ON THE RELATION BETWEEN PERCEPTION AND RECOGNITION IN SHOGI[1]

Reijer Grimbergen[2]

Tokyo, Japan

ABSTRACT

The ultimate goal of our research is to make a computer model of the cognitive behaviour of human game players using Marvin Minsky's *Society of Mind* theory about human cognition. The first step for building such a model is to understand the most primitive building blocks of human cognition, namely those dealing with perception. In the two reproduction experiments given in this article, a number of hypotheses about the importance of perceptual features for recognition were investigated. These experiments were carried out using *shogi* (Japanese chess), but neither the hypotheses nor the experimental set-up is particularly shogi-specific, so the results are expected to carry over to other games as well. The results of the experiments showed that knowledge in long-term memory is very important for perception and that perceptual features play only a minor role in recognition.

1. INTRODUCTION

Like many other research areas in Artificial Intelligence, game research has been a success story for the engineering approach. DEEP BLUE, probably the most famous of all game programs, searched between 100 million and 200 million positions per second in the 1997 match against Kasparov (Campbell, Hoane Jr., and Hsu, 2002). Human players clearly use a different approach, considering only a small number of positions per second and a small number of candidate moves (between 3 and 5) in any position (De Groot, 1965).

In the past, there has been research by De Groot (1965) into the behaviour of chess players and also well known is the work by Chase and Simon (1973), who introduced the idea of *chunking* of game knowledge to explain the difference between the performance of expert players and beginners in memory tasks. The nature of these chunks of game knowledge has been studied in other games such as Go (Reitman, 1976; Burmeister, 2000), but there is not much known about chunks in games other than that they exist and that they are the building blocks of human cognitive behaviour in games as well as other domains.

In general, it is believed that chunks are internal pieces of game-specific knowledge that are triggered by perception. However, the exact nature of this relation between perception and knowledge is unknown, but it seems that the idea of perception triggering chunks is not accurate. Rather, earlier work suggests that the knowledge in chunks is actually guiding the perception process. To investigate the relation between perception and knowledge in memory, we have performed two reproduction experiments that will be described in this article. (The results of the first of these two experiments have been presented earlier in Grimbergen (2008).) Shogi (Japanese chess) has been used because we have performed earlier cognitive experiments in this game (Ito, Matsubara, and Grimbergen, 2002), but it is believed that the results are general and do not depend on any shogi specific knowledge.

The remainder of this article is built up as follows. In Section 2 a cognitive model for perception in games is presented. Also, it will be explained why we believe that perception is mostly guided by knowledge in long-term memory. This assumption leads to four hypotheses for perception in shogi that are given in Section 3. To investigate these hypotheses, in Section 4 two reproduction experiments are described. The results of these

[1]This is a slightly amended version of the author's article, "Cognitive Modeling of Knowledge-Guided Information Acquisition in Games", published as a contribution in *Computers and Games 2008* (eds. H.J. van den Herik, X. Xu, Z. Ma,and M.H.M. Windands), pp. 169-180. It is reproduced with some changes and with permission of the Editors and publisher Springer Verlag, Heidelberg, Germany.

[2]School of Computer Science, Tokyo University of Technology, Japan, email: grimbergen@cs.teu.ac.jp

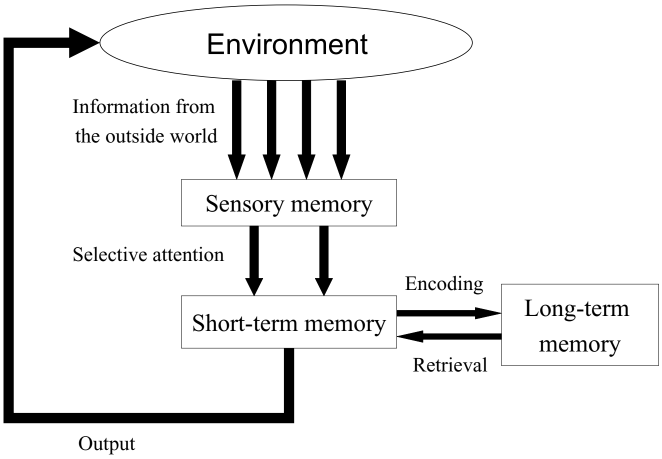

Figure 1: Interaction between sensory memory, short-term memory, and long-term memory.

Figure 2: Perception guided by knowledge.

experiments show that there seems to be no relation between the perceptual features and recognition of pieces in shogi. Finally, in Section 5 the conclusions and plans for future work are given.

