A Reproduction Experiment Concerning the Relation Between Perceptual Features and Memory in Shogi

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Abstract

To use Minsky's *Society of Mind* theory to model human cognitive behavior in games, we first need to understand more about the interaction between perception and knowledge in memory. In this paper a reproduction experiment in shogi will be described that confirms or invalidates a number of hypotheses about perception in shogi without the use of game specific knowledge. These hypotheses are: 1) It is easier to perceive one's own pieces than the pieces of the opponent, 2) It is easier to perceive pieces in hand than pieces on the board, 3) It is easier to perceive promoted pieces than pieces that are not promoted, 4) Pieces closer to oneself are easier to perceive than pieces further away, and 5) Bigger pieces are easier to perceive than smaller pieces. No evidence was found that one's own pieces are easier to perceive than the pieces of the opponent. Also, there was no evidence that promoted pieces are easier to perceive than non-promoted pieces. However, size and closeness of the pieces and the difference between pieces on the board and pieces in hand seem to be factors influencing perception.

Keywords: Perception, Memory, Cognition, Society of Mind theory, Game playing.

1 Introduction

The goal of our research is to build a game playing program based on a general theory of human cognition. Marvin Minsky's *Society of Mind* theory [4] provides such a general theory and we will use this theory as our starting point.

Minsky uses *agents* and *agencies* as the building blocks of human cognition. He defines an agent as: "Any part or process of the mind that by itself is simple enough to understand". Complicated behavior is the result of the interaction between groups of simple agents. These groups of agents are called agencies.

To use Minsky's theory in games, the first step is to find out what the most primitive agents are. The most primitive agents are the agents that deal with input and output. For board games this translates to agents dealing with the perception of board and pieces (input) and agents dealing with playing moves (output). In this paper, we will investigate the perception of board and pieces, which should give us insight into the nature of the primitive agents used in game playing. We will use the game of shogi in our experiments, but the results are expected to carry over to other board games as well because perception in different board games is very similar.

2 Hypotheses

The experiment was designed to test the following hypotheses regarding the perception of board and pieces:

Hypothesis 1: It is easier to perceive one's own pieces than the pieces of the opponent. This hypothesis was based on the fact that the kanji characters of the pieces of the opponent are reversed and therefore more difficult to perceive.

Hypothesis 2: It is easier to perceive pieces in hand than pieces on the board. This hypothesis is based on the fact that pieces in hand cannot be promoted and knowledge about the square on which the piece is placed is not necessary.

Hypothesis 3: 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 simple than the kanji for unpromoted pieces.

Hypothesis 4: 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 5: 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.

Next, a reproduction experiment will be described to test these hypotheses.

3 Experiment

We performed a reproduction experiment using seven subjects. All of the subjects were in their early twenties and had only a rudimentary knowledge of shogi. This is important to ensure that only perception and no shogi-specific knowledge is used during reproduction.

The experiment consisted of ten 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.

The set-up of this experiment is different from earlier experiments by Chase and Simon in chess [1] and earlier experiments we performed in shogi [3] [2]. The reason for this is that the positions used in those reproduction experiments had too many pieces to say anything about the way the pieces were memorized. By significantly reducing the number of pieces, it was hoped to get better insight in the perceptional features that are important in memory tasks.

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.

3.1 Hypothesis 1: Own pieces vs opponent pieces

The hypothesis that one's own pieces are easier to perceive than the pieces of the opponent was tested

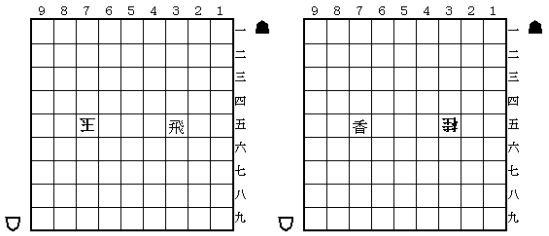

Figure 1: Position 1 (left) and Position 2 (right) to test the hypothesis that one's own pieces are easier to perceive than the pieces of the opponent.

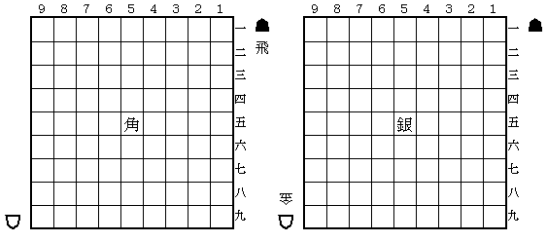

Figure 2: Position 3 (left) and Position 4 (right) to test the hypothesis that it is easier to perceive pieces in hand than pieces on the board.

using the two positions in Figure 1. The first piece reproduced by the seven subjects for these two positions is given in Table 1. From these results it can 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, the hypothesis must be rejected.

