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Towards Understanding the Commander's "Coup d'Oeil". Part 2

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Towards Understanding The Commander's "Coup d'Oeil". Part 2

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Abstract

This is the second paper in a series where we try to understand what Clausewitz called the commander's "coup d'oeil", i.e., the ability to understand the situation on the battle field at a glance. We employ a standard paradigm from research on expertise where participants study a scenario and then reproduce it from memory. Last year we reported results consistent with other results from studies of expertise, viz., that experts recall meaningful scenarios better than meaningless scenarios whereas novices recall both types of scenarios equally badly. This year, we report four follow-up experiments. The first two study experts' and novices' recall of scenarios after having seen how the scenario developed over time and we do so under two conditions, one where the scenario develops violating constraints on how military units should move and one where they do not in an attempt to distinguish between two possible explanations for last year's results: The constraints hypothesis and the pattern matching hypothesis. The results show that both experts perform better than novices but that both groups recall scenarios where the development did not violate constraints better than scenarios where the development violated constraints. We interpret these results as support for the constraints hypothesis. In Experiments 2 and 3 we vary the time allowed for inspecting static scenarios on the interpretation of these scenarios with both expert and novice participants. The results show that a short time for inspection affects the interpretation by novices to a greater extent than it affects the interpretation by experts, as was predicted by Clausewitz. We interpret this to mean that novices and experts achieve their understanding of a military scenario in different ways.

Introduction

At last year's ICCRTS, we (Brehmer & Kuylenstierna, 2010) presented a first study of the kind of fast sensemaking that Clausewitz (1934/1989) referred to by the phrase "the commander's *coup d'oeil*", using a term that was popular in his day. He had this to say about it:

> "…the *idea of a rapid an accurate decision* was … based on an evaluation of time and space, and consequently received a name that refers to visual estimates only. …But soon it was also used of any sound decision taken in the midst of action—such as recognizing the right point of attack, etc. *Coup d'oeil* therefore refers not alone to the physical but, more commonly, to the inward eye. The expression, like the quality itself, has certainly always been more applicable to tactics, but must also have its place in strategy, since here as well quick decisions are often needed. Stripped of metaphor and of the restrictions imposed on it by the phrase, the concept merely refers to the quick recognition of a truth that the mind would ordinarily miss or would perceive only after long study and reflection." (Clausewitz, 1834/1989, p. 102, italics in original).

In contrast to Clausewitz who saw the ability to decide what do by a *coup d'oeil* as something that characterized a military genius, our point of departure has been that this ability, if it exists, is part of the professional expertise of every officer (which is not to say that every officer is equally good at it, only that as a group, officers are better at it than other groups). We therefore employed a widely used experimental paradigm developed by psychologists to study expertise, a paradigm that has now been used to study expertise in a wide variety of fields, from chess to medical diagnosis (Vicente & Wang, 1998). The paradigm assesses expertise by examining recall. Specifically, experts and novices in the field of interest are asked to study, for a brief time period, some relevant material from the field, for example, chess board with chess men. They are then asked to recall what they have seen by reproducing it. The results show, for a wide variety of fields of expertise that when the materials to be recalled were actual examples of materials from the field, for example, a chess board where the positions of the chess men on the board represent a the result of actual play, experts (masters and grand masters) are able to reproduce the positions of the chessmen much better than novices, but when the positions are the result of random placement of the chess men, experts do no better than novices. In our study, the experts were army majors participating in the higher staff course at the Swedish National Defence College and the novices were students of political science without military experience at the college. They were given five minutes to study the positions of a number of military units on a map and then asked to reproduce what they had seen on a test map. The results were the same as those in other studies using this paradigm: experts performed better when the positions of the units on the map represented a meaningful military scenario than when they had been positioned randomly on the map, but for novices there was no difference between these two conditions.

The literature on expertise offers two different explanations for this kind of result, and thus different conceptions of the nature of expertise. The first, is called the *constraints attunement*

hypothesis, the second the *chunking*, or *pattern recognition hypothesis*. According to the former hypothesis, which was first proposed by Vicente and Wang (1998), experts have learned to pick up information about the goal-related constraints in the domain and use that information to cut down on the number of possibilities when reproducing the scenario. In contrast, the chunking, or pattern recognition hypothesis, first proposed by Chase and Simon (1973) suggests that experts have learned to categorise information in terms of recurring patterns in their domain. They then remember the patterns and use them in recall.