2. A COGNITIVE MODEL FOR PERCEPTION IN GAMES

To reproduce game positions, information about the positions must be stored in memory. For this, the general three-stage memory model proposed by Atkinson and Shiffrin (1968) is often used. The model states that human cognition is the result of the interaction between three different types of memory: sensory memory, short-term memory, and long-term memory (see Figure 1). This three-way memory model is also the basis for the perception model for chess proposed by Simon and Chase (1973).

Sensory memory interacts with the environment by acquiring information through the senses. This is a subconscious process and can therefore not be guided. The amount of information that comes in through the senses is too high to process, so selective attention is used to limit the amount of information stored for further processing. The limited amount of storage is called short-term memory. Information in short-term memory can then be used to store and retrieve information from long-term memory or manipulate the environment.

Admittedly, the model of memory is too simplistic, but it will serve our modelling purposes except for one important extension. This is the phenomenon that we usually only see what we expect to see. For example, if we look at the picture of Figure 2 for the first time, without any hints about what is in the picture, it is hard to see anything but a blur (McCracken and Wolfe, 2004). However, once we are told that the head of a cow is in the left

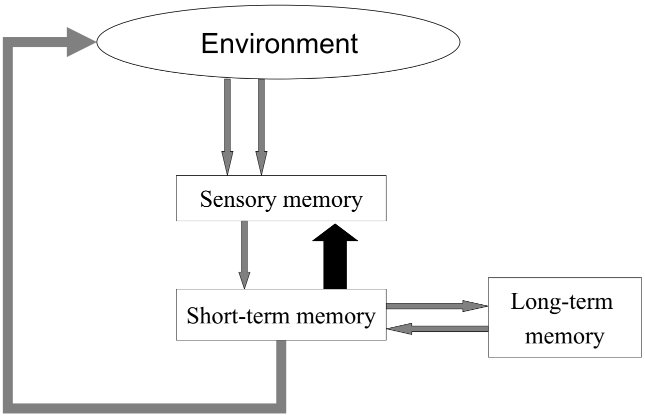

Figure 3: Perception guided by knowledge in long-term memory.

side of the picture the blur changes into a cow. Furthermore, if we look at this picture again, we will find it very hard to "unsee" the cow.

The point of this example is to illustrate that perception seems to be guided by knowledge in long-term memory. Therefore, the actual three-stage memory model should be the one in Figure 3, where knowledge from long-term memory is transferred to short-term memory. This information is often only confirmed using sensory memory. In the example above it means that because we know that there is a cow in the picture (long-term memory knowledge), we just need to check that it is really there. When using this model, the task of short-term memory is threefold: gathering information, guiding environment interaction, and confirming information.

Guiding perception in games by information in long-term memory is not a new concept. It was already found by Tichomirov and Poznyanskaya (1966), who investigated sensory memory in chess by tracking the eye movement of an expert chess player. One of the findings was that the eye fixations of the expert chess player were mostly on squares occupied by pieces that could be considered important for that position. Also, the fixations moved between pieces that could be considered to have a relation.

Further evidence of this finding can be found in the experiments by Chase and Simon (1973) about knowledge chunking in games. They repeated earlier work by De Groot (1965) in which chess players of different playing strength were asked to reproduce chess positions after viewing them for 5 seconds. The important difference in their experiments was that they also provided random positions. There were big differences in the reproduction ability of normal chess positions, but the reproduction ability was almost the same for random positions. The conclusion was that the difference in reproduction was caused by the fact that stronger players have bigger chunks of chess knowledge. If the recognition process would only be guided by perceptual features, there would be no difference between the reproduction of meaningful positions and random positions.

How important are perceptual features for recognition? This is precisely the question that we will investigate in this article. We start presenting four hypotheses on how a number of perceptual features of pieces in shogi (Japanese chess) are expected to influence recognition. We will then attempt to reject these hypotheses using two reproduction experiments. The research is described in the next sections.

3. PERCEPTION IN SHOGI: THE HYPOTHESES

Shogi pieces have the following specific perceptual features.

- On each piece, the name of the piece is written in kanji characters.
- The pieces of the opponent are reversed, so the names of the pieces of the opponent are upside down.

- When a piece is promoted (and most pieces promote), the piece is turned over, revealing a different kanji character.
- Players sit behind a shogi board with one's own pieces closest to oneself in almost all cases (it is rare but not impossible that there are more pieces by the opponent closer to oneself).
- Pieces differ in size, based on their importance. For example, the King is the biggest piece in shogi and the Pawn is the smallest piece.

