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棋力に対する駒のイメージ的操作能力の関係

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将棋では深く読む能力と棋力には相関関係があるように思われる。我々は、これまでの研究で、次の一手課題における実験を通して、棋力が高くなるにつれて、深く読むことを確かめた。また、中級者ほど幅広く読む傾向があることも確認した。

本報告では、今までに行った研究を先読みという点に着目して整理したデータを示す。さらに、思考上で駒を動かす能力を調べるために、候補手を挙げさせて可能な限り先を読むように教示する実験を中級者とプロ棋士に対して行った。その結果、プロ棋士ほどではないが、中級者でも思考上でルール通りに駒を動かす能力があることが示された。しかし、先読みの正確さという点では差が見られた。

On the Relation Between the Ability to Calculate Moves and Playing Strength in Shogi

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In shogi, it is assumed that there is a direct relationship between playing strength and the ability to search variations deeply. In recent studies, we have analyzed the width and depth of the search of a number of subjects. One of our main conclusions was that stronger players search deeper. It was also shown that players of intermediate playing strength (about 1-dan amateur) search wider than novices and expert players.

In this paper, we will focus on the data concerning search depth. To analyze the ability to calculate moves without actually playing them on a shogi board, we conducted an experiment in which we asked intermediate players and experts to generate moves and search positions as deeply as possible in a number of test positions. The results indicate that there is not much difference between the ability to calculate moves of the intermediate player and the expert, but it is likely that the difference in playing strength is due to the accuracy of the search.

1. Introduction

De Groot's work in chess is probably the most famous cognitive science study conducted on games. De Groot stressed the role of selective search, perception, and knowledge in expert chess playing. Some of his key empirical findings were that (i) world-class chess grandmasters do not search more than weaker (but still expert) players, both in the number of positions considered and in search depth; and (ii) grand-masters and masters can memorize and reproduce positions (consisting of about 24 pieces on average) presented for only a few seconds almost perfectly, while weaker players can reproduce only about 6 pieces on average[1].

In earlier work, we have extended De Groot's work to shogi by performing experiments on a set of next move problems, collecting data in the form of verbal protocols and eye movements[2]. Our experiments showed that expert Shogi players can also memorize positions very quickly and accurately. However, unlike the result obtained in chess, we found evidence that expert Shogi players search more than weaker players, both in the number of positions considered and in depth of the search.

In this paper, we will first outline the earlier results. After this, we will give the results of a new experiment that focused on the ability of calculating moves without actually playing them on a board.

2. Next Move Test Experiments

2.1 Experimental Set-up

The first question we investigated was how much Shogi players of different playing strength search in order to decide their next move. We performed experiments on ten subjects: two beginners, three intermediate level players (Japanese grade: amateur 1-dan), two strong club players (Japanese grade: amateur 4-dan) and three experts (professional 8-dan).

To the ten subjects, we presented 10 Shogi problems that were constructed with the help of an advanced player (the test positions are given in Appendix 1). During the subjects solve each problem, we asked them to think aloud.

2.2 Results

Table 1 shows the answers of all subjects. N1,2, M1-3, E1,2, and P1,2 stand for novice players, intermediate level players, strong club players, and professional players respectively. Table 2 gives the answer time in seconds for each subject. The data shows considerable individual differences regarding answer and answer time. Figure 1 shows the average answer time related to strength for all problems. An interesting result is that intermediate level players use more

	Prob. 1	Prob.2	Prob.3	Prob.4	Prob.5	Prob.6	Prob.7	Prob.8	Prob.9	Prob.10
P1	R2e	P*4e	N3g	S4f	P*2b	R2d	P*9d	K7h	B8f	S4ix4h
P2	P*7g	P*4e	N3g	G6i-6h	P*2b	R2d	P*9d	G6f	B8f	S4ix4h
P3	P9e	P5e	P4e	P4f	P*2b	B*8c	P*9d	G6g	B8f	S4ix4h
E1	G4g	P*4e	P9f	G6i-6h	P4e	R2d	P*9d	G6g	B8f	S4ix4h
E2	P9e	P*4e	B8f	S4f	P4e	R2d	P*9d	G3h	B8f	S4ix4h
M1	R2f	P*4e	P4e	P3e	R*4a	R3f	P*9g	G4h	Rx3c+	S4ix4h
M2	P4e	P*4c	P4e	S3g	P*2b	R3f	S4f	G4h	Px9e	S4ix4h
M3	P9e	P*4e	P9f	P4f	R*2h	B*8c	P*9g	G3h	Bx5c+	S4ix4h
N1	P4e	P*4e	P4e	G6h	P*2b	R3f	P*9d	G7h	Px9e	S4ix4h
N2	P4e	P*4e	N3g	S3g	P4e	P*2d	P*9i	P1f	P2d	G2b