Although the two hypotheses sound very different, it is in fact, difficult to distinguish between them empirically for they make the same predictions and they do it on a very similar basis. Thus, both hypotheses assume that the advantage enjoyed by the experts has its basis in their having to store less information than novices do to perform well at recall. According to the constraints hypothesis, experts have to store less information because they know the goal related constraints, i.e., in this case, what can and cannot be done with military units to achieve a given goal. Once they have understood what the goal is, they can use their knowledge of these constraints to cut down on the number of possibilities for actually placing the units in the recall condition. To put matters differently, the experts find the task easier than novices because they reproduce what they know *must have been the case*, given their understanding of the goals. They therefore do not have to remember the positions as such as the novices are forced to do. In contrast, the pattern recognition hypothesis assumes that the experts have learned to recognize patterns of positions. When inspecting a scenario, they recognize and store the pattern as a unit (or *chunk*, hence the name "the chunking hypothesis") by assimilating it to one of the patters they have stored. They then reproduce the chunk from memory without having to recall the positions of each individual unit as such. Both hypotheses thus predict an advantage for experts, based on their having to store less information to reproduce what they have seen, and both hypotheses explain the experts' ability to do this in terms of what they have acquired on the basis of experience. They differ in what is assumed to have been learned, however: constraints or patterns. The explanation for the inferior performance in the meaningless condition is, in the case of the constraints hypothesis, that for this condition, it is difficult to understand what the goal is, and knowing constraints that are goal related, will not help when the positions of units to be remembered violate the constraints they know about. In this case, knowing the constraints will not help at reproduction and it becomes necessary to remember the individual units, just as a novice has to do. According to the chunking, or pattern matching, hypothesis recall will be worse for meaningless material because the expert cannot rely on the patterns that he or she has learned to reproduce the positions of the units. This is because the scenario will not match any of the patterns that the expert would have stored. For novices, who have neither earned the constraints nor the patterns, both hypotheses, predict that meaningful material will not give any advantage at recall. Knowing neither the constraints and nor any patterns, novices have to remember the positions of the individual units for both meaningful and meaningless material, making both conditions equally difficult. Moreover, in contrast to experts, novices will not be helped by the fact that they have understood what is going on in the scenarios. Even if they know the goals, they do not know the goal related constraints of the domain which help the experts perform well.

For static displays, such as a situation reproduced on a map (or a chess board) the hypotheses are, however, not really all that different. The patterns that an expert detects and remembers, if that is indeed what he or she does, must, of course, have some basis in reality to be of any use. That is, they must have a basis in *possible* patterns in military scenarios. In the present case, these possible patterns are, of course, generated by the goal related constraints. If there were no constraints, there would not be any limit to the patterns to detect and learn. It is not surprising, therefore, that the two hypotheses make the same predictions.

It will therefore be very difficult to distinguish between the two hypotheses from static displays. However, using dynamic displays it may be possible to distinguish between them. Such displays offer a possibility to present not only the final positions, but also how the scenario evolved up to this final stand. Thus, it would be possible to present final positions that evolved either naturally or by violating constraints. Here the constraints hypothesis predicts an advantage in recall for the scenarios that have developed naturally compared to scenarios that have evolved by violating constraints. A chunking hypothesis would not make this prediction, since it only takes the pattern of positions of the units into account. If this pattern is the same, recall should be the same regardless of how the scenario had evolved. Our first two experiments were designed to test this hypothesis. In these experiments we compare the recall of the final positions of military units in a scenario that the participants have seen develop over time, under conditions where scenario development violates constraints and when it does not. One might object that also the movement up to the scenario to be recalled represent a pattern, a "pattern of movements". However, it is not this pattern of movements that we will ask our participants to recall, but only the final position.

As noted above, in our earlier study (Brehmer & Kuylenstierna, 2010), we also asked our participants to interpret the scenario we presented to them. We found, as we have already mentioned, that our novices gave the same general explanation of what was going on in the meaningful scenario as the experts. Clausewitz had hinted at such a possibility in the last sentence of the quote above where he said "…the quick recognition of a truth that the mind would ordinarily miss or would perceive only after long study and reflection." That is, it may well be that we had given our participants enough time for reflection to arrive at a reasonable interpretation of the scenario. In the third and fourth experiment of this paper, we examine Clausewitz's hypothesis by examining the effects of the time available for inspection of the scenario on the explanations given by experts and novices. Our expectation, based on Clausewitz's observation is that novices would be affected by the available time to a greater extent than experts.