Based on these perceptual features[3], the experiments were designed to test the following four hypotheses.

Hypothesis 1: It is easier to perceive one's own pieces than the pieces of the opponent. This hypothesis is based on the fact that the kanji characters of the pieces of the opponent are seen upside down from the viewpoint of the player and are therefore more difficult to perceive.

Hypothesis 2: It is easier to perceive promoted pieces than pieces that are not promoted. This hypothesis is based on the fact that the kanji for promoted pieces is more straightforward than the kanji for unpromoted pieces.

Hypothesis 3: Pieces closer to oneself are easier to perceive than pieces further away. This is the general perception principle of information about things near to oneself being more important than information about things that are further away.

Hypothesis 4: Bigger pieces are easier to perceive than smaller pieces. This is also a general perception principle of bigger things being more important than smaller things.

The experiments have been performed only for shogi, but by focussing on different perceptual features for different games, similar hypotheses may be made for any board game. Therefore, the results are not expected to be game-specific.

4. REPRODUCTION EXPERIMENTS

To test the hypotheses, two experiments are performed. The first experiment uses positions consisting of random configurations of all shogi pieces. The second reproduction experiment uses positions that have only two pieces with different perceptual features.

4.1 Reproduction Experiment 1: Randomly Generated Positions

In Subsection 4.1.1 we provide an outline of the experiment. In Subsection 4.1.2 the experimental results are given.

4.1.1 Outline of the Experiment

The first reproduction experiment to test the hypotheses was performed as follows (see Figure 4). First, subjects were shown a shogi board without any pieces. When they felt ready to be shown the position, they pushed a button and a position would appear. This position would be shown for 5 seconds and then it would disappear, being replaced by an empty board with pieces lined up at the bottom of the screen. These pieces could then be moved to the board. There was no time limit for the reproduction phase of the positions. When the subjects felt that they were finished, they could click on a button and be shown the next position.

There were two practice positions used to explain the experiment. No data for the practice positions was recorded. In the experiment 10 positions were used where each position was a random configuration of all of the 40 pieces

[3] Shogi has one other important perceptual feature: pieces in hand. When a piece of the opponent is taken, it is placed at the side of the board and can be placed on an empty square when it is the player's turn to move. Because this perceptual feature is very specific to shogi and does not carry over to other games, we have decided not to add this to the article.

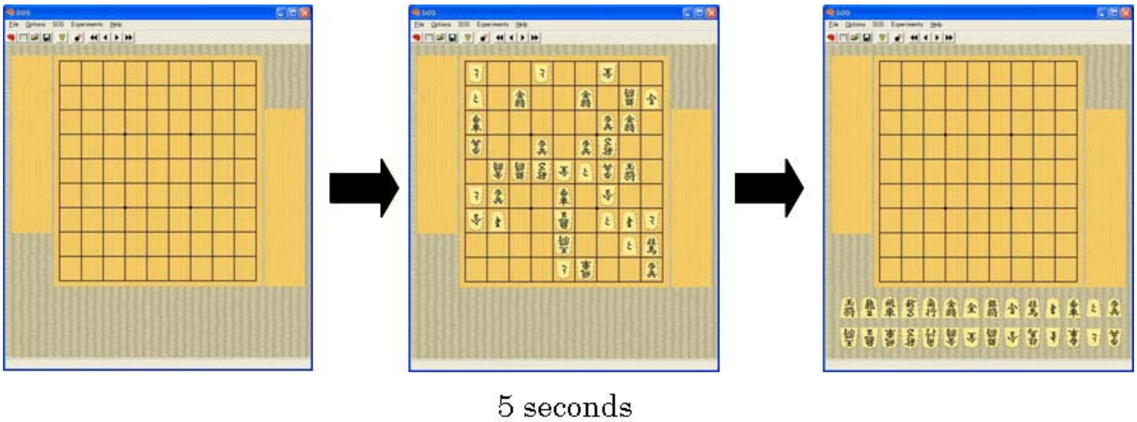

Figure 4: Example of a position from the reproduction experiment.

in shogi. For each piece, it was also randomly decided to show it in its promoted or unpromoted state. The experiment is similar to reproduction experiments we performed earlier (Ito *et al.*, 2002), but there is an important difference. The positions in our earlier experiments were generated by playing randomly from the starting position. Because of this, the generated position will have similarities with the well-known starting position, thus risking the use of chunks by the subjects.

