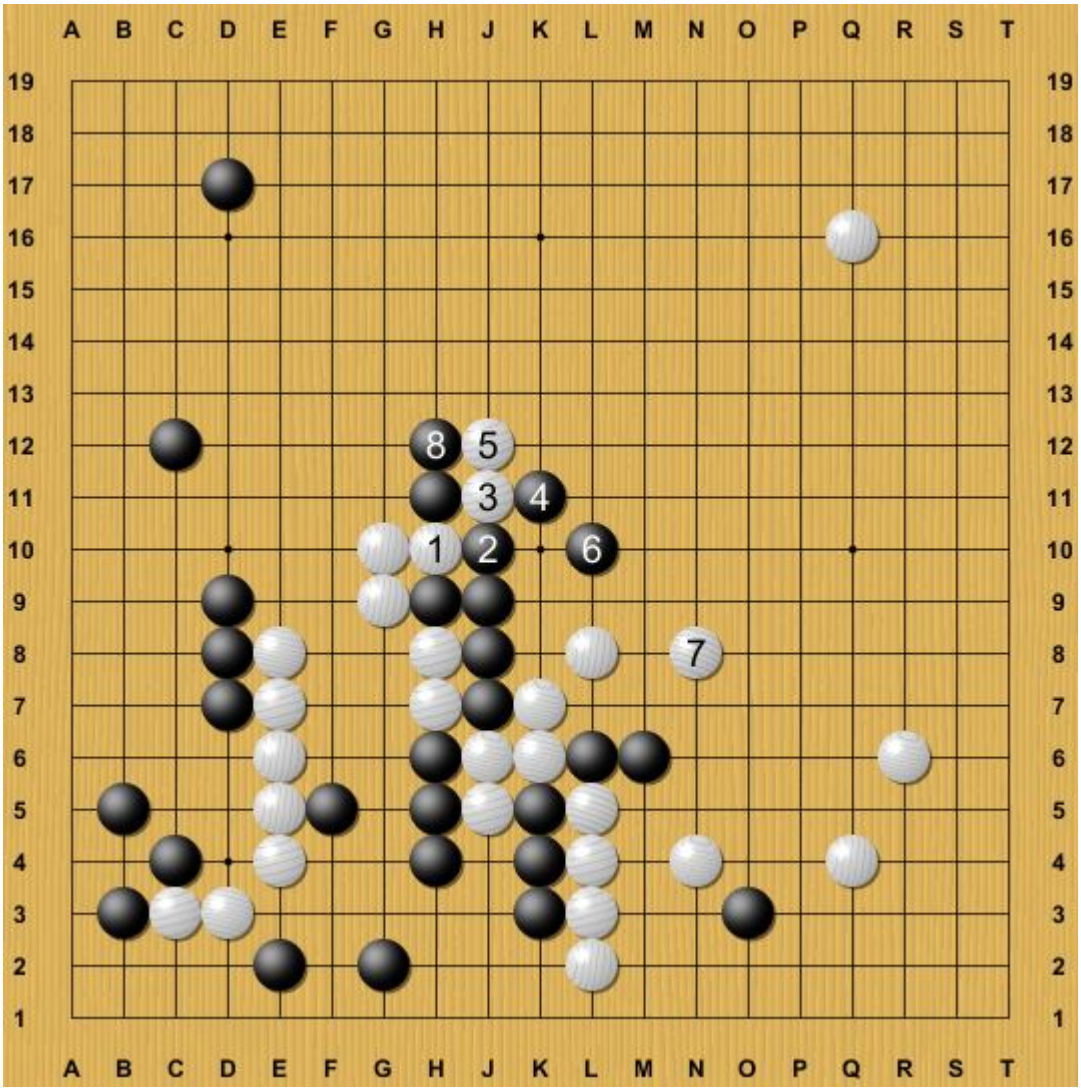
Diagram 7



Black can play more strongly with the jump at 1. To compensate the losses on the right, Black must intensify the pressure on the left. White will still play 2, then push out with 4 and 6. Black's shape is better than the game.

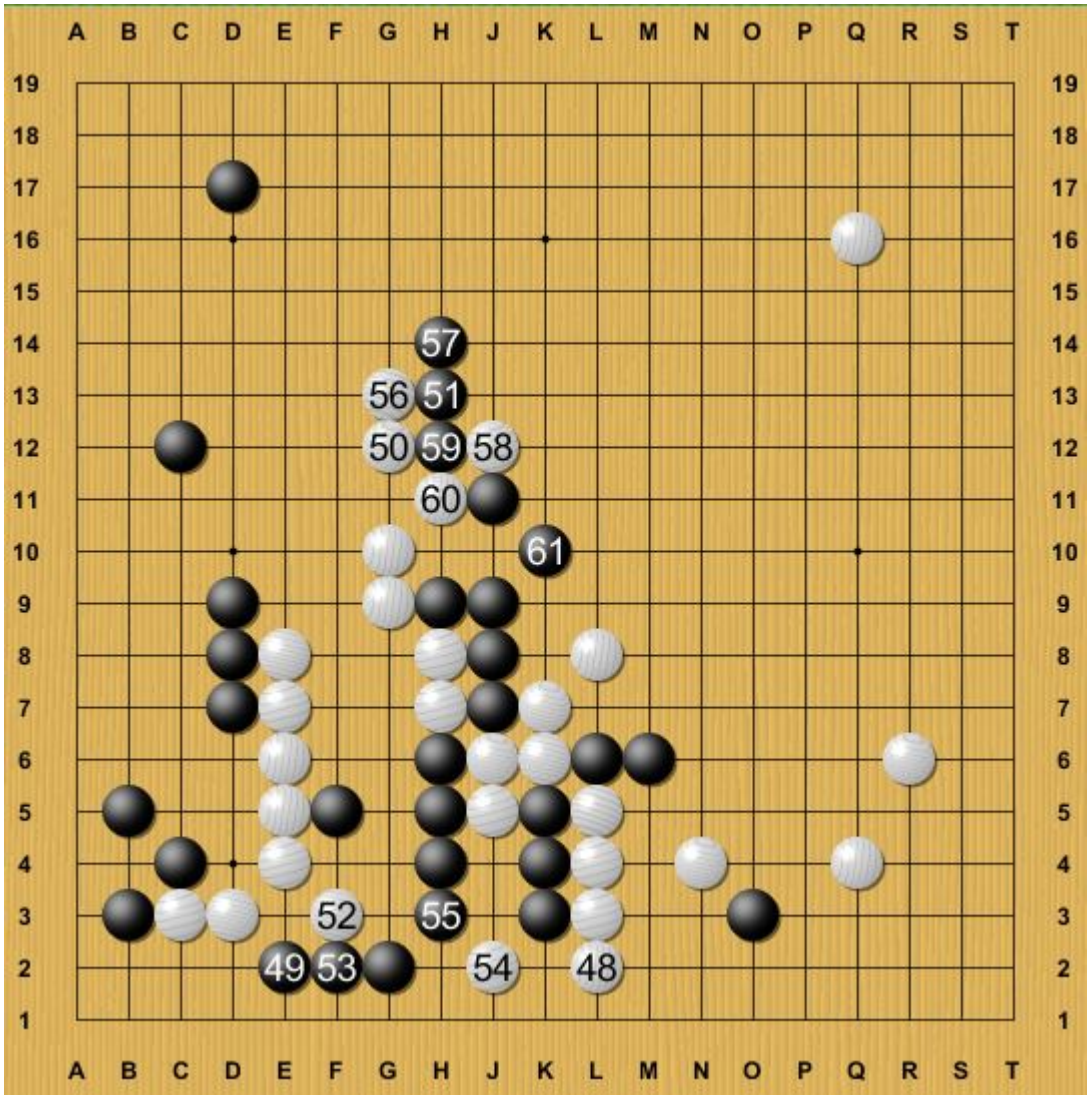
Note that when Black jumps at 1, White cannot push and cut. See diagram 8.

Diagram 8



If White cuts, Black can utilize White's weaknesses to play 6 in sente. White must defend the center stones, but when Black extends with 8, White is left with two weak groups and a tough battle ahead.

Moves 48-61



After the exchange of 48, White jumped out at 50 and Black kept up the pressure on White's dragon, attacking fiercely at 51. The simplifying exchanges at 52 and 54 might seem early to a human player, but were very much in AlphaGo's style. It is difficult to evaluate the pros and cons of making these exchanges now.

Lee played quickly during this fight. When Black extended at 57, Lee had 1 hour and 30 minutes, AlphaGo 1 hour and 29 minutes.

When AlphaGo attached at 58, however, Lee slowed down once more.