Experiments 1 and 2. Effects of meaningful dynamics on recall of a scenario that is meaningful from a military standpoint

In Experiments 1 and 2, we compare recall by experts (Experiment 1) and novices (Experiment 2) of the same final positions when they have been given the opportunity to see the scenario evolve in two different ways. In the first condition, it was the result of a meaningful military development, i.e., the units whose final positions are to be recalled reached these po-

sitions as military units would do, not violate any constraints. In the second condition, the same scenario was the result of random movements of the units. Such dynamic scenarios have been used to good effect in studies of expertise in sports, e.g., in soccer (Williams, Davids, Burwitz & Williams, 1993). However, our use of dynamic scenarios differ from that in studies of expertise in sports in that we do not ask our participants to recall the dynamics as such. Instead, we employ dynamic scenarios to provide information that a static scenario cannot provide, but we still ask our participants to recall the final positions of the units, i.e., they are, in fact, asked to recall the same kind of information as in our earlier experiments.

Participants

In Experiment 1, 18 Army Majors from the Higher Staff Officers program at the Swedish National Defence College, all male and aged around 40 years, and 12 Lieutenant Colonels who serve as teachers in that program, all male and between 40-60 years old, participated in the experiment. Each participant volunteered to take part and received two cinema vouchers as a reward.

In Experiment 2, thirty undergraduate civilian students without a professional military background, from the political science program at the college participated in the experiment. Their age was around 25 years, and 12 were male and 18 female.

Design

Both experiment followed a between-groups design with 15 participants in each condition. The independent variable was the meaningfulness of the approach to the final stand in a dynamic display of military units moving on a map. The dependent variables were the participants' interpretation of the scenarios and their ability to reproduce the scenarios immediately after the scenario presentation was finished.

Scenario construction

The dynamic scenarios for the two conditions were constructed by a Lieutenant Colonel from the Swedish Armed Forces Land Warfare Centre. Both scenarios had the same final positions for a set of blue and red military units. The task for the red force was to attack and that for the blue force it was to delay Red's progress. In the meaningful condition both the approach to the final positioning and the final positions followed constraints set by conventional military wisdom given this task, the units involved and the terrain. In the meaningless condition the final positions (naturally) were consistent with the same constraints as in the meaningful task, but the approach was deliberately constructed to violate the constraints that normally would put restrictions on the units' movements in order to make the approach as incomprehensible

as possible. The meaningful and meaningless approaches were equal with respect to the distribution speeds, distances travelled and times for reaching the final positions.

Experimental set-up

The participants were seated at a table. Facing them, at a distance of 1.04 m, was a 52 inch LCD monitor with a 1920 X 1080 resolution. The monitor dynamically displayed a military scenario with units moving over a map. The area covered by the map was 72 cm x 65 cm. The scenario rolled for about 2 minutes, then there was a 10 second pause, after which the scenario rolled again. In front of the participants was a white (96 cm x 80 cm) sheet of paper. Hidden underneath this sheet of paper was a 72 cm x 65 cm map similar to the one presented on the screen, but without any units. This map was covered with a sheet of transparent plastic.

Procedure

The subjects first signed an informed consent form. They were then orally informed that a military scenario was going to be presented to them showing a development from a starting point to a final point, that the scenario would roll for 2 minutes and that they would see it twice with a ten second pause in between the presentations. They were also told that their task after the presentation would be to interpret the scenario from the perspective what “red” and “blue” respectively, were trying to accomplish and write down their interpretations on an answering sheet. They were also told that the time for writing would be 5 minutes. They were shown the symbols for the various military units in the scenario and what the symbols signified on a special sheet. The novices in Experiment 2 who, naturally, are less familiar with these symbols than the officers, were allowed to keep this sheet throughout the experiment Then the experiment proceeded in accordance with the instructions. When the 5 minutes for writing down the interpretations had passed, the participants were asked to put their answer sheet aside and the scenario map sheet was turned over exposing the “empty map” with its plastic sheet. Only then, the participants were informed that there would now be a second task, viz., to reproduce the positions of the units in the scenario map on the plastic sheet. The reason for not informing the participants that there would be a second task beforehand was to prevent them from entering into a “memorizing mode”. There is evidence that such a mode may reduce effects of meaningfulness (Norman, Brooks & Allen, 1989). The participants were informed that time for reproduction was free. The participants were then given a blue and a red marker pen and instructed to reproduce the scenario they had just seen, that is; to put the right unit in the right position. The whole experimental session normally required about 15 minutes.