We used 11 subjects in this experiment, all in their early twenties. Nine of the subjects had only a rudimentary knowledge of shogi, and two played a little more seriously in elementary school, but without ever gaining an official grade.

4.1.2 Experimental Results

Below, the results of the reproduction experiment related to the hypotheses will be presented.

Hypothesis 1: It is easier to perceive one's own pieces than the pieces of the opponent

To test this hypothesis, data about the difference between the reproduction of own pieces (kanji characters on the pieces displayed in the normal way) and opponent pieces (kanji characters displayed in reverse) was collected. The results are given in Figure 5. From these results it may be concluded that hypothesis 1 must be rejected. Only four subjects reproduced more of their own pieces than pieces of their opponent and in only one case this difference seemed to be significant (S8). Furthermore, the total number of own produced pieces was 321 (30.7%), while the total number of produced opponent pieces was 342 (31.7%).

Hypothesis 2: It is easier to perceive promoted pieces than pieces that are not promoted

To test this hypothesis, the difference between the reproduction of promoted pieces and non-promoted pieces was investigated. The results of this comparison are given in Figure 6. From these results it may be concluded that in general non-promoted pieces are reproduced more than promoted pieces. However, there are a number of subjects (S2, S3 and S11), who made an effort reproducing promoted pieces instead of non-promoted pieces. This did not lead to better performance regarding the correctness of the reproduced pieces, so this strategy seems to have no positive effect on recognition. Therefore, this hypothesis should also be rejected.

Hypothesis 3: Pieces closer to oneself are easier to perceive than pieces further away

To test this hypothesis, a definition of *nearness* is needed. In the experiment, nearness is defined as the rank of the square on which a piece is placed. The nearest pieces are therefore the pieces placed on the bottom rank, i.e., the rank closest to the player. Each rank further away is assumed to be decreasing the nearness of the pieces.

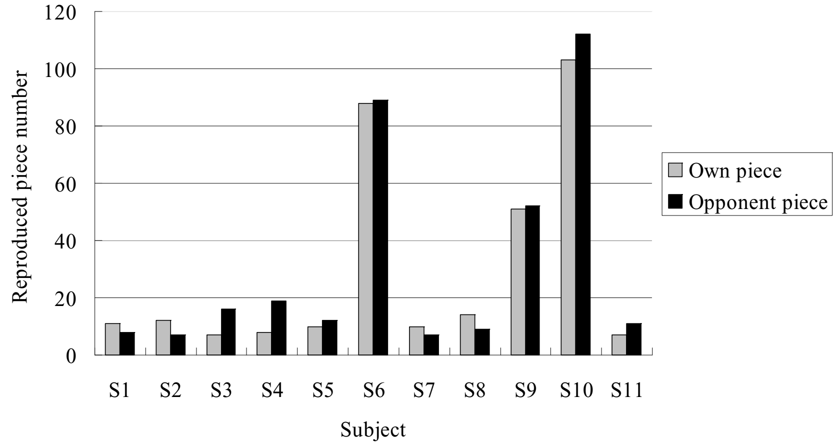

Figure 5: Reproduction differences between own pieces and opponent pieces.

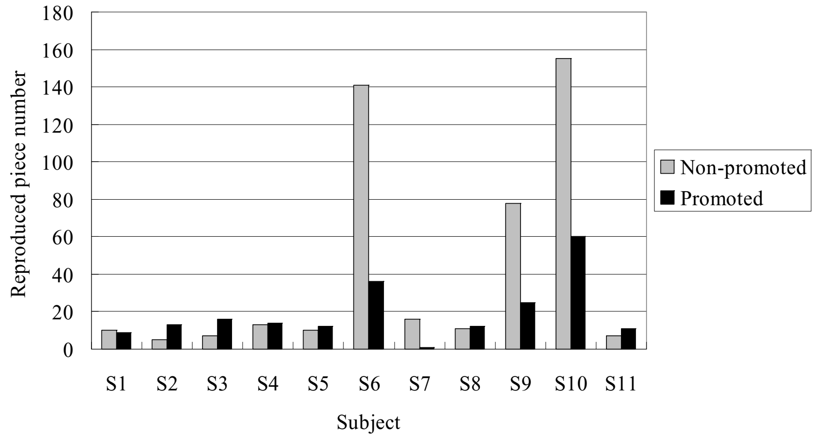

Figure 6: Reproduction differences between promoted pieces and non-promoted pieces.