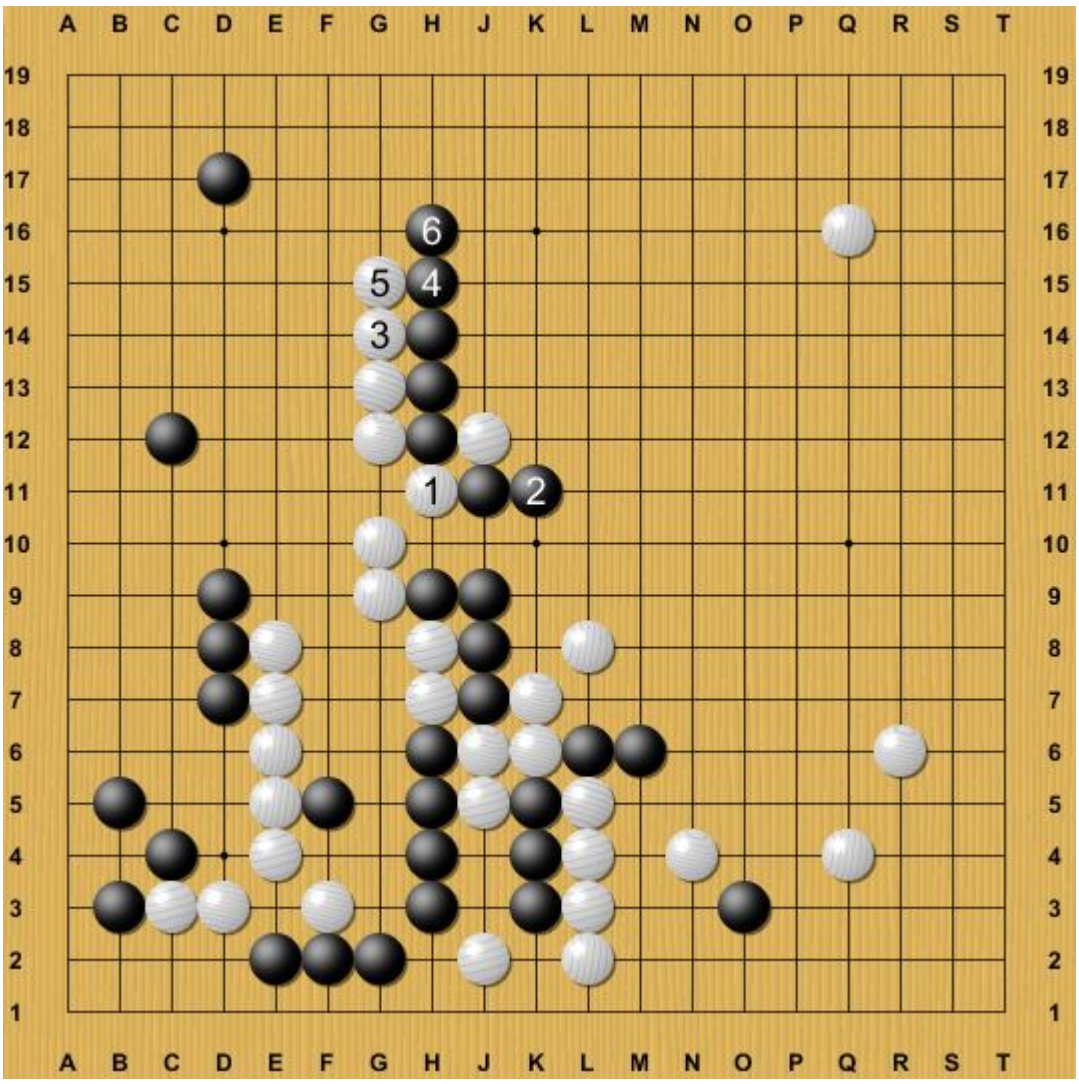
In normal matches, Lee often seeks opportunities to play startling moves that throw his opponents off their rhythm. This time, the roles had been reversed. It was AlphaGo that played these moves, rattling the opponent while maintaining equanimity itself.

After 4 minutes of reflection, Lee chose the tiger's mouth at 61, a bizarre shape in this position!

Compared to the rest of the match, Lee played quite quickly in this game. Subconsciously, it seemed, he believed that entering byo-yomi against AlphaGo would count as a failure in itself. Of course, playing so fast might also induce careless mistakes. AlphaGo thought 61 was one such move. See diagram 9.

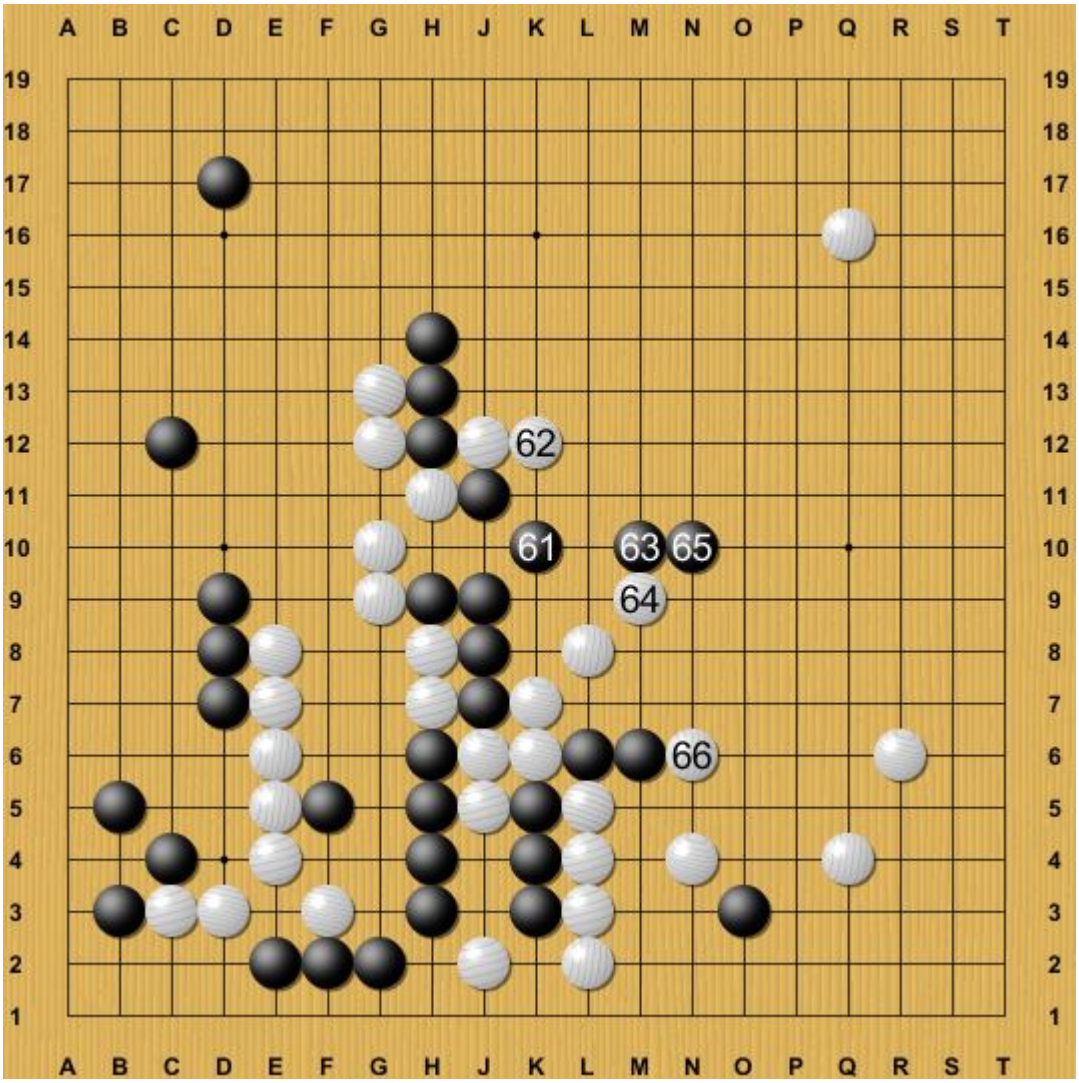
At move 61, Lee Sedol had 1 hour and 27 minutes left, AlphaGo 1 hour and 26 minutes.

Diagram 9



AlphaGo thinks Black should extend at 2, and White will push outwards just as in the game. Gu Li and Zhou Ruiyang agreed.

Moves 61-66

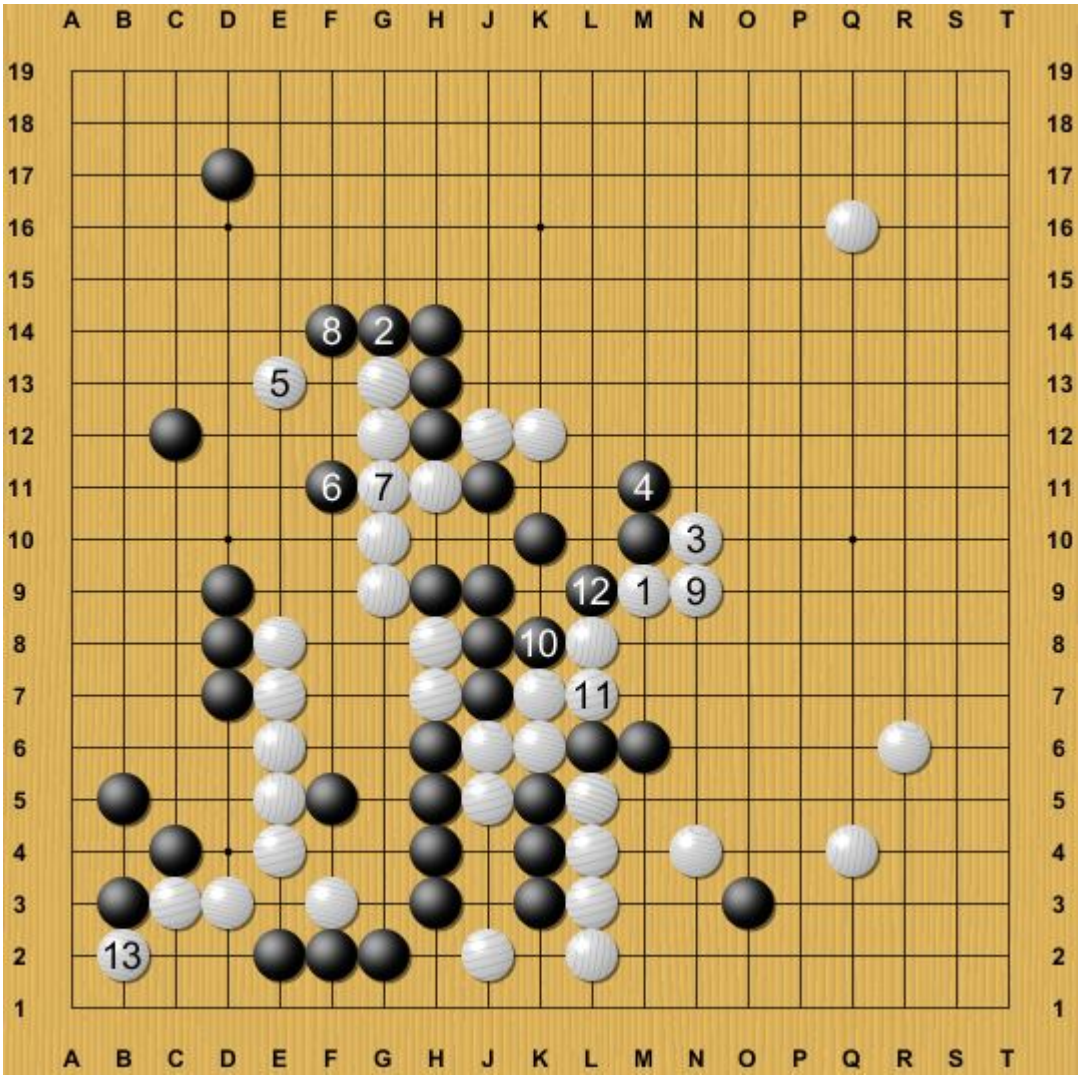


When AlphaGo extended at 62, David Silver, technical lead of the AlphaGo team, came to the players' room and sat down to observe. I asked about the outlook, and he replied only with a smile. This confirmed my analysis - White was ahead!