Table 1 Answer of each subject

	Prob.1	Prob.2	Prob.3	Prob.4	Prob.5	Prob.6	Prob.7	Prob.8	Prob.9	Prob.10
P1	345	336	269	134	229	410	170	296	146	196
P2	63	102	188	41	78	95	135	91	184	272
P3	39	30	36	50	60	214	20	35	77	97
E1	191	143	189	77	112	256	68	142	139	265
E2	135	210	275	128	220	113	113	220	167	237
M1	254	133	377	104	192	147	210	149	207	544
M2	367	379	281	56	322	207	365	186	115	155
M3	672	143	502	72	332	825	100	255	56	330
N1	574	121	127	56	124	115	151	112	154	141
N2	157	157	124	92	98	69	122	131	89	168

※Time is given in seconds.

Table 2 Answer time of each subject

		Prob.1	Prob.2	Prob.3	Prob.4	Prob.5	Prob.6	Prob.7	Prob.8	Prob.9	Prob.10
P1	Depth	10	14	15	25	12	15	16	17	12	20
	Width	3	2	3	3	2	2	3	4	2	1
P2	Depth	4	7	7	4	6	12	5	7	6	8
	Width	1	1	2	1	2	1	1	2	2	2
P3	Depth	3	2	3	1	1	21	1	1	8	8
	Width	1	1	1	1	1	1	1	1	2	1
E1	Depth	7	8	8	3	5	14	5	5	8	9
	Width	3	1	5	1	2	2	1	1	2	3
E2	Depth	9	12	11	9	13	9	5	4	11	10
	Width	5	2	1	1	2	1	2	2	3	1
M1	Depth	7	7	5	6	7	3	9	7	9	9
	Width	4	3	1	2	1	2	3	3	4	2
M2	Depth	9	3	6	1	5	4	4	7	5	5
	Width	3	4	3	3	3	6	5	2	2	2
M3	Depth	8	5	7	1	8	11	3	5	5	6
	Width	5	2	3	4	4	8	1	2	2	4
N1	Depth	3	5	5	1	9	2	4	4	5	2
	Width	4	2	1	2	3	2	2	1	2	1
N2	Depth	7	5	5	1	5	2	4	1	3	6
	Width	2	5	3	2	1	3	2	2	1	1

Table 3 Width and depth of searching for each subject

time to decide upon their move than the others.

In addition, we investigated search depth and the number of generated candidate moves by the analyzing the verbal protocol data.

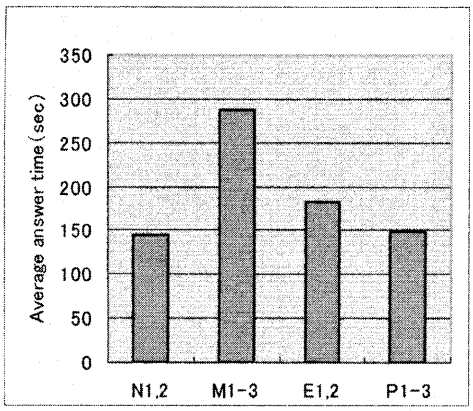

Figure 1 Average answer time of the strength on shogi

We define search "width" as the number of the candidate moves mentioned for the problem. We also define search "depth" as the length of the longest variation that was mentioned. In Table 3 the width and depth of the search depth for each subject is given.