Results

Recall performance was scored by two observers in this same manner as in our earlier experiment (Brehmer & Kuylenstierna, 2010). A 10 cm template with 10 concentric circles 0.5 cm apart was placed with the center at the actual position of each unit. If the participant had drawn the symbol for the correct unit and placed it in the innermost circle, he, or she, received a score 10 points, if in was in the next innermost circle, the participant received a score of 9, and so on. If the participant had placed the unit outside the 10^{th} circle, or if he or she had drawn the wrong unit, the score was 0. The scores were then summed over units. The maximum possible score was thus 230 and the minimum 0. In the earlier paper, we showed that measurements using this technique yields reliable results, and it did so also in these experiments. The correlation between the scores produced by the observers was .92 in Experiment 1 and .97 in Experiment 2.

In Experiment 1, mean performance in the condition where the final scenario was the results of meaningful dynamics was 35.80 and in that with the meaningless dynamics it was 18.80. A t-test comparing the means yielded $t = 2.63$, $df = 28$, $p < .02$. For Experiment 2, the corresponding results were 24.33 for the meaningful condition and 12.47 for the meaningless condition. The difference was significant also in this experiment, $t = 2.25$, $df = 28$, $p < .04$.

The participants interpretation of the scenario. All expert participants understood that Red was attacking Blue in the meaningful condition. The interpretation by the novices was more variable, and the impression as that, as a group, they seemed to be less attuned to the constraints than the experts. The interpretations in the meaningless condition were more variable, but both experts and novices were able to extract some meaning also in this condition where Red is seen as the more aggressive part.

Discussion

As in our earlier study (Brehmer & Kuylenstierna, 2010), the experts outperform the novices at recall. This was expected, and agrees with the results from numerous studies on a variety of experts using this experimental paradigm. However, in contrast to what we had expected, both experts and novices were affected by the extent to which the development of the scenario violated constraints. When it did, performance was worse than when it did not violate constraints. In both cases, the average performance in the meaningless condition is about 50% of that in the meaningful condition. This result cannot be predicted from a pattern matching hypothesis, even if the pattern concept is interpreted as “movement patterns” for it seems highly unlikely that our novices have any experience with moving military objects that could serve as a basis for developing the kinds of patterns or chunks in memory that this hypothesis requires. We conclude that these results are evidence against the chunking hypothesis. They can, however, be seen as consistent with the constraint hypothesis. The ideal results here would, of course, have been that the experts had been affected by the constraints violations while the novices had not. Thus, the result that novices are affected by the extent to which the development of the scenario violates constraints in conjunction with the result that experts outperform novices can be interpreted as consistent with the constraints hypothesis when we remember that some of the constraints that are violated in the meaningless condition are very

general in nature, and does not require much military knowledge. For example, even a novice would understand that a supply troops do not attack tank units. This is, of course, only a hypothesis, to be tested in future experiments aiming at finding what constraints are actually used. Thus, at the very least, the results of this year's experiments provide direction for future work in the area.'

Experiments 3 and 4

Experiments 2 and 3 were concerned with the effects of the time available for inspection of the target scenario on the interpretation of that scenario. Both experiments employed the same dependent and independent variables, but differed with respect to the number of levels of the independent variable and some minor details in the procedure.

Participants

Participants in Experiment 2 were 24 undergraduate college students taking courses in political science at our college. This group included 13 male and 11 female participants and their average age was 24 years. The students were asked about their military experience and it turned out that four of them had gone through basic military training in the Army, one of them had a background of three terms of officers training in the Amphibious Corps and one had an Amphibious Corps background as a conscript, and one had done service as non-commisioned officer in a mission abroad. The participants in Experiment 3 were 16 Army Majors from the Higher Staff Officers program at the Swedish National Defence College, all male and aged around 40 years. Each participant volunteered to take part and rewarded by two cinema tickets.