After the jump at 63, it is painful to endure the bump at 64, but AlphaGo disapproved of Black's extension at 65. See diagram 10.

In reply, AlphaGo regarded the nose attachment at 66 as the only move.

Diagram 10

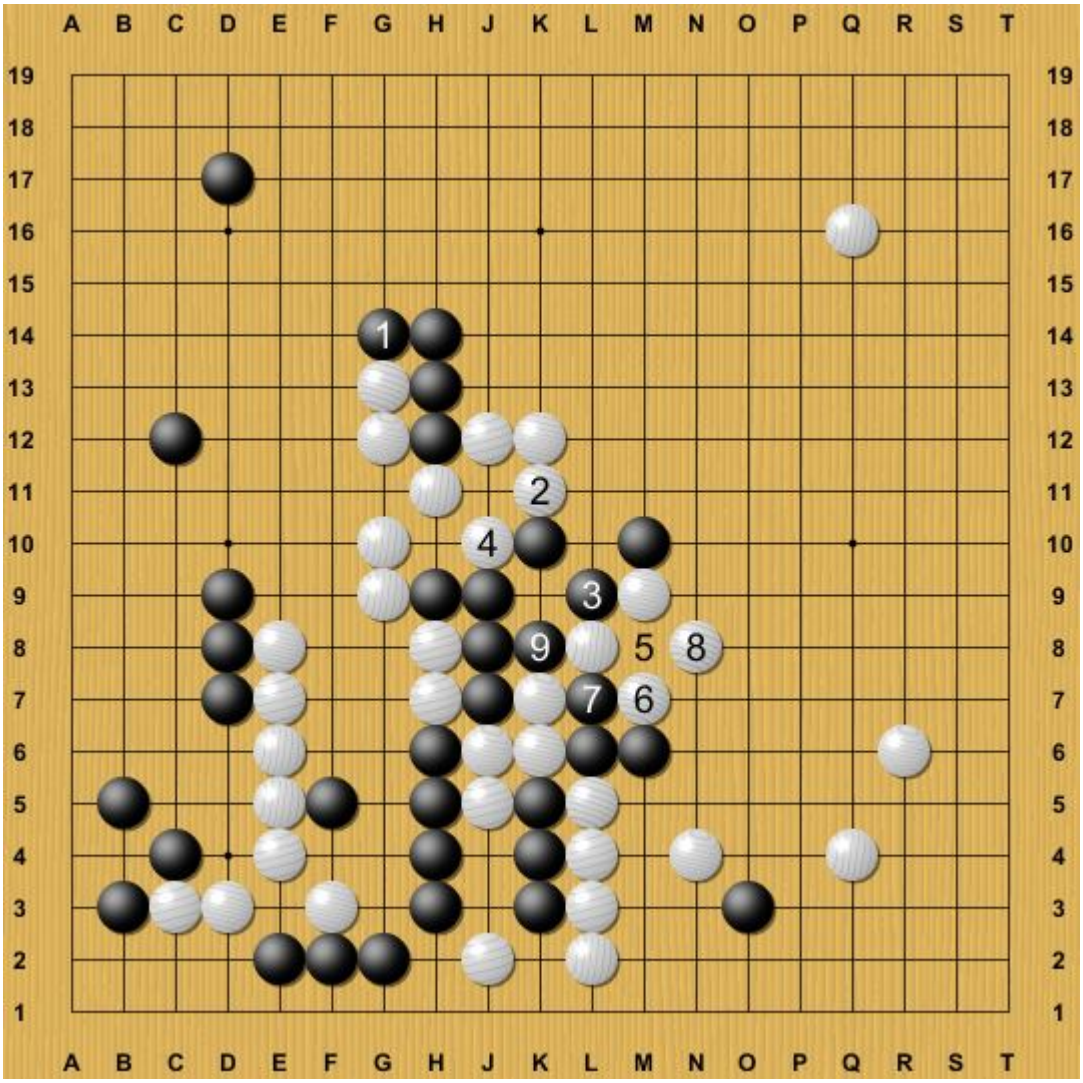


AlphaGo thinks Black should turn firmly with 2. White has no way to kill Black's center directly, as shown in diagram 11.

When white extends with 9, Black can simply force with 10 and 12 to fix the shape in the center. Plenty of aji remains on the lower side for Black to aim at later.

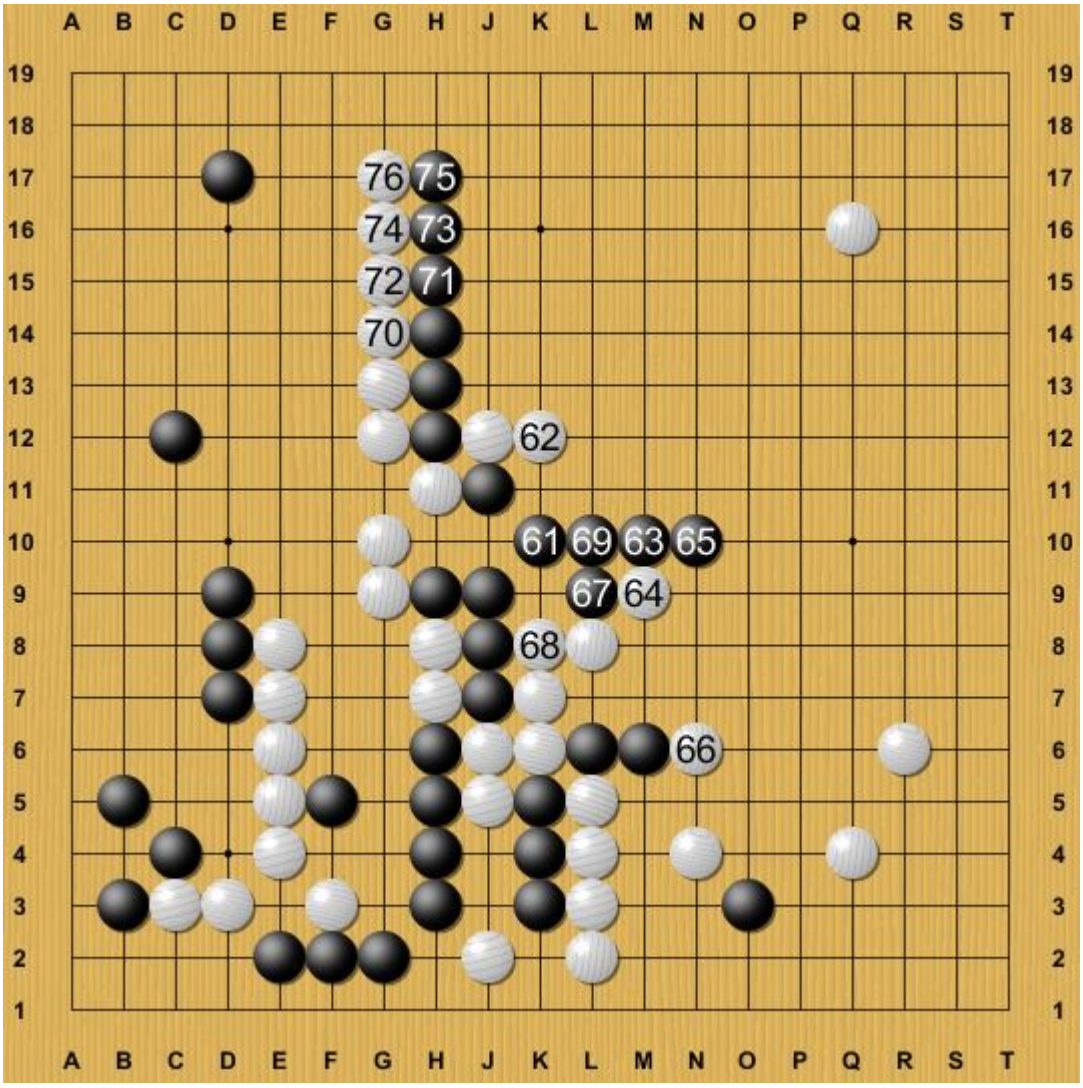
AlphaGo still prefers White here, but gives Black better chances than the game. Gu Li and Zhou Ruiyang concurred with this analysis.

Diagram 11



White's atari at 2 fails, as Black can answer at 3. Through 9, Black captures the critical center stones and White's position falls apart.

Moves 62-76



When Black pressed at 67, Lee had 1 hour and 24 minutes left, AlphaGo 1 hour and 22 minutes.