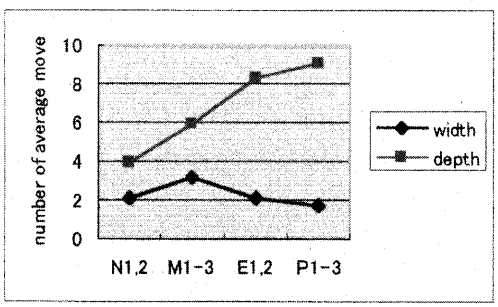

Figure 2 Width and depth of the search in relation to playing strength

Figure 2 shows the average results of width and depth of the search in relation to playing strength. It seems clear that there is a relation between search depth and playing strength. Additionally, there is an indication that intermediate level players search the widest.

We also tried to find a relation between the total amount of search and playing strength. We defined the total amount of search as the number of moves mentioned in the verbal protocol. However, in the experiments there was no limit on the answer time, and Table 2 shows that this lead to considerable individual differences, even among players of the same playing strength. Therefore, we looked at both the search amount and search speed, the latter defined as the number of moves mentioned per minute. The results are given in Figure 3.

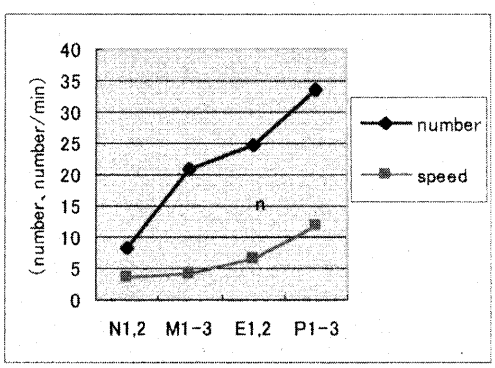

Figure 3 Amount and speed of searching for the strength on shogi

The results indicate that there is a

relation between playing strength in shogi and the amount of search that is performed. This is a different result from that which was obtained by De Groot in chess.

2.3 Discussion

According to Figure 1, intermediate level players tended to take longer for their answers than beginners and expert players. This seems to support the data given in Figure 2, indicating that intermediate level players search wider than beginners and expert players. This effect is most likely caused by the number of combinations and standard opening moves that is being learned when advancing from beginner to intermediate level. At this point in a player's development, there will be many possible candidate moves in each position. The problem here is that the player has not yet acquired a sophistication necessary to reject the learned combinations based on certain features. As experience with the use of standard moves grows, the awareness of positional features related to the applicability of the standard moves increases and the number of candidate moves will decrease. Expert players therefore are able to perform deep, narrow searches.

3. Candidates and Depth Experiment

3.1 Experimental Set-up

We now focus on how much candidate moves players generate and how deeply they search. We specifically wanted to investigate the difference between intermediate players and expert players.

We performed our experiment on three subjects: two intermediate level players (Japanese grade: amateur 1-dan) and one expert (professional 8-dan). For our experiment we selected 10 positions from 10 professional games taken from a collection of expert games on a Shogi Yearbook CD-ROM. From each game only one position was selected (the positions are given in Appendix 2).

We first asked the subjects to generate candidate moves without any time limit. After that, we asked them to search variations as deep as possible with a 2 minute time limit.

	Prob.1	Prob.2	Prob.3	Prob.4	Prob.5	Prob.6	Prob.7	Prob.8	Prob.9	Prob.10
P	6	6	4	4	3	3	7	4	4	5
M1	4	6	5	5	5	5	6	5	5	6
M2	8	5	7	5	7	6	5	6	4	7

Table 4 Number of candidate moves for each problem

	Prob.1	Prob.2	Prob.3	Prob.4	Prob.5	Prob.6	Prob.7	Prob.8	Prob.9	Prob.10
P	9	11	10	11	12	6	12	9	6	3
M1	6	9	9	8	4	3	8	7	5	7
M2	7	11	6	14	3	7	6	6	4	6

Table 5 Depth of searching for each problem

3.2 Results

Table 4 shows number of candidate moves for each problem. Table 5 shows the search depth for each problem.