Design

Both experiments used a between-group design with 8 participants in each condition. The independent variable in each experiment was the time for inspection of military scenarios of the kind used by Brehmer and Kuylenstierna (2010). The dependent variable was the quality of the participants' interpretation of these scenarios after inspection. In Experiment 3 i.e., that where the participants were novices, the independent variable had three: 5 minutes, 1 minute and 20 seconds. In Experiment 4, i.e., that in which the participants were Army Majors, there were only two levels: 1 minute and 20 seconds.

Scenario construction

The two scenarios for the two experiments were constructed by a Lieutenant Colonel from the Swedish Land Warfare Centre. Both scenarios involved an attacking force and a defending

force and both scenarios were meaningful in the sense that the positioning of individual units followed the constraints set by “conventional military wisdom”, given the task, the units and the terrain. The first scenario had 13 blue units and 8 red units. The second had 9 blue units and 10 red units.

The scenarios are illustrated in Figures 1 and 2.

Experimental set-up

The participants were seated at a table. In front of them was a white (1.20 m x 1.07 m) sheet of paper. Hidden underneath this sheet of paper was another 1.20 m x 1.07 m sheet of paper with a 0.74 m x 0.82 m scenario map on it. The scenario map had a legend naming the various red and blue units. On top of the white sheets there was also a list with the same units as in the legend on the scenario maps, although in black and white. Underneath the scenario map there was another white paper followed by a map with the other of the two scenarios. The order of presentation of the two scenarios was counterbalanced.

Procedure

The participants first signed an informed consent form. Then the task was presented to them orally. It was explained that underneath the sheet of white paper in front of them, there was a map with a ground warfare scenario with blue and red units fighting each other They were also informed that their task was to write down a few lines on an answering sheet explaining what they thought that the blue and the red side, respectively, were trying to achieve. Finally they were told that they had five minutes (or 1 minute or 20 seconds depending on the condition) to inspect the map with the clock starting as soon as the scenario map was uncovered.