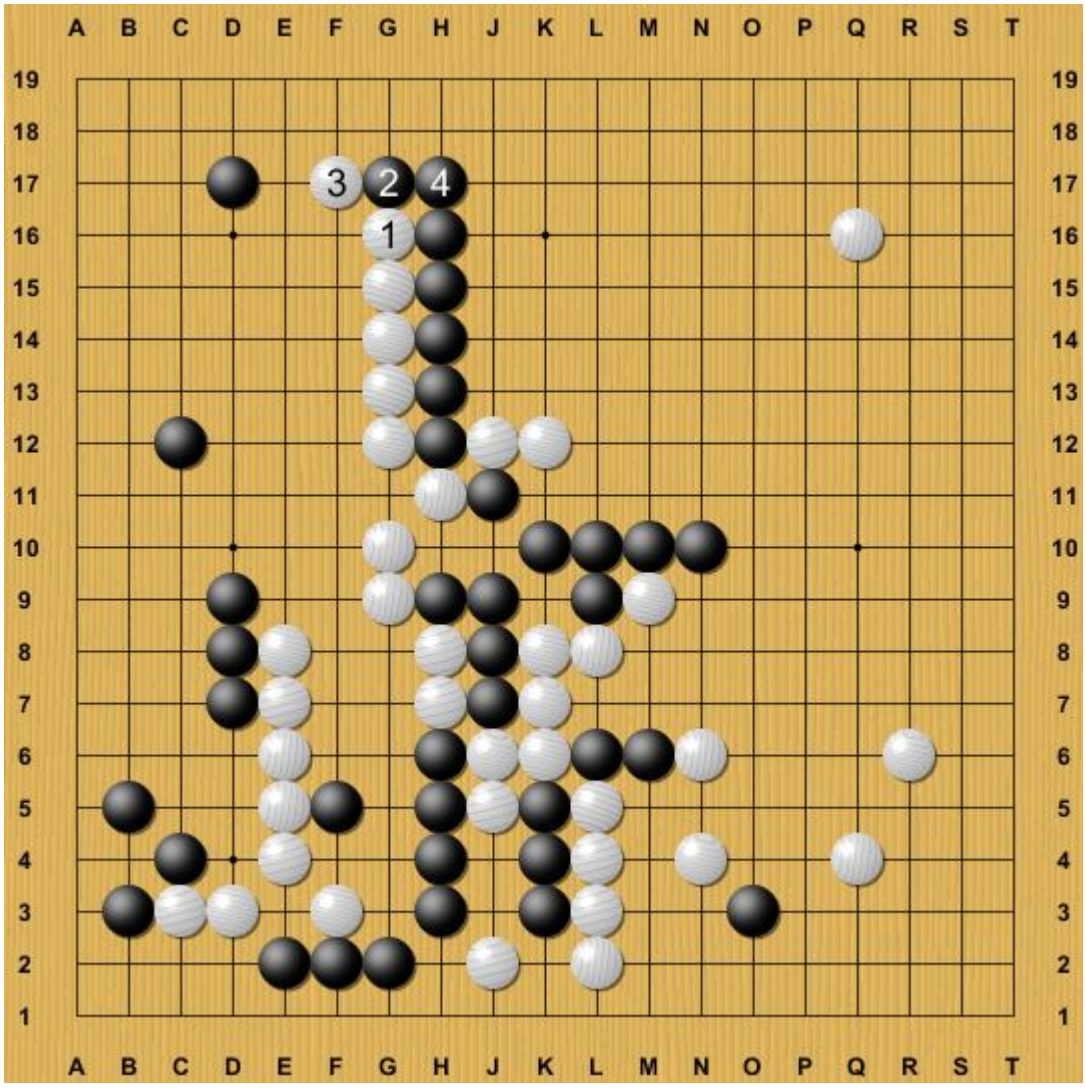
Black 69 was ugly but necessary, allowing White to return to the left side and push out with 70 through 76.

Lee had played the preceding moves almost instantly, so after move 73, Black had 1 hour and 23 minutes to White's 1 hour and 18 minutes. Lee glanced at the clock and shook his head.

After White 76, AlphaGo’s win rate rose a little further to over 70%. Although this value theoretically represents the chance of victory, in practice it is an extremely conservative indicator of AlphaGo's true estimate. A value of 70% means that AlphaGo already believes the outcome of the game is nearly decided.

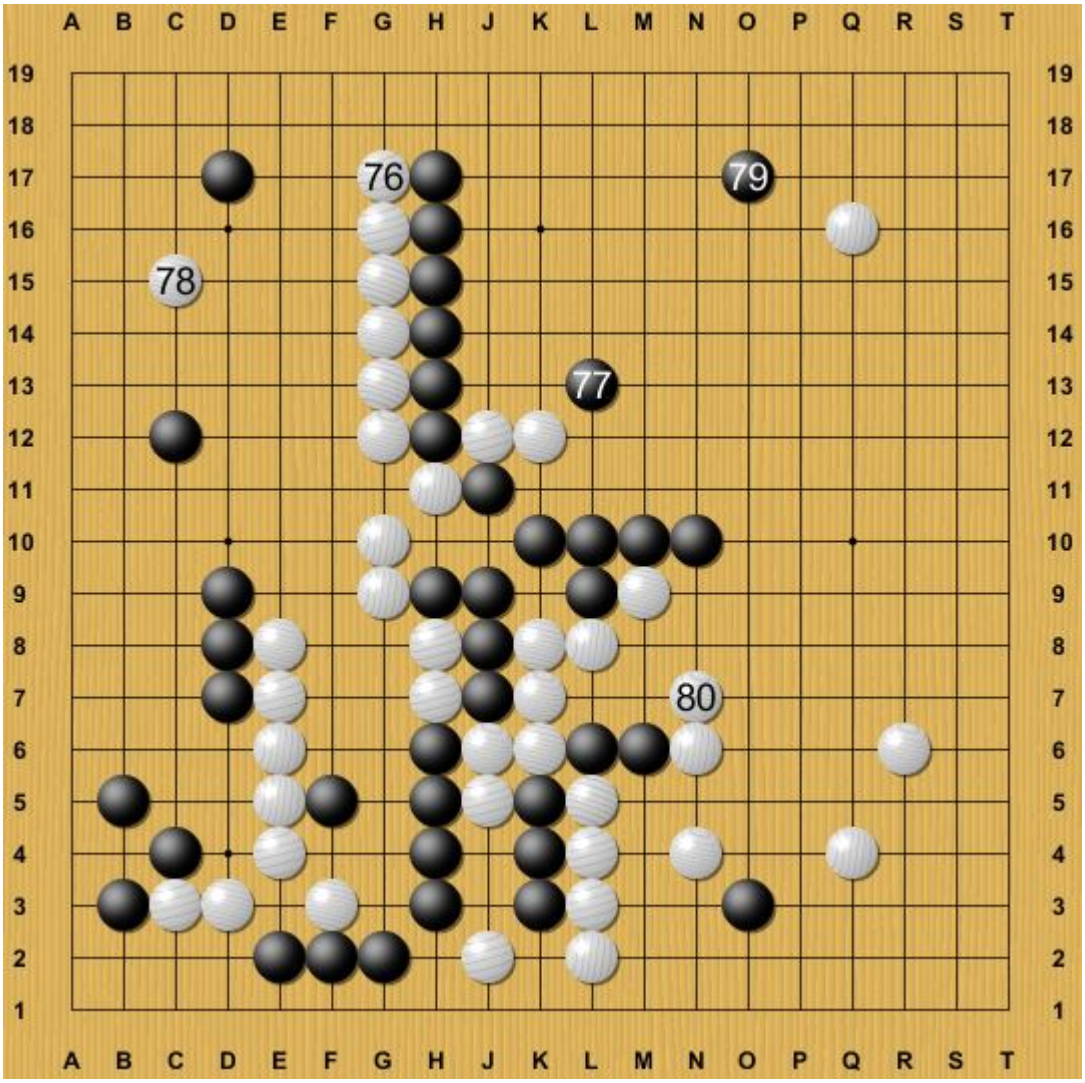
AlphaGo thought move 75 was problematic, and suggested diagram 12 instead.

Diagram 12



When White pushes at 1, Black should hane at 2. Gu Li and Zhou Ruiyang suggested the same during the live commentary, as White's thickness would be less imposing and Black would suffer less from shortage of liberties.

Moves 76-80



When Lee played Black 77, he shook his head unhappily. Sure enough, Black's outlook was pessimistic. For the first time in the match, Lee left the room for a smoking break. (This also gave the referees the chance to use the restroom.) According to the competition rules, there would be no stopping the clock during the match, so when White played 78, Lee's clock continued to run.

With one player absent, the tension lessened dramatically. It was as if the room were a bow, and the hunter had relaxed the bowstring. It was then that we realized how strongly affected we were by the pressure of the game.

At move 78, both AlphaGo and Lee Sedol had 1 hour and 15 minutes remaining.