Figure 4 gives the average number of candidates and the search depth. P is the professional player and M is the average for the two intermediate players. The data indicates that intermediate level players generate more candidate moves than a professional player. As a result, a professional player can search deeper.

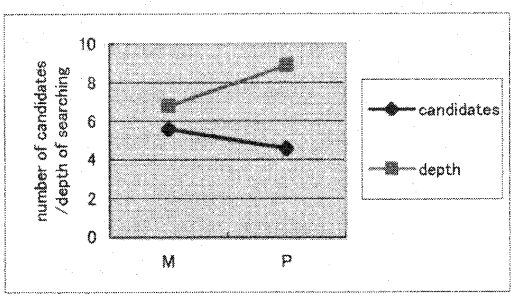

Figure 4 Average of number of candidates and depth of searching

3.3 Discussion

From Figure 4, we concluded that an intermediate level player is unable to search as deeply as a professional player. However, in Table 5 we can see that there are a number of cases where the intermediate player searches as deep or even deeper than the professional player. In these cases the credibility of the generated move sequence is the important issue. For example, in Prob. 2 intermediate level M2 generated the following 11 ply sequence: "Bx4d Px4d P3d N4e Rx2e P*2c P*7d N6e P7c+ Sx7c B*9f" but indicated that it was highly unlikely that this move sequence was actually going to be played like this. Therefore, despite the ability of generating long sequences, it is the accuracy of the generated variations that makes the difference between an intermediate player and an expert player.

In future, we will carry out similar experiment for players of as many different playing strengths as possible. We want to examine in detail how the general ability to calculate move variations evolves into accurate search.

References

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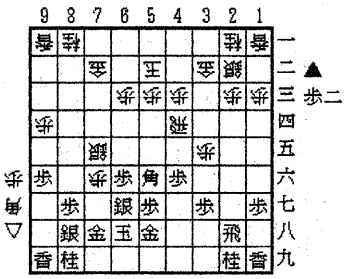
2) Ito, T., Matsubara, H. and Grimbergen, R. The Use of Memory and Causal Chunking in the Game of Shogi, The Third International Conference on Cognitive Science , pp. 134-140. (2001).

Appendix 1



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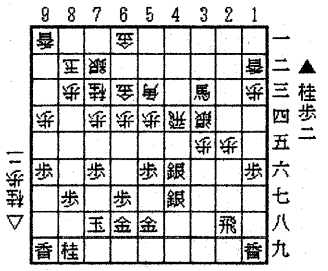

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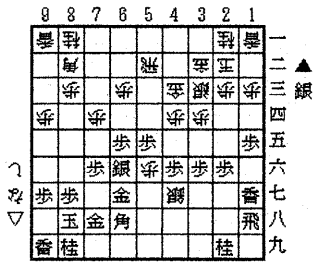

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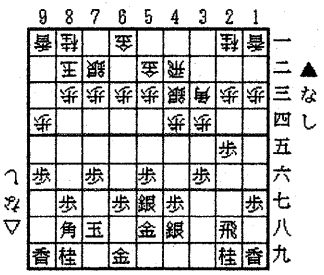

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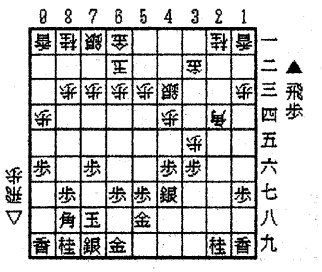

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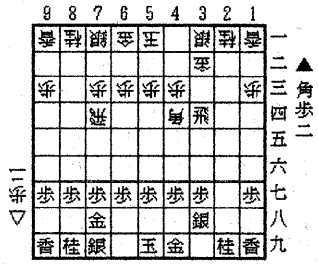

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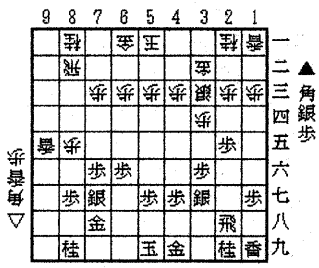