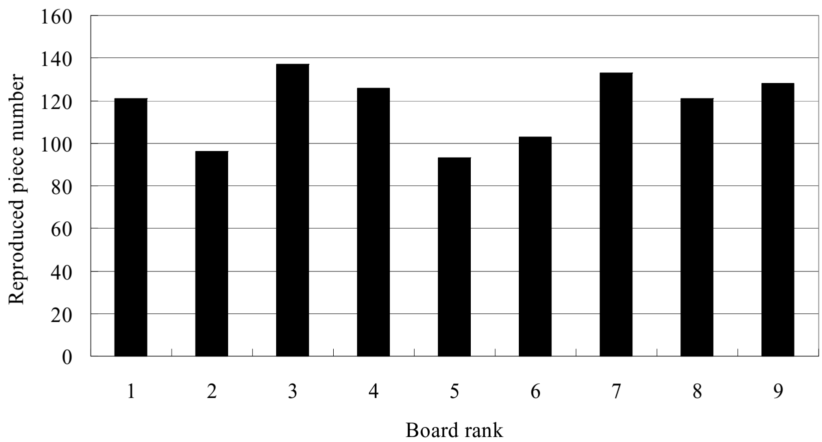

Figure 7: Comparison of piece reproduction and nearness. Rank 1 represents the rank of the board closest to the subjects.

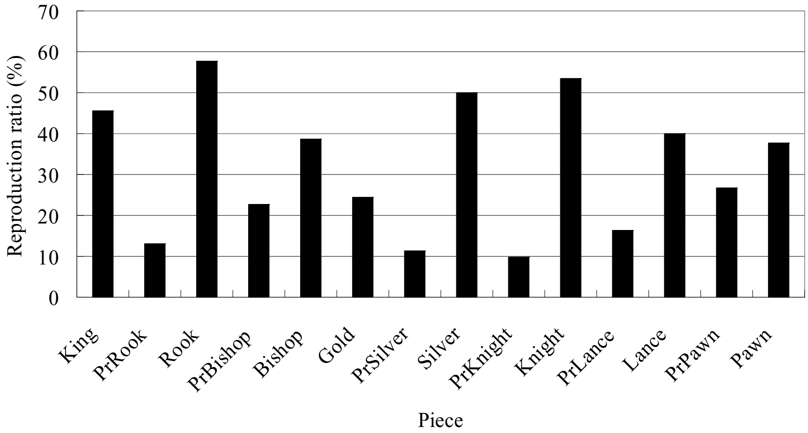

Figure 8: Number of reproduced pieces for each piece type.

This assumption is consistent with the normal way of sitting behind a board. The results of piece reproduction according to this definition of nearness are given in Figure 7. From this histogram it is clear that there is no obvious relation between nearness and the reproduced pieces. In this case there was one subject who seemed to use a memorizing strategy where nearness played a role, but this subject reproduced pieces that were furthest away first. Again, the hypothesis should be rejected.

Hypothesis 4: Bigger pieces are easier to perceive than smaller pieces

To test this hypothesis, data about the differences between the piece types of the reproduced pieces was collected. The standard relative size of each piece is given in Table 1. The pieces in the positions used in the experiment have the same relative piece size.

According to this table, the King should be reproduced more than the (promoted) Rook and (promoted) Bishop, which should in turn be reproduced more than Gold and (promoted) Silver, followed by (promoted) Knight, (promoted) Lance and (promoted) Pawn. The results of reproduction by piece type are given in Figure 8. From this graph it may be concluded that there is no relation between reproduction ratio and piece size. Therefore, this hypothesis should also be rejected.

4.2 Reproduction Experiment 2: Positions with Limited Perceptual Features

A problem with using a full board of pieces is that the amount of information presented to the subjects can be overwhelming. The order in which the pieces were reproduced showed that some subjects just tried to remember a number of pieces in one of the corners of the board after they figured out that it was impossible to remember many pieces. The second reproduction experiment was designed to have each position target a specific aspect of the hypotheses being investigated.

Piece	*RelSize*	*Piece*	*RelSize*
King	100	Silver	79
Rook	90	Knight	69
Bishop	90	Lance	59
Gold	79	Pawn	53

Table 1: Piece sizes of shogi pieces in percentages relative to the size of the King. Note: promoted pieces have the same size as their unpromoted versions.