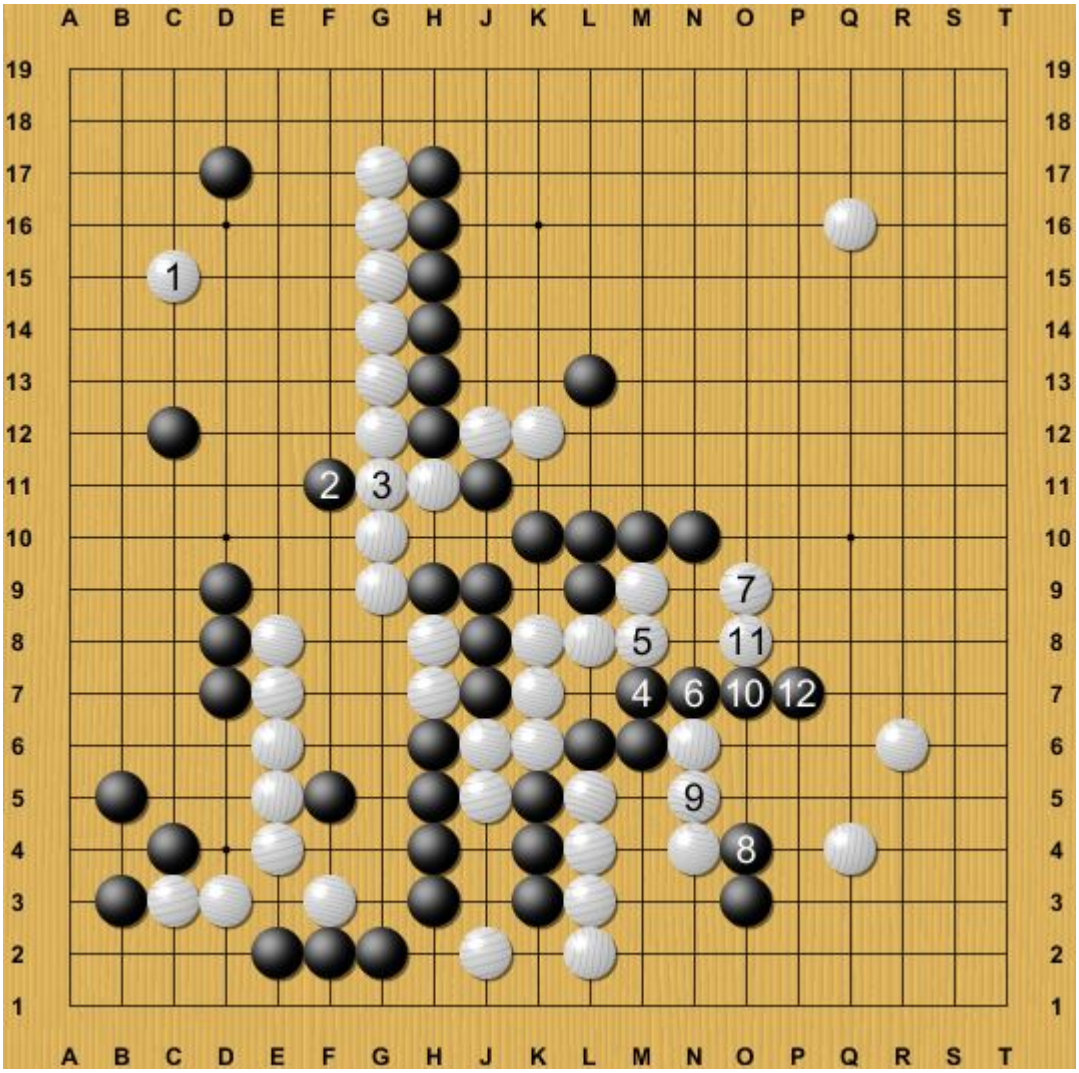
When Lee resumed his seat, he quickly played the corner approach at 79. When I saw AlphaGo's response at 80, I wrote down in my notebook: "Statement of victory!"

During the match, all the commentators thought move 80 was extremely soft, and answering in the upper right corner was far bigger. However, I believe I know AlphaGo as well as anybody, and in my view a move like 80 is really a demonstration of its matchless

confidence. AlphaGo does not pursue the biggest victory, only the most certain one. Once it has a lead of two or three points, AlphaGo is completely capable of holding it until the end.

At this point, AlphaGo showed a 74% win rate, confirming my impressions. Apparently, AlphaGo thought that move 79 was not best, preferring diagram 13 instead.

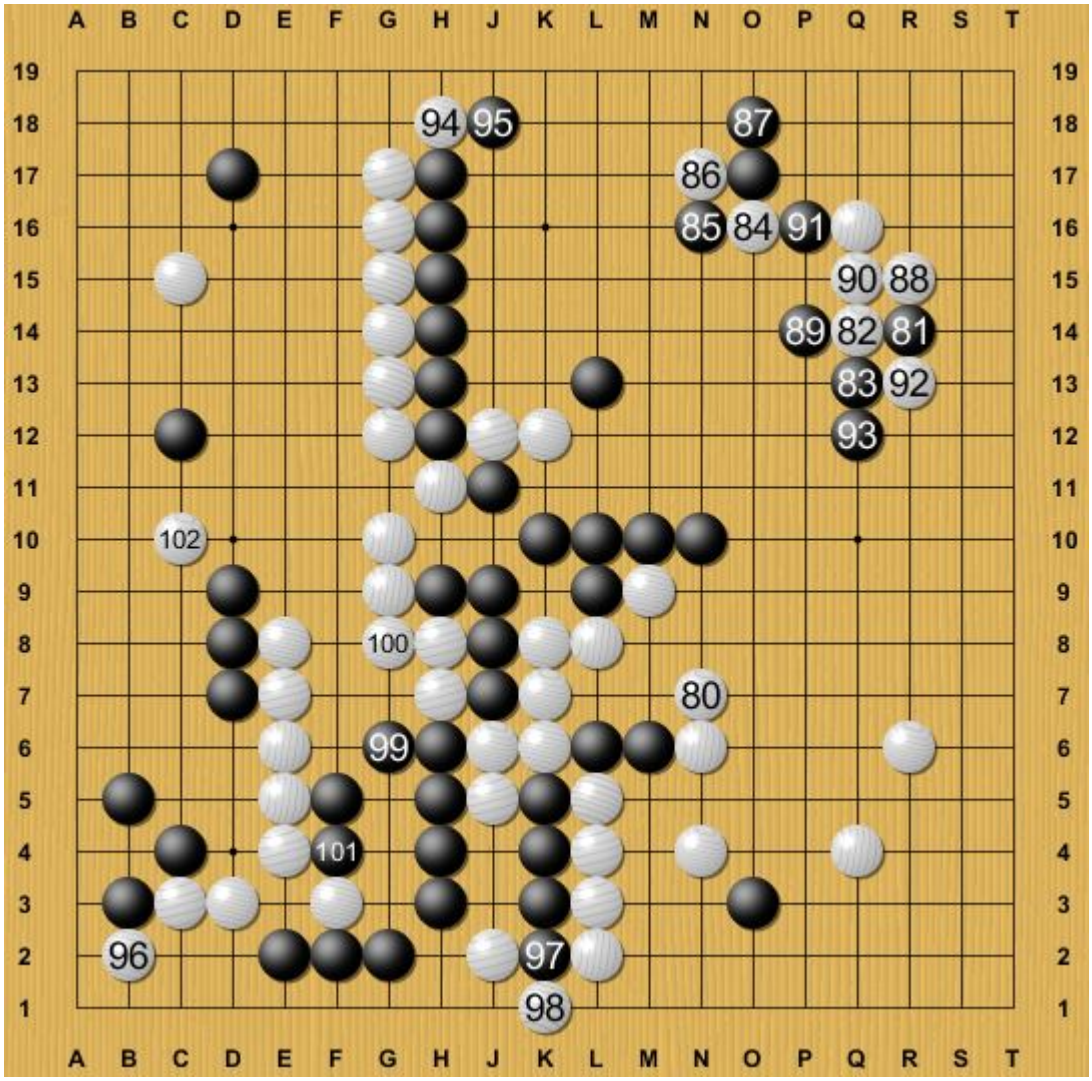
Diagram 13



After exchanging the peep at 2, Black extracts the black stones at the bottom with 4. This would lead to an extremely complicated fight with many uncertain elements.

Gu Li and Zhou Ruiyang did not comment much on this sequence, because it is both intricate and difficult to evaluate. However, this variation might offer Black more opportunities to turn the game around.

Moves 80-102



After White protected with 80, Black had no choice but to seek compensation from the double approach. After the two attachments at 82 and 84, 86 was a beautiful move! Sacrificing a stone where the opponent is strong is a common strategy, but it is nonetheless refreshing to see White brazenly cutting through in the face of Black's wall.

When AlphaGo played 86, I looked over at the 8-dan professional who was that day's referee. He shook his hand under the table, indicating that he thought the game was already over for Lee.

One might have the impression from this commentary that Lee had not played well so far, or that he had not deployed his full power. Yet, I believe that's not the case. Rather, it is AlphaGo's strength that makes Go look easy.

At move 86, AlphaGo and Lee Sedol had 1 hour and 8 minutes each on the clock.

Move 86 was breathtaking, but the follow-up was baffling. With the tiger's mouth at 88, AlphaGo simply let Black swallow up the center! Was it already so confident in White's territorial lead? One way or the other, I thought White's move was far too slow. AlphaGo's judgment is not based on the size of its lead, but on the ease of controlling the outcome, so

from that perspective there may be nothing wrong with this move. However, Lee seemed happy, as the game had certainly taken a turn for the better.

At move 98, Lee Sedol had 1 hour and 4 minutes left, AlphaGo 59 minutes.