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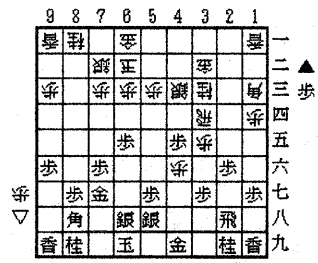

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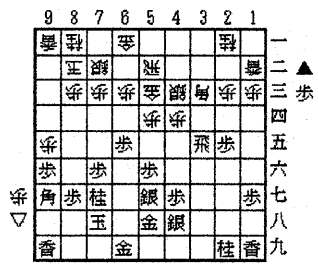

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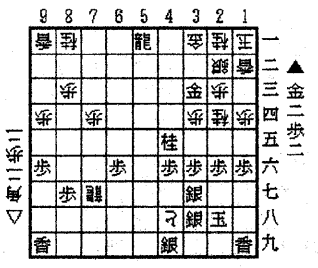
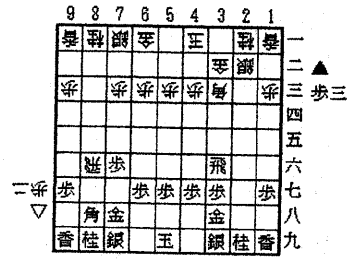


【Prob.10】

Appendix 2



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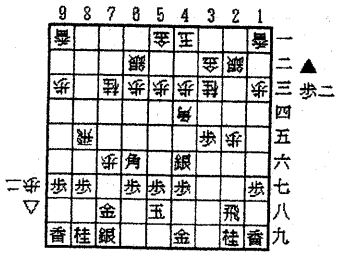

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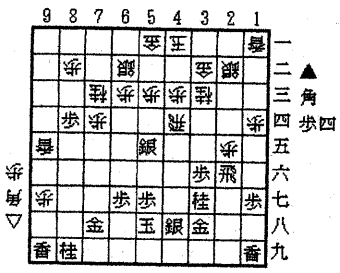

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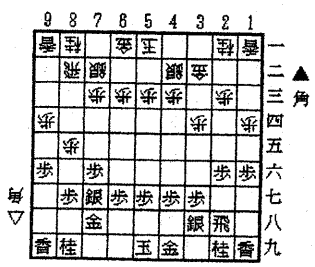

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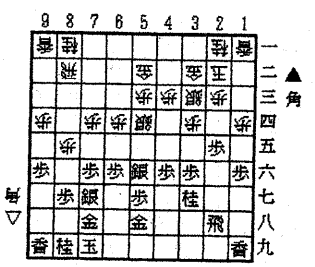

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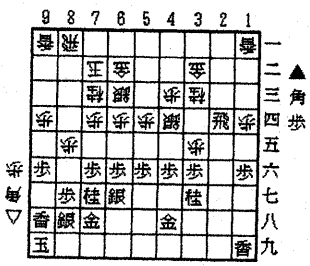

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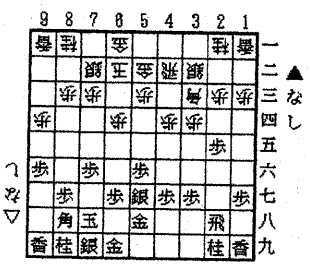

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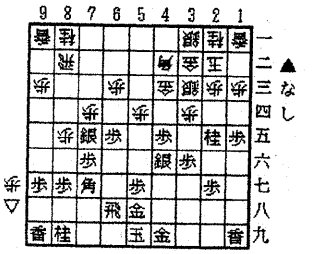

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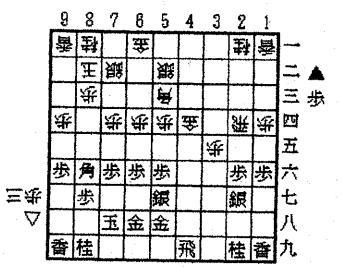

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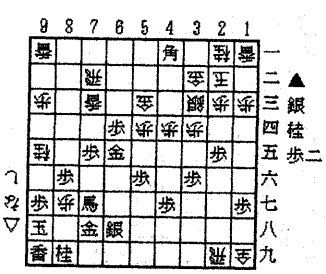

【Prob.10】