# A Cognitive Science Approach to Shogi Playing Processes

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**Abstract**

There have been a number of cognitive studies in chess and Go, but there has been no attempt at analyzing the cognitive behavior of shogi players. Shogi has a number of features that are different from chess, so it is not necessarily the case that cognitive science results for chess carry over to shogi. Therefore, we have started our cognitive study into shogi by repeating three cognitive experiments performed in chess in the 60s. In this paper we present the results of these three memory tasks. The first memory task is memorizing a set of shogi positions without any time limit. The second memory task is memorizing shogi positions with a time limit of 3 seconds. The third memory task is memorizing random shogi positions. Our experiments have been performed on a beginner, a club player and an expert player. Also, the eye movements of the subjects during all experiments were tracked with an eye camera. Despite the differences between chess and shogi in both rules of the game and perception of the board and pieces, we found no significant differences between the results of our experiments and the earlier results for chess.

## 1. Introduction

Shogi is a two-player complete information game in which the goal of the game is the same as in chess: capture of the king of the opponent. The most important difference between chess and shogi is that in shogi the pieces that have been captured do not disappear from the game. The pieces a player has captured from the opponent become *pieces in hand* and when it is a player's turn to move, he can choose between playing a move with one of his pieces on the board or put one of the pieces he previously captured on an empty square (this is called a *drop*).

As there are almost no exceptions to where the piece can be dropped back on the board, the average number of legal moves is much larger than in chess. For shogi this average is estimated at about 80, while in chess this is only 35 [5]. In the endgame, positions with more than 150 legal moves are the rule rather than the exception.

Because of this large number of average moves, it is clear that expert human players do not look at all the legal moves before making a decision about which move to play next. They use their intuition to select a small number of candidate moves, exploring only a few lines of play deeply. There are several reasons

why shogi is a good domain for studying the cognitive skill of problem solving. First, it might give us insight in how to make strong game playing programs for shogi. In chess, full-width search has been a very successful approach, resulting in programs that can compete with the human world champion. However, in shogi, the hardware is not fast enough to search to a sufficient depth for strong play using the full-width search approach. Therefore, studying the behavior of human shogi players might give us new ideas for improving the strength of shogi programs.

A second reason for doing cognitive science research in shogi is that so far there has been very little work in this area. In chess there has been cognitive research into the behavior of expert players [1,2]. For example, Chase and Simon [3] introduced the notion of "chunking" chess positions, dividing a chess position into smaller piece configuration sets that have meaning. Stronger players have bigger chunks of chess knowledge than weaker players. There has also been research into the role of high-level knowledge in memorizing chess positions [4]. In Go, there is for example Saito's work on protocol analysis [6]. We think that chess and Go are different from shogi in many respects, so doing cognitive research in shogi might give different results than for those games. To this end, we have started cognitive experiments with an eye camera on shogi players of different strength.

## 2. Related work

As a first step in our cognitive study of shogi, we repeated some experiments by De Groot on memorizing game positions [1]. There are several reasons why we feel that this repetition is necessary. First, the experiments by De Groot have been performed a long time ago. Since then, technology has advanced, so it is not clear that the same experiments will give the same results today.

Second, there are some important differences between chess and shogi from a perception point of view. Both the pieces and the squares of the shogi board have the same color (one's pieces can be distinguished from those of the opponent by the shape of the pieces which is not symmetrical, e.g. the pieces are "pointing" in a certain direction). Furthermore, in shogi the pieces in hand have no relation to a square on the board, thus potentially complicating perception. There are also more pieces in shogi than in chess, 40 instead of 32. Finally, it is unclear how the Kanji characters that are written on each piece influence perception.

In this paper we present the results of three memory tasks that we performed and which are similar to the ones performed by De Groot. First, we had subjects memorizing shogi positions without a time limit (memory task 1). Second, we had subjects memorizing shogi positions with a time limit of 3 seconds (memory task 2). Third, we had subjects memorizing random shogi positions (memory task 3).

## 3. Memory Task 1: Memorizing Shogi Position without Time Limit

### 3.1 Experimental set-up

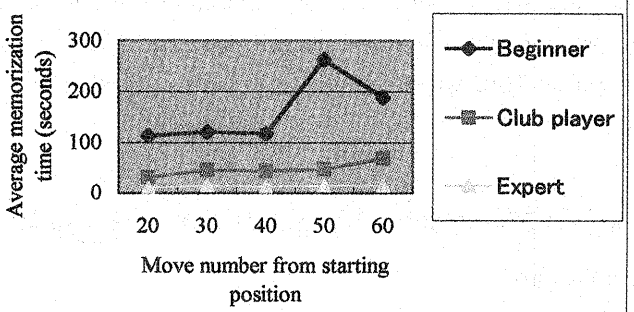
The first question we investigated was how much time it takes for shogi players of different playing

strength to memorize shogi positions. We had three subjects: a beginner, a strong club player (amateur 3-dan) and an expert (professional 8-dan). Our experiment consisted of 10 positions from 10 professional games that were taken from the game collection on a Shogi Yearbook CD-ROM. We selected 2 positions each after 20, 30, 40, 50 and 60 moves played from the starting position in those games. From each game only one position was selected. To make sure that there are no simple opening positions, we started at move 20.