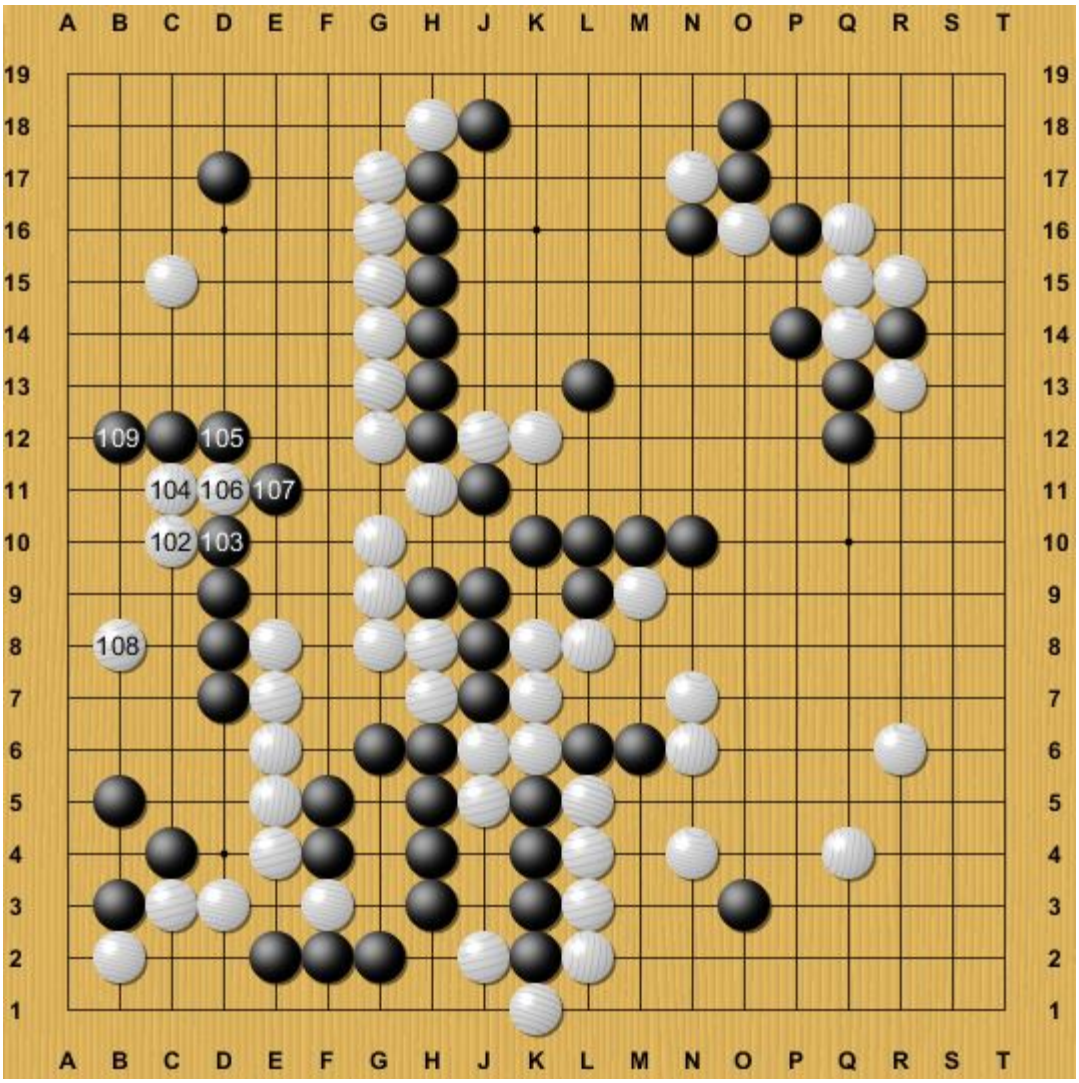
The following moves were a string of minor exchanges. To me, they felt like shots of anaesthetic in preparation for surgery. However, anaesthetic or no, Black must have felt the sharp pain of the incision at 102.

Perhaps the answer to the riddle is right before our eyes, and the point of AlphaGo's move at 88 was to win back sente for the invasion on the left side?

A smile crossed Lee's face when he saw White 102, and he sank into deep calculation. This was his longest reflection of the game. At last, the deciding moment was at hand! The time had come to fight as if his life depended on it - but how does one fight an opponent that knows no fear?

At move 102, Lee Sedol had 1 hour left, AlphaGo 56 minutes.

Moves 102-109



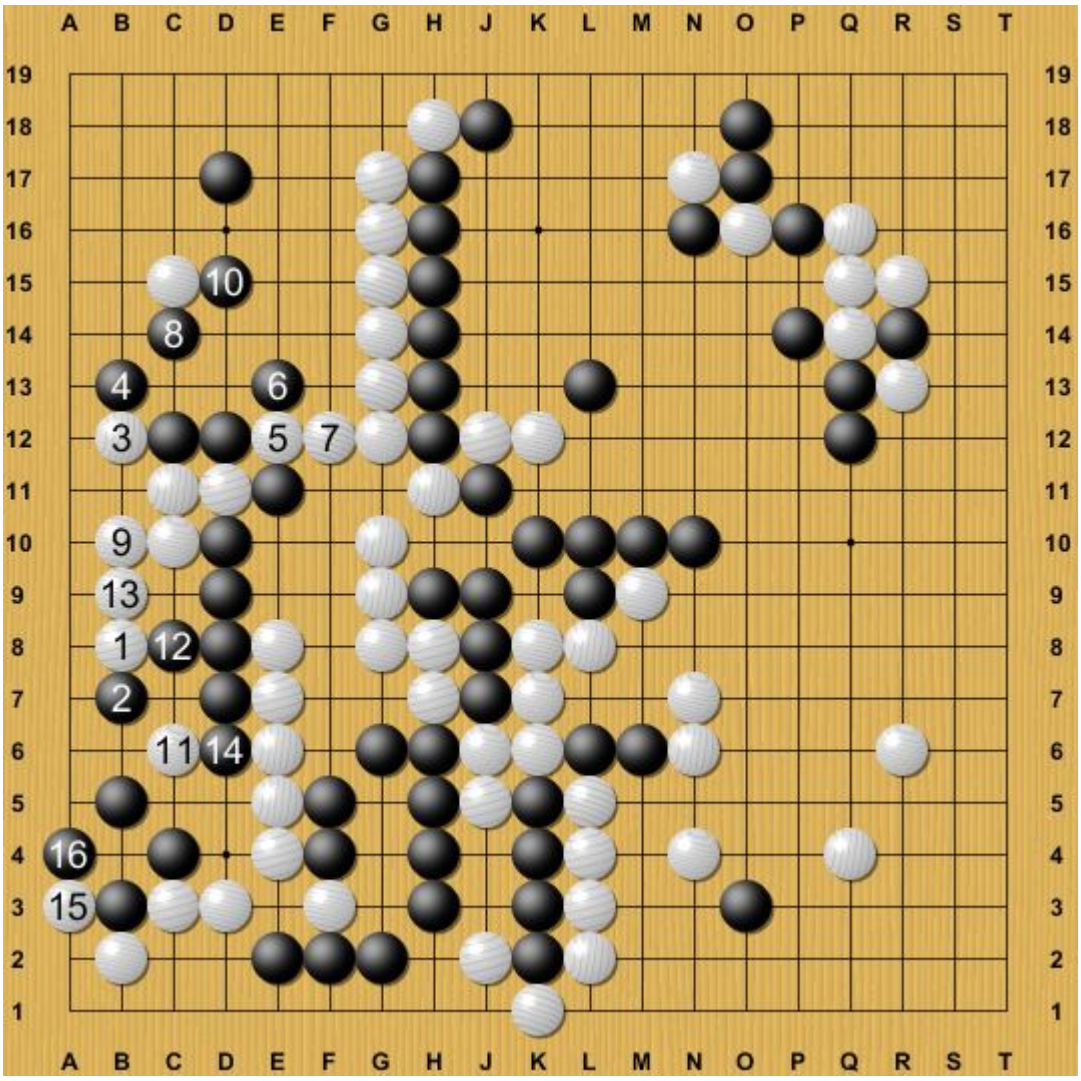
After seven minutes of contemplation, Lee finally blocked from above at 103. AlphaGo immediately answered at 104. Although it normally plays at a constant pace, it seems even AlphaGo sometimes has a sense of "the only move."

When white played the knight's move at 108, Lee Sedol sighed again. The game held so many possibilities, but with no way to read the opponent's intentions, it became more difficult to accept or reject any one of them. Because AlphaGo lacked any sense of mental or emotional pressure, the psychological burden grew twice as heavy on Lee's shoulders!

At move 108, Lee Sedol had 47 minutes left, AlphaGo 53 minutes.