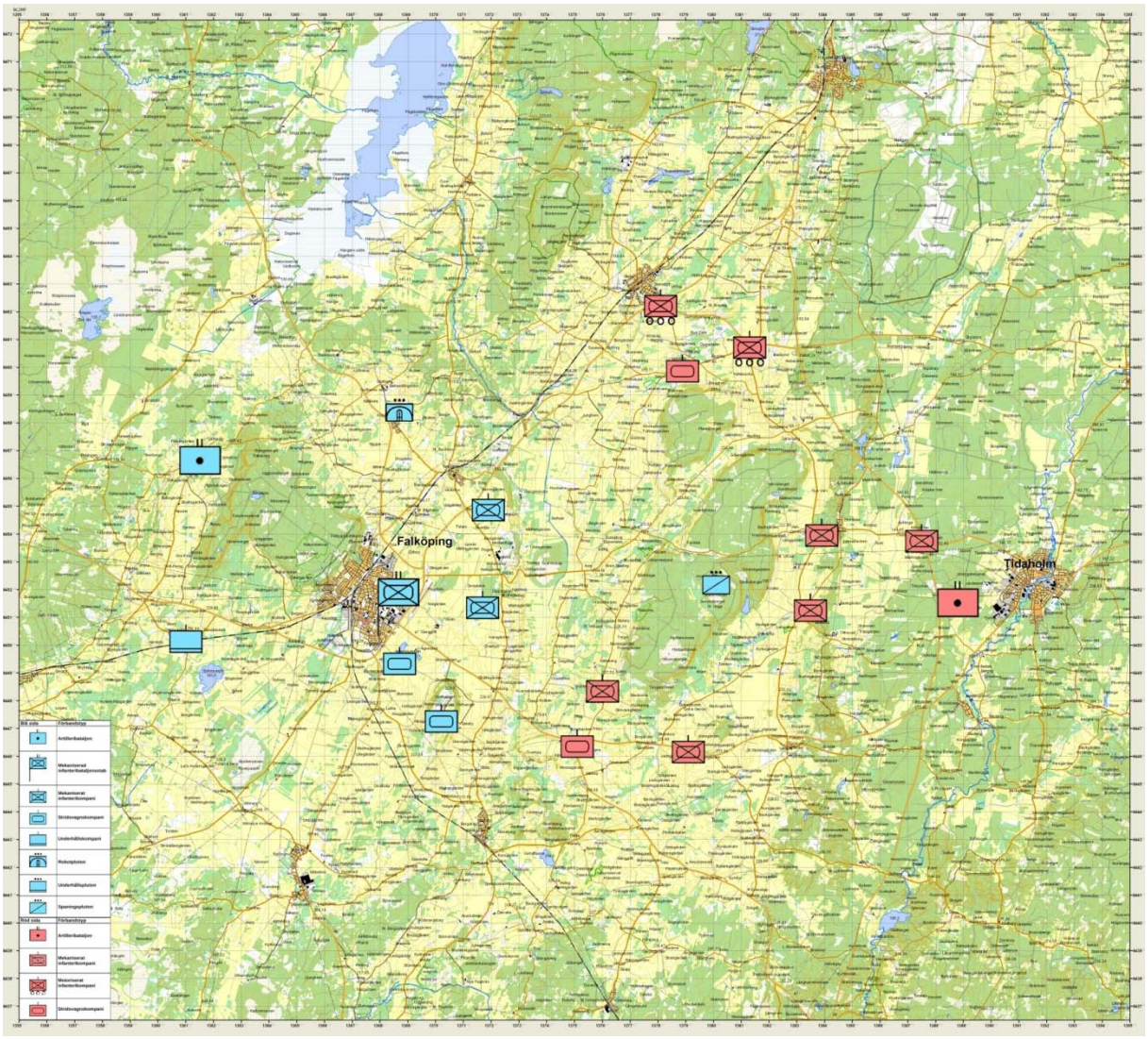

Fig. 1. Scenario 1.

Before the map was uncovered, the participants could familiarize themselves with the units used in the scenario. Then the cover sheet was removed and the clock started. When the inspection time had passed the map was removed and they were then allowed to write down their interpretation on the answering sheet. The time for writing was 5 minutes. When the first task was finished they continued with the second task in the same way. The experimental session took about 15 minutes to accomplish.