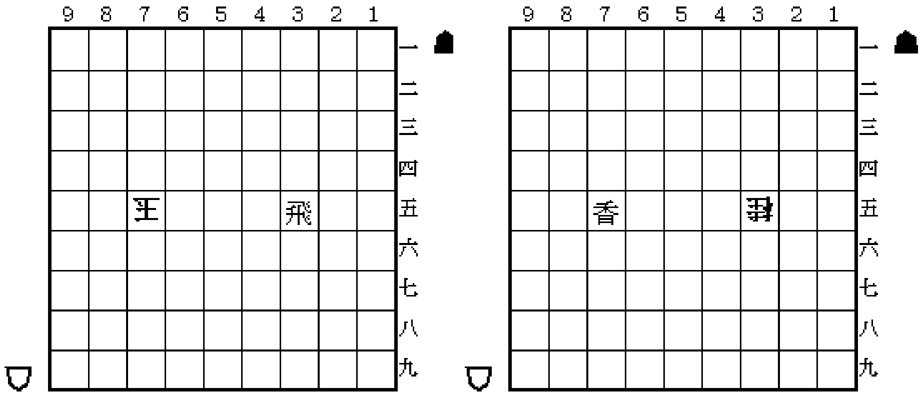

Figure 9: Position 1 (left) and Position 2 (right) to test the hypothesis that one's own pieces are easier to perceive than the pieces of the opponent.

4.2.1 Outline of the Experiment

The second reproduction experiment was performed using seven subjects. Again, all of the subjects were in their early twenties and had only a rudimentary knowledge of shogi.

The experiment consisted of eight positions, each hypothesis being tested using two positions. Each position had two pieces, with the perceptual difference between the pieces decided by the hypothesis that was being tested. The perceptual features related to the other hypotheses were are identical for both pieces. The subjects were shown each position for five seconds and then asked to reproduce the position. We recorded the complete reproduction process, including pieces that were moved to different squares or taken from the board.

Although the subjects were told to reproduce the complete position, we were only interested in the piece that was placed first. Our assumption was that the piece that was reproduced first was easier to remember and therefore easier to perceive as none of the subjects had additional shogi knowledge to guide the perception.

4.2.2 Experimental Results

Hypothesis 1: It is easier to perceive one's own pieces than the pieces of the opponent

This hypothesis was tested using the two positions in Figure 9. The first piece reproduced by the seven subjects for these two positions is given in Table 2. From these results it may be seen that one's own piece was produced first 8 times, while the opponent piece was reproduced 6 times. Also, there was only one subject (S2), who reproduced his own piece first for both positions. Therefore, we must reject the hypothesis.

Subject	*Position 1*	*Position 2*
S1	Opponent piece	Own piece
S2	Own piece	Own piece
S3	Own piece	Opponent piece
S4	Own piece	Opponent piece
S5	Opponent piece	Own piece
S6	Own piece	Opponent piece
S7	Opponent piece	Own piece

Table 2: First piece reproduced for the two positions testing hypothesis 1.

Hypothesis 2: It is easier to perceive promoted pieces than pieces that are not promoted

This hypothesis was tested using the two positions in Figure 10. The first piece reproduced by the seven subjects for these two positions is given in Table 3. From these results it may be seen that the promoted piece was

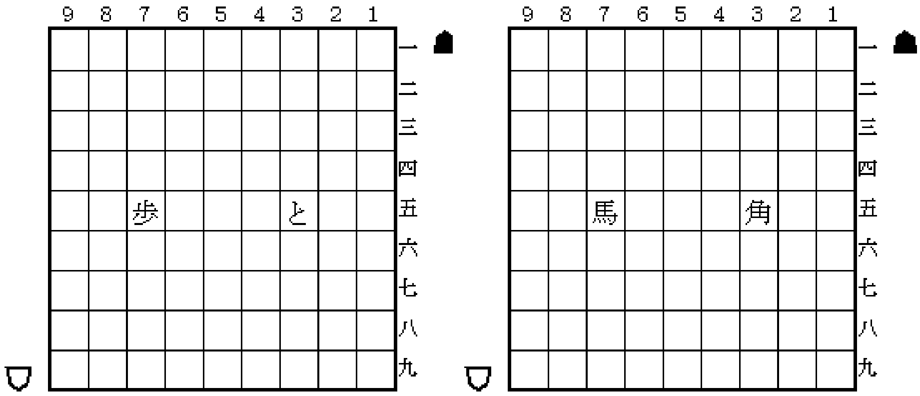

Figure 10: Position 3 (left) and Position 4 (right) to test the hypothesis that it is easier to perceive promoted pieces than pieces that are not promoted.