Each position was shown to the subject on a computer monitor. The subjects were given as much time as they thought they needed to remember the positions. When the subject decided that he had memorized a position, he would click an OK button. After clicking the button, an empty shogi board is displayed with the pieces next to the empty board. The position could now be reconstructed by dragging the pieces to the squares. Our system measures the time between the appearance of the position on the screen and clicking the OK button. The system also records the number of pieces that have been placed correctly during the reconstruction stage.

Finally, the eye movements of all subjects were tracked with an eye camera during both the memorizing stage and the reproduction stage.

Figure 1: Average memorization time for 10 positions (no time limit)




## 3.2 Results

In Figure 1 we can see that beginners use more time to remember the positions than the club player, who in turn uses more time than the expert player. We can also see in the figure that the beginner slows down at positions that are later in the game. Even though this effect is less pronounced for the club player, in Figure 1 we can see that the club player also slows down for positions that are later in the game. In contrast, there is almost no difference between the different positions for the expert player. A final observation was that the beginner was often confused during the reproduction stage while the club player and the expert confidently put the pieces on the board.

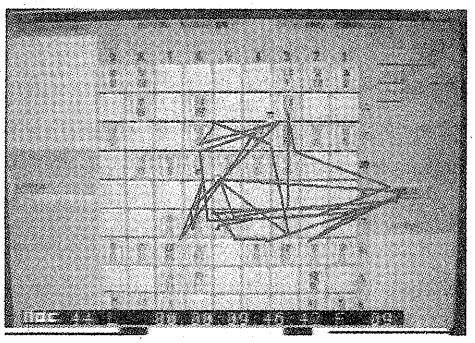


Figure 2: Eye tracking diagram of the expert

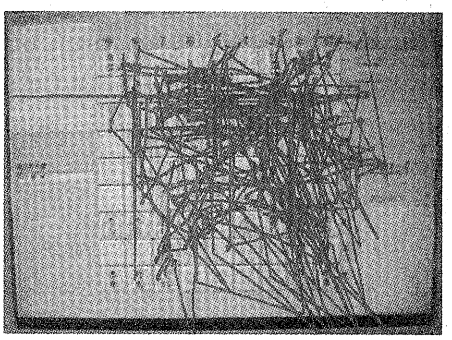


Figure 3: Eye tracking diagram of the beginner

### 3.3 Conclusions

We have shown that the expert player can do this memory task very quickly. In Figure 2 we can see how the eyes of the professional moved during the 6 seconds it took to remember this position. He focuses on the center of the board and the only time he focuses outside the board is when he considers several times to push the OK button (positioned outside of the board on the right). This indicates that the expert player can memorize the position much faster than the 6 seconds he actually took, but that he just checked the position a couple of times to make sure. The difference with Figure 3 is clear. Figure 3 gives an example of the eye camera data of the beginner. The beginner needs to look at every piece of the board and tries to remember them individually.

## 4. Memory Task 2: Memorizing Shogi Position with Limited Time

### 4. 1 Experimental set-up

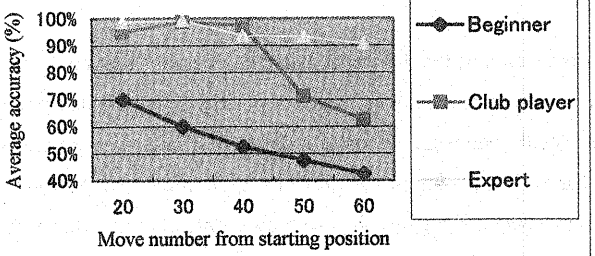
This time we wanted to know the relation between playing strength and the rate of correctness of the reproduction. The experimental set-up for this memory task is the same as before, but this time the positions were shown only 3 seconds. Of course the positions were all different from the ones used in the previous experiment. After the 3 seconds have passed, the position is replaced automatically with an empty position and the subjects have to put the pieces on the board with the mouse. In this experiment, we also tracked the eye movements with an eye camera.

### 4.2 Results

The results of our three subjects are given in Figure 4. Especially the beginner has a low score, which gets worse for positions that are later in the game. The results of the expert player and the club player start out the same, but the expert player still has about 80% of the pieces correct at higher move numbers.

The eye camera data in Figure 5 shows that the expert player does not focus on every piece on the board. This indicates that the pieces outside the focus area can also be remembered.