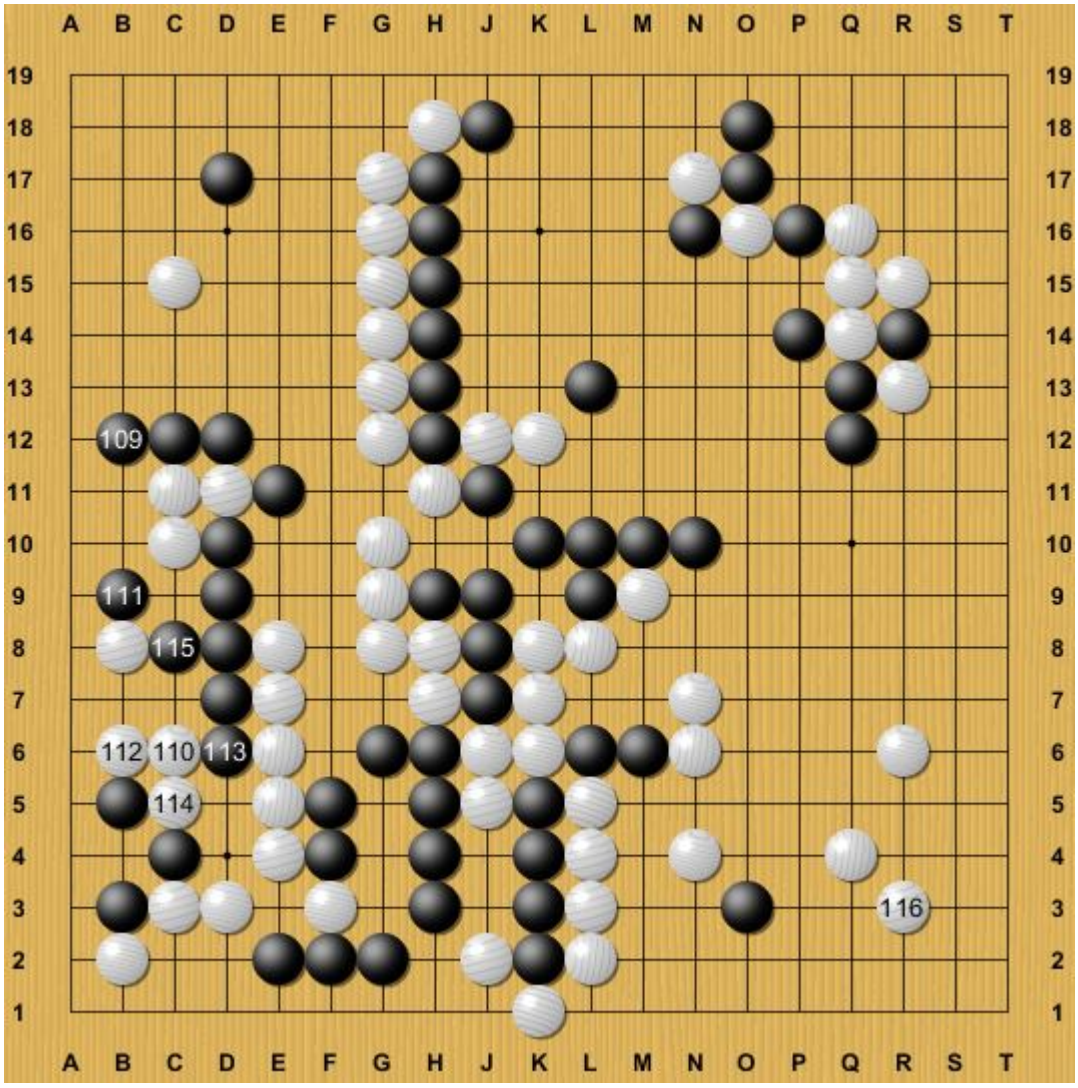
In the game, Lee Sedol chose to descend at 109. AlphaGo, however, thought Black's only chance was to stake the game on the desperate fight in diagram 14.

Diagram 14



AlphaGo thinks Black should block at 2, leading to a complicated fight that will probably end in ko. Gu Li and Zhou Ruiyang felt that Black would resist choosing this variation unless every alternative looked hopeless. Perhaps AlphaGo believed that Black had already lost the chance to retreat, and this was the only way forward.

Moves 109-116

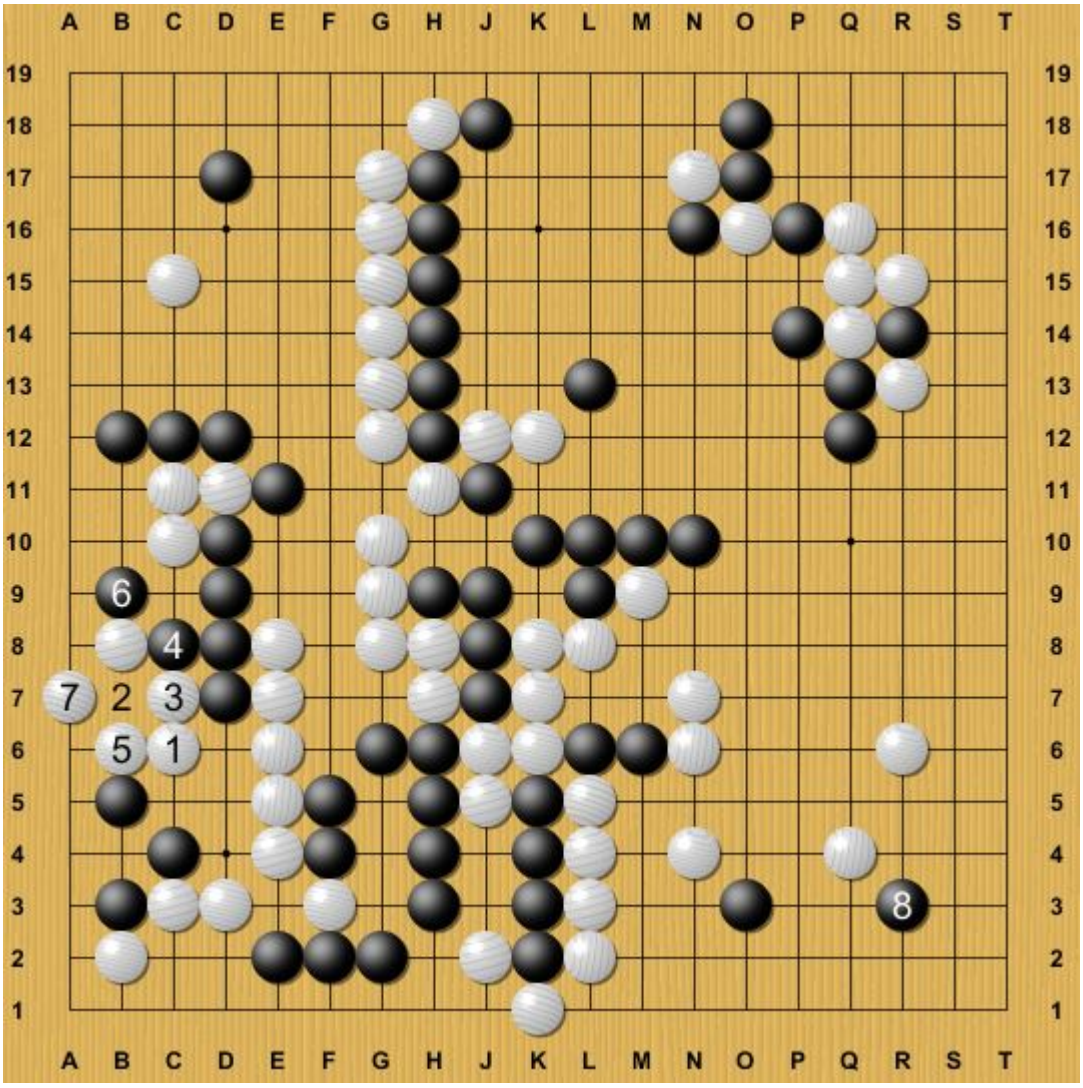


At move 111, Lee Sedol had 44 minutes left, AlphaGo 51 minutes.

Move 111 is clearly problematic, as shown in diagram 15. In the game, White was able to capture the three stones in the lower left in sente, an enormous gain in both security and profit.

When AlphaGo took the 3-3 point at 116, its win rate rose to 82%. A value this high means AlphaGo already considers the game won, even if the absolute difference is small.

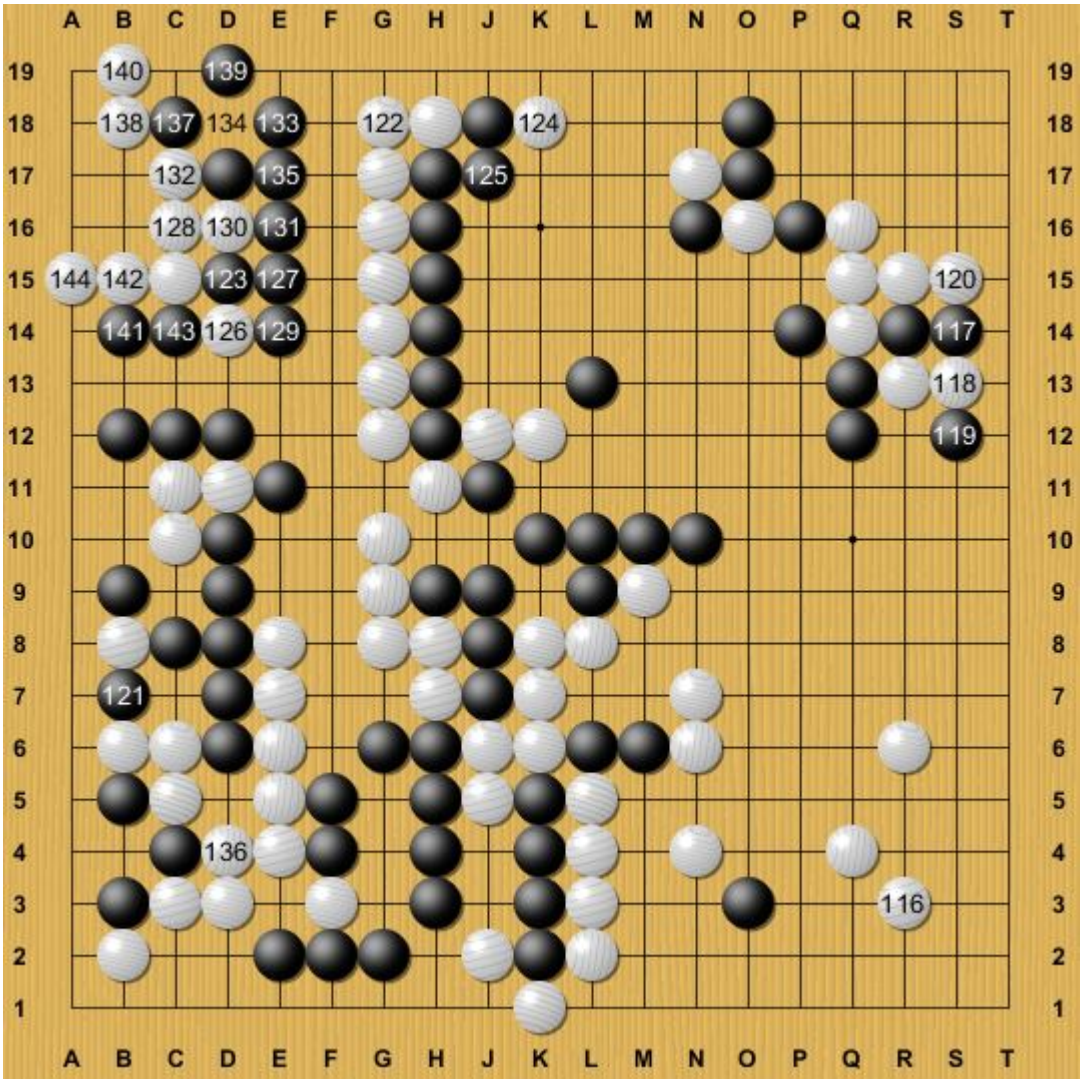
Diagram 15



Black's attachment at 2, although it loses points compared to the game, allows Black to sacrifice one stone for sente. Keeping the initiative to invade the lower right with 8 makes a huge difference.