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

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

3.2 Hypothesis 2: Board pieces vs pieces in hand

The hypothesis that it is easier to perceive pieces in hand than pieces on the board was tested using the two positions in Figure 2. The first piece reproduced by the seven subjects for these two positions is given in Table 2. From these results it can be

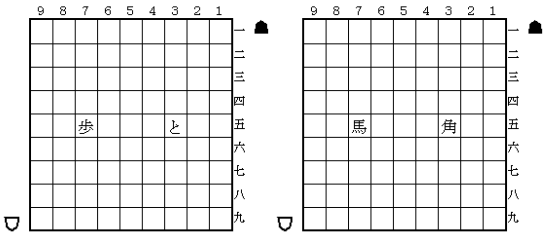

Figure 3: Position 5 (left) and Position 6 (right) to test the hypothesis that it is easier to perceive promoted pieces than pieces that are not promoted.

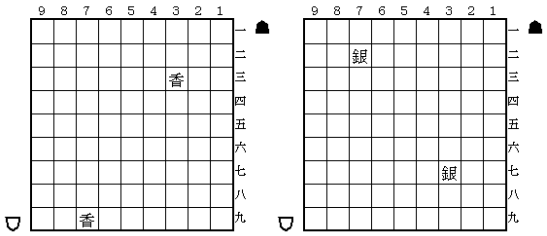

Figure 4: Position 7 (left) and Position 8 (right) to test the hypothesis that pieces closer to oneself are easier to perceive than pieces further away.

seen that the board piece was reproduced first 13 times, while the piece in hand was produced first only once. It seems that board pieces are easier to perceive than pieces in hand, which contradicts the assumption behind our hypothesis.

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

Subject	*Position 3*	*Position 4*
S1	Board piece	Board piece
S2	Board piece	Board piece
S3	Board piece	Board piece
S4	Piece in hand	Board piece
S5	Board piece	Board piece
S6	Board piece	Board piece
S7	Board piece	Board piece

3.3 Hypothesis 3: Promoted pieces vs unpromoted pieces

The hypothesis that it is easier to perceive promoted pieces than pieces that are not promoted was tested using the two positions in Figure 3. The first piece reproduced by the seven subjects for these two positions is given in Table 3. From these results it can be seen that the promoted piece was reproduced 7 times and the non-promoted piece also 7 times. Therefore, the hypothesis must be rejected.

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

Subject	*Position 5*	*Position 6*
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

3.4 Hypothesis 4: Closeness

To test the hypothesis that pieces closer to oneself are easier to perceive than pieces that are further away, we need a definition of nearness. We have defined nearness as the rank of the piece 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 considered to be decreasing the nearness of the pieces. This assumption is consistent with the normal way of sitting behind a board. The hypothesis was tested using the two positions in Figure 4. The first piece reproduced by the seven subjects for these two positions is given in Table 4. From these results it can be seen that the closer piece was reproduced first 9 times and the piece higher up the board 5 times. There seems to be some evidence supporting the hypothesis and further experiments are needed to confirm it.

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

Subject	*Position 7*	*Position 8*
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

3.5 Hypothesis 5: Bigger pieces vs smaller pieces

To test the hypothesis that bigger pieces are easier to perceive than smaller pieces, we looked at the differences between the piece types of the reproduced pieces. The standard relative sizes of pieces are given in Table 5. These relative piece sizes are used in the positions of our experiment.

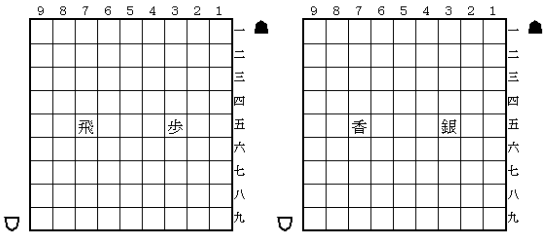

Figure 5: Position 9 (left) and Position 10 (right) to test the hypothesis that bigger pieces are easier to perceive than smaller pieces.

Table 5: 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.

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

According to this table, the king should be reproduced earlier than the rook and bishop, which should in turn be reproduced earlier than gold and silver, followed by knight, lance and pawn.

Table 6: First piece reproduced for the two positions testing hypothesis 5.

Subject	*Position 9*	*Position 10*
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

The hypothesis was tested using the two positions in Figure 5. The first piece reproduced by the seven subjects for these two positions is given in Table 6. From these results it can be seen that the bigger piece was reproduced first 7 times, and the smaller piece was also reproduced first 7 times. Therefore, it seems like 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, 5 subjects reproduced the bigger piece first, so to confirm or reject this hypothesis also further experiments are needed.

4 Conclusions and Future Work

We have presented a reproduction experiment to test five hypothesis concerning the perception of board and pieces in shogi. We found no evidence that one's own pieces are easier to perceive than the pieces of the opponent. We also found no evidence that promoted pieces are easier to perceive than non-promoted pieces. However, size and closeness of the pieces and the difference between pieces on the board and pieces in hand seems to be a factor influencing perception.

In future work, we will increase the number of subjects to reach a conclusion about the hypotheses that could not be verified or discarded at this point. Also, further experiments are needed to find out if our primary assumption that the piece that was reproduced first was easier to remember and therefore easier to perceive, is indeed correct.

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