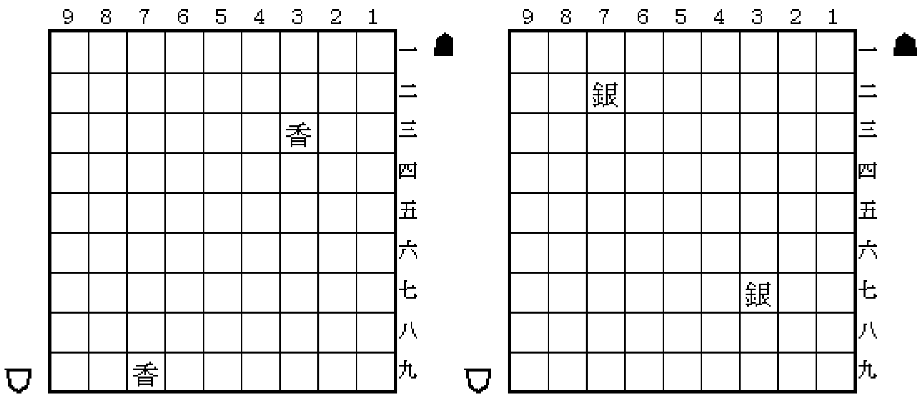

Figure 11: Position 5 (left) and Position 6 (right) to test the hypothesis that pieces closer to oneself are easier to perceive than pieces further away.

reproduced 7 times and the non-promoted piece also 7 times. Again, we must reject the hypothesis.

Subject	*Position 3*	*Position 4*
S1	Promoted piece	Promoted piece
S2	Unpromoted piece	Promoted piece
S3	Promoted piece	Unpromoted piece
S4	Promoted piece	Unpromoted piece
S5	Unpromoted piece	Unpromoted piece
S6	Unpromoted piece	Promoted piece
S7	Unpromoted piece	Promoted piece

Table 3: First piece reproduced for the two positions testing hypothesis 2.

Hypothesis 3: Pieces closer to oneself are easier to perceive than pieces further away

This hypothesis was tested using the two positions in Figure 11. The first piece reproduced by the seven subjects for these two positions is given in Table 4. From these results it may be seen that the closer piece was reproduced first 9 times and the piece higher up the board 5 times. Since we cannot straightforwardly reject the hypothesis, there seems to be some support for the hypothesis and further experiments are therefore needed.

Subject	*Position 5*	*Position 6*
S1	Close piece	Close piece
S2	Close piece	Close piece
S3	Close piece	Close piece
S4	Far piece	Far piece
S5	Close piece	Far piece
S6	Close piece	Close piece
S7	Far piece	Far piece

Table 4: First piece reproduced for the two positions testing hypothesis 3.

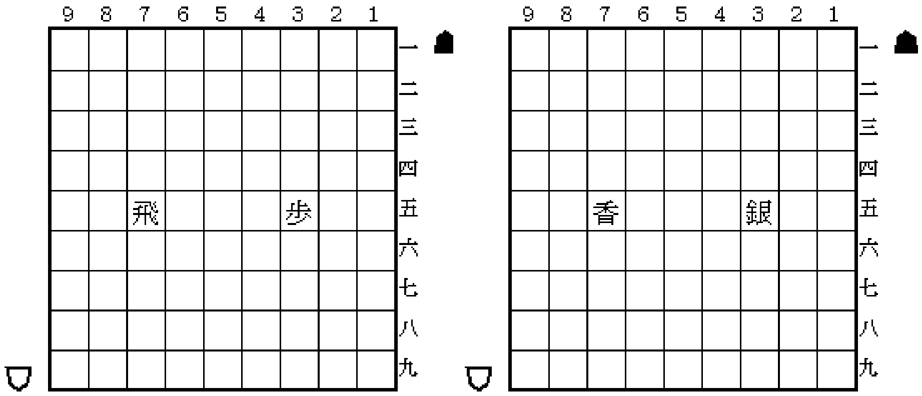

Figure 12: Position 7 (left) and Position 8 (right) to test the hypothesis that bigger pieces are easier to perceive than smaller pieces.

Hypothesis 4: Bigger pieces are easier to perceive than smaller pieces

This hypothesis was tested using the two positions in Figure 12. The first piece reproduced by the seven subjects for these two positions is given in Table 5. From these results it may be seen that the bigger piece was reproduced first 7 times, and the smaller piece was also reproduced first 7 times. Therefore, it seems that the hypothesis must be rejected. However, for the first position the difference in size between the two pieces is larger than for the second position. When looking at the results for the first position where the difference in size is most pronounced, 5 subjects reproduced the bigger piece first. This is some slight support for the hypothesis, so further experiments are needed.