Figure 4: Accuracy rates for memorizing 10 positions with 3 seconds time limit



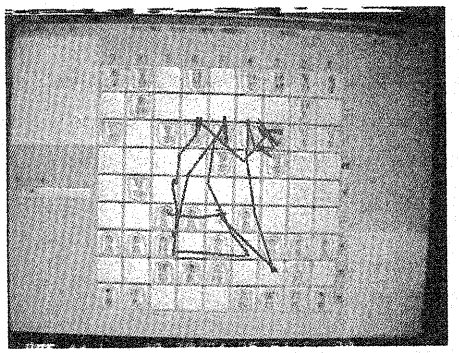



Figure 5: Eye tracking diagram of the expert

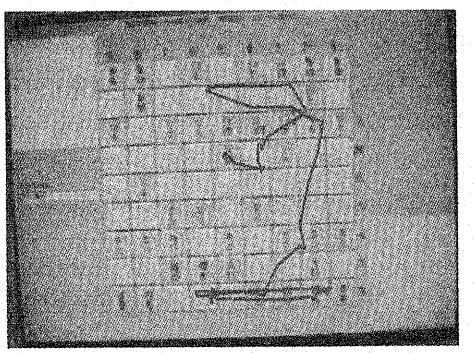


Figure 6: Eye tracking diagram of the beginner

### 4.3 Conclusions

From the eye camera data of the beginner in Figure 6 we can conclude that the beginner tries to remember each piece individually. However, this takes too much time and when the time is up, he just puts all the pieces in the starting position and moves them from there. This also explains why the results will be worse at higher move numbers. Less pieces will be on their original square, so there will be more mistakes if pieces are first put on their original squares.

The expert player is capable of dividing the position in chunks very quickly. In the early stages of the game, it is even conceivable that the full board position is one chunk (further analysis of the eye camera data is necessary to confirm this). The club player also has a set of chunks that help him to remember the position, for example for certain castle formations and piece formations in the opening and early middle game. However, in the later stages of the game these chunks are insufficient, so in these positions the club player can't compete with the expert player at this task.

# 5 Memory Task 3: Memorizing Random Positions

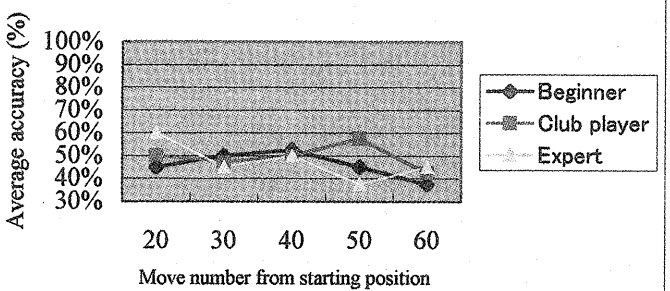
## 5.1 Experimental set-up

The final question we investigate is the difference between positions that have meaning (i.e. that have been played by strong players with a purpose) and random positions. We created random positions by moving pieces in a random (but legal) way from the starting position. In this way, we created 2 random positions at 20, 30, 40, 50 and 60 moves each. As in the previous experiment, the positions were only shown for 3 seconds. Again, in this task we also tracked the eye movements of each subject by an eye camera.

## 5.2 Results

Figure 7 shows that reproduction capability of random positions has almost no relation with playing strength. Also, the eye movement of the expert player as tracked by the eye camera in Figure 8 is very similar to that of the beginner. It is interesting that the three subjects now behave in the same way as the beginner in the previous experiment. After the position is replaced by an empty board, all three subjects first put the pieces in the starting position before moving them to different squares.

Figure 7: Accuracy rates for memorizing 10 random positions with 3 seconds time limit



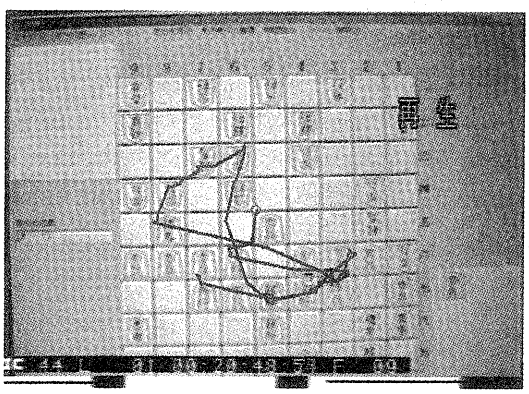



Figure 8: Eye tracking diagram of the expert

## 5.3 Conclusions

We have shown that for positions without meaning, there is no difference between the reproduction capability of beginners and experts. Only if a position has been created with a certain purpose, experienced players outperform beginners. It is possible that putting the pieces in the starting position is a way to give meaning to the piece formation to try and get some grip on the otherwise meaningless position. Another explanation can be that the only pieces with familiar meaning in the test positions are the pieces that were still on their original square.

## 6 Conclusions and Future Work

In this paper we have presented results for three memory tasks in shogi that had been performed in chess in the 60s and early 70s. This was necessary as we had reasons to believe that the difference between chess and shogi might lead to different results. Our experiments showed that this was not the case. There is a clear difference between the performance in the memory tasks between a beginner, a club player and an expert. This difference was also clear in chess. Also, for random positions there is no difference in performance between a beginner, a club player and an expert. This also was the same result as was found in chess.

We know now that shogi is cognitively similar to chess and our plans are to move on to other experiments that are more specific to shogi, aiming at analyzing the problem solving behavior of players of different playing strength. Our next work will focus on how players of different levels decide upon their next move.

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