Gu Li and Zhou Ruiyang completely approved of this sequence, and Gu even mentioned it during the live commentary. Perhaps Lee, satisfied with the gains in the upper right, had not yet fully appreciated how dire Black's situation was.

Moves 116-144

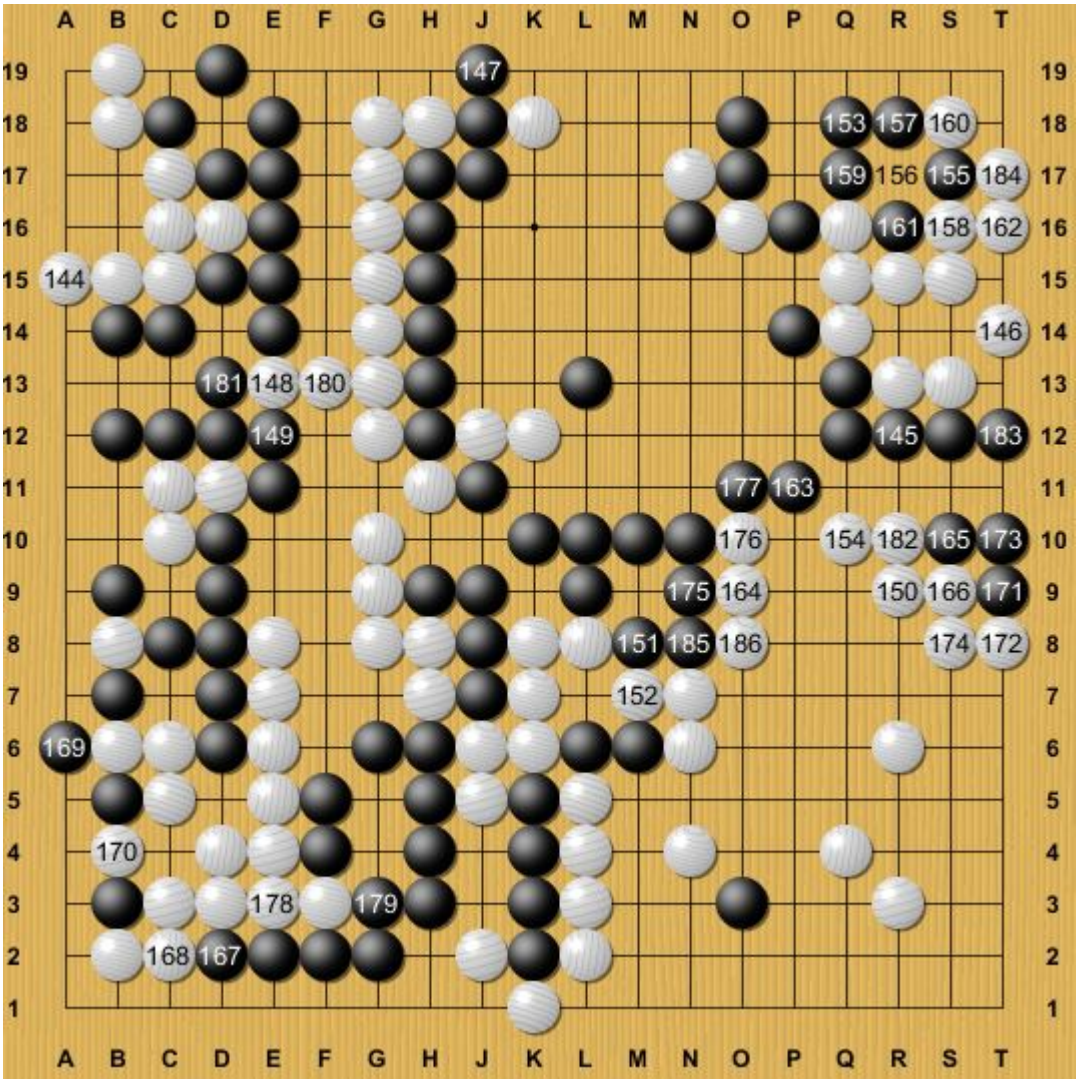


Although many commentators found better ways for Black to handle the upper left corner, Black had no chance of victory either way. Against a human player, one can still try to provoke a blunder, but against the untiring AlphaGo such hope is futile.

When white lived in the corner at 140, AlphaGo's win rate was 90%.

The tension faded from Lee's expression as he faced the inevitable.

Moves 144-186

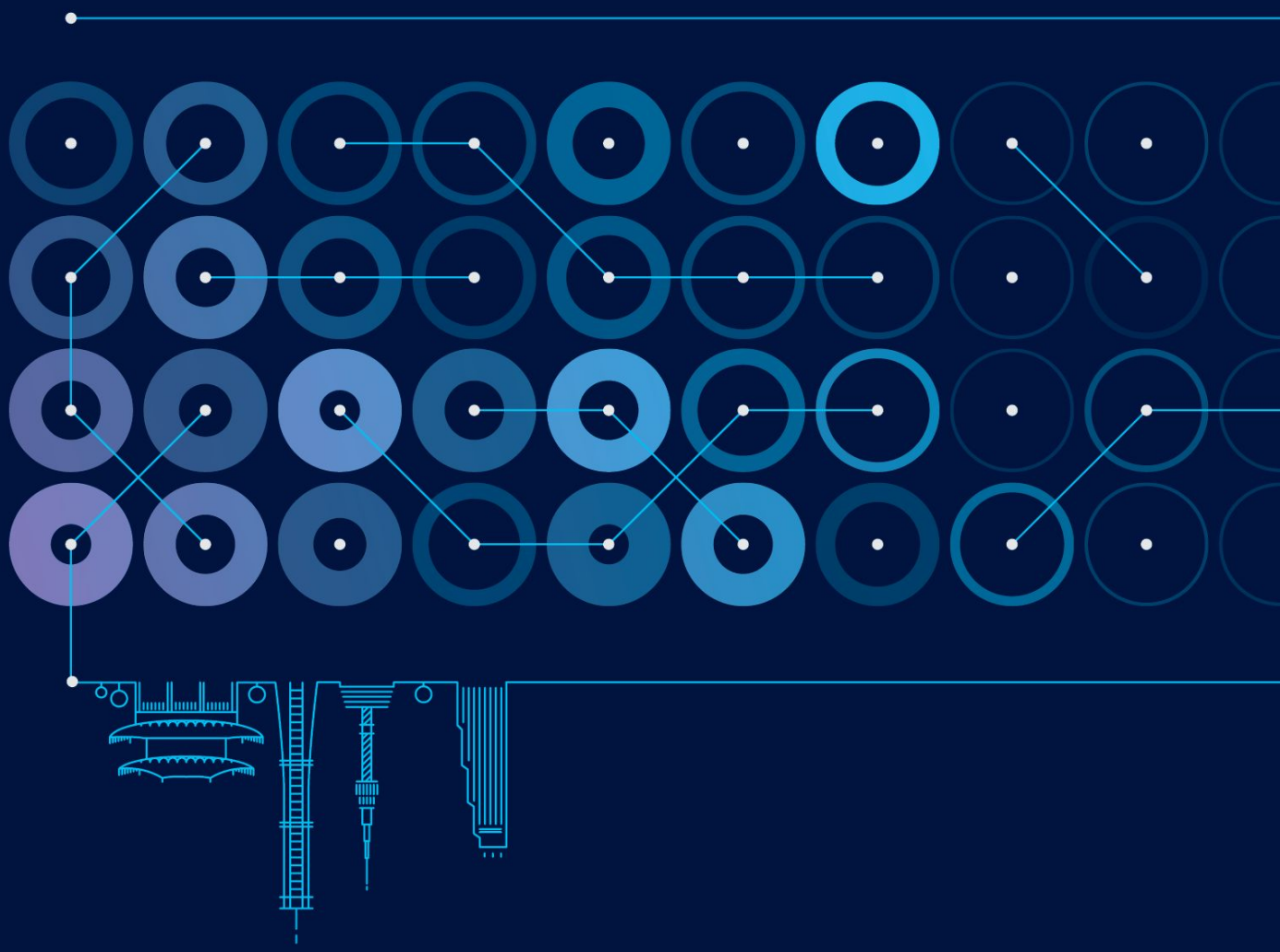


As the endgame continued, it became clear that although the score remained close, Black's defeat was unavoidable.

When Lee played 181, he muttered a few words. Sadly, since they were in Korean, I cannot tell you what they were, but they must have shown the depth of his dissatisfaction.

After White 186, Lee picked up two black stones and lightly tapped them against the bowl. The sound echoed crisply through the room, and it felt as if time had frozen. I knew Lee was about to resign. Afterwards, many people said that I must have been happy in that moment. Now the world would know AlphaGo's true strength, and I would not be the only one it had defeated. The truth is, in the moment when he tapped those two stones, my mind was blank. Although I had known this day would come sooner or later, it had always felt so remote before, suddenly, it arrived. I felt as if I had been cast into outer space, adrift on waves of nothingness.

Lee Sedol resigned, and I returned to the present. The Korean referee's announcement of the result marked a historic shift. From that moment on, humanity was no longer alone in exploring the mysteries of Go. We had gained a new partner in our quest: AlphaGo!



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