Subject	*Position 7*	*Position 8*
S1	Bigger piece	Smaller piece
S2	Bigger piece	Smaller piece
S3	Smaller piece	Bigger piece
S4	Smaller piece	Bigger piece
S5	Bigger piece	Smaller piece
S6	Bigger piece	Smaller piece
S7	Bigger piece	Smaller piece

Table 5: First piece reproduced for the two positions testing hypothesis 4.

5. CONCLUSIONS AND FUTURE WORK

In this article it was explained why it is believed that knowledge in long-term memory (chunks) are not triggered by perceptual features, but that perception is guided by this knowledge. This assumption led to four hypotheses about the recognition of shogi pieces based on their perceptual features. The hypotheses were investigated by two reproduction experiments. The first experiment used random positions of all shogi pieces, while the second experiment used only two pieces to target each hypothesis individually. The results of the experiments show that hypothesis 1 and 2 must be rejected straightforwardly and hypothesis 3 and 4 require more research. All in all it means that there is no evidence that any of the perceptual features have a correlation with recognition ability. Therefore, the information flow from long-term memory to short-term memory to sensory memory in Figure 3 is much more important than the reverse information flow from sensory memory to short-term memory to long-term memory. Even though some additional experiments are needed, we found no evidence that perceptual features are important for recognition. Our experiments support the assumption that perception is guided by knowledge in long-term memory and that perceptual features are only used to confirm this knowledge.

In future work, some further experiments are needed considering *nearness* and *piece size*. However, considering the majority of the results indicate that there is no relation between perceptual features and recognition, we feel that it is unlikely that this will drastically change the results. Our main objective will therefore be to use the result of this experiment to start building a cognitive model for game playing using Marvin Minsky's *Society of Mind* theory (Minsky, 1988). We now know that the most primitive building blocks of such a cognitive model are not the perceptual features of board and pieces, but the primitive knowledge concepts contained in the most basic chunks like *piece*, *board*, *King* and so on. Implementing these primitive concepts and the relation between them will be our next target.

6. REFERENCES

Atkinson, R. C. and Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. *The psychology of learning and motivation: Advances in research and theory (vol. 2)* (eds. K. W. Spence and J. T. Spence), pp. 89–195. Academic Press: New York, NY.

Burmeister, J. (2000). Memory Performance of Master Go Players. *Games in AI Research* (eds. H. J. van den Herik and H. Iida), pp. 271–286. Van Spijk, Venlo, The Netherlands.

Campbell, M., Hoane Jr., A. J., and Hsu, F. (2002). Deep Blue. *Artificial Intelligence*, Vol. 134, pp. 57–83.

Chase, W. and Simon, H. (1973). Perception in Chess. *Cognitive Psychology*, Vol. 4, pp. 55–81.

De Groot, A. D. (1965). *Thought and Choice in Chess.* The Hague, The Netherlands: Mouton & Co.

Grimbergen, R. (2008). Cognitive Modeling of Knowledge-Guided Information Acquisition in Games. *Computers and Games: Proceedings CG 2008. LNCS 5131* (eds. H. J. van den Herik, X. Xu, Z. Ma, and M. H. M. Winands), pp. 169–180. Springer, Heidelberg, Germany.

Ito, T., Matsubara, H., and Grimbergen, R. (2002). Cognitive Science Approach to Shogi Playing Processes (1) Some Results on Memory Experiments. *Journal of the Information Processing Society of Japan*, Vol. 43, No. 10, pp. 2998–3011. (In Japanese).

McCracken, D. and Wolfe, R. (2004). *User-Centered Website Development.* Prentice Hall: New Jersey. ISBN 0-13-041161-2.

Minsky, M. (1988). *The Society of Mind.* Simon and Schuster: New York, NY. ISBN 0-671-65713-5.

Reitman, J. (1976). Skilled Perception in Go: Deducing Memory Structures from Inter-Response Times. *Cognitive Psychology*, Vol. 8, pp. 336–356.

Simon, H. and Chase, W. (1973). Skill in Chess. *American Scientist*, Vol. 61, pp. 394–403.

Tichomirov, G. K. and Poznyanskaya, E. D. (1966). An investigation of visual search as a means of analyzing heuristics. *Soviet Psychology*, Vol. 5, Nos. Winter 1966–1967, pp. 2–15.