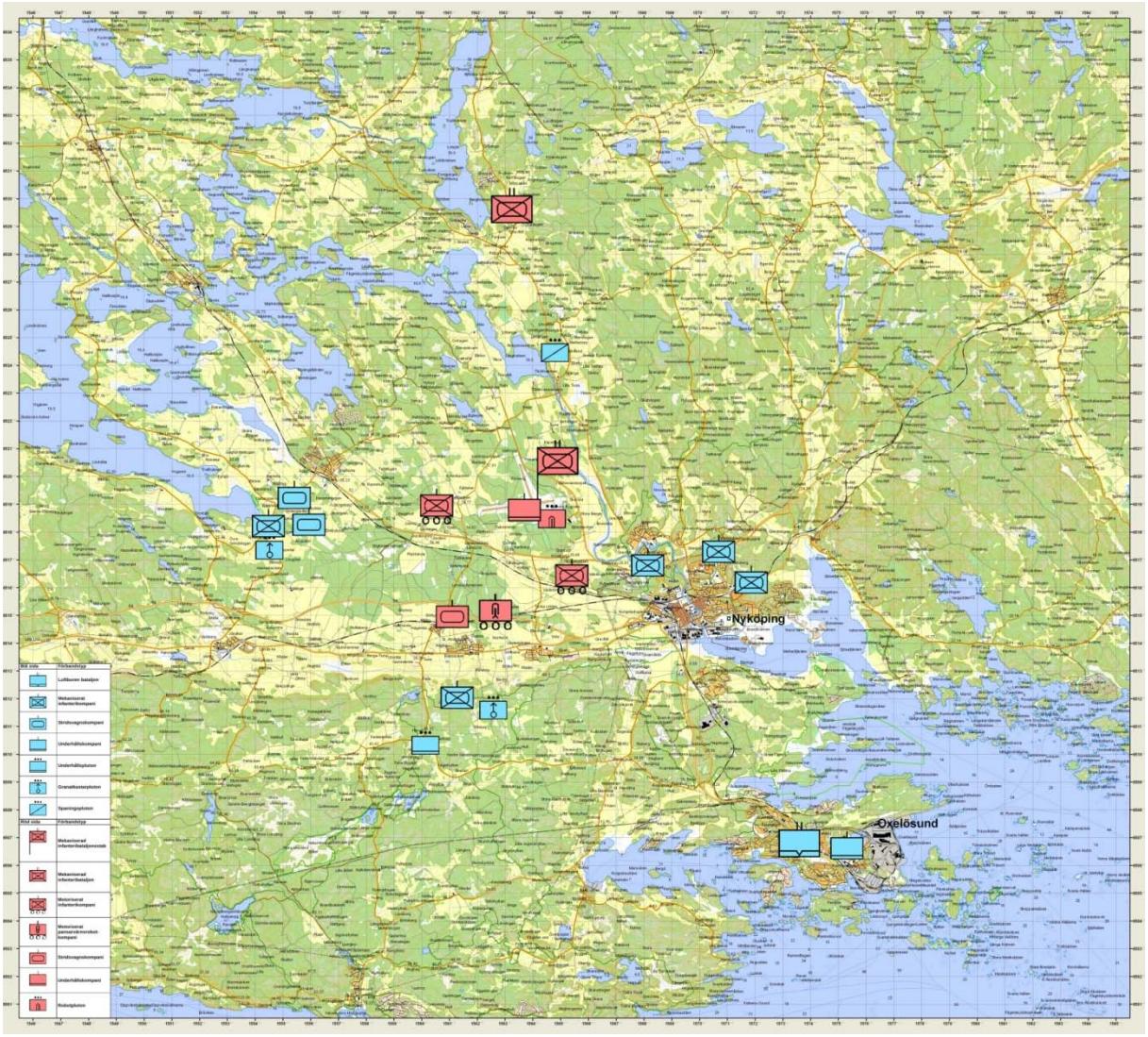

Fig. 2. Scenario 2.

Results

Scoring

Each participant's description was scored by a military expert (a Lieutenant Colonel from the Swedish Armed Forces Land Warfare Center), using seven criteria for each scenario He did it blindly, i.e., without knowing the condition to which the participant he scored belonged, or whether the participant being scored was an officer or a civilian. The criteria used for the first scenario, and the score given for meeting each are given in Table 1 and the corresponding information for the second scenario is given in Table 2. The scores were summed to give a total score for each participant and scenario, and the mean score over both scenarios was computed. The possible range of means is from -1 to 5. These mean scores were then subjected to 3 (conditions) one-way analysis of variance for Experiment 3 and a t-test for Experiment 4.

Table 1. Criteria used to score scenario 1

Wrong choice of attacking side	-1
Uncertain about which side attacks	0
Blue side is defending the city of Falköping	1
Red is attacking in at least two directions	1
Red has a reserve	1
Has noted blue reconnaissance unit	1
Having noted Blue's choice of terrain	1

Table 2. Criteria used to score scenario 2

Only red attacks	-1
Has not decided on what side is attacking	0
Blue attacks	1
Also Red can be attacking	1
Blue has taken important terrain in the city of Nyköping	1
Blue intends to take the airport	1
Red is defending the airport	1

The mean scores were 3,63, 3.25 and 1.13 for the 5 minute, 1 minute and 20 second conditions in Experiment 3. The analysis of variance yielded a significant result ($F\ 2/21 = 3{,}54$, $p < .05$), due to the fact that the level of performance in the 20 second condition is considerable below that in the 5 and 1 minute conditions which do not differ.

In Experiment 4, the mean score for the 1 minute condition was 3.38 and that for the 20 second condition was 3.50. The difference is not significant. Thus, the officers perform equally well in both conditions, and, at the same level as the civilian participants in Experiment 3 do in the 5 and 1 minute conditions.

Discussion of the results from Experiments 3 and 4

The results of Experiments 3 and 4 would presumably not have surprised Clausewitz. They are in agreement with our hypothesis that the time available for inspection will affect novices to a greater extent than it will experts. Interestingly, officers and novices perform at the same level except when the time is very short (20 sec.). In this condition the officers outperform the novices as they are not affected by the time available for inspecting the scenario. A possible explanation for these results is that officers and novices perform the task in different ways, just as Clausewitz said they would. Officers perform it by "seeing directly" what is going on, i.e., by a "coup d'oeil" in the original sense of the word. Novices, on the other hand have to infer what is going on by analysis. Hence, officers are able to perform the task also when they are given a very short inspection time, something that the novices cannot do. However, given the fact that officers and novices perform at the same level when they are given more time, we cannot tell whether the officers perform the task in the same manner in both conditions. It may well be, that they switch to an analytical mode when there is enough time. To answer this question, further experimentation is needed.

General discussion and conclusions

Apart from demonstrating that officers actually possess expertise when this is assessed by the standard experimental paradigm in the field of expertise studies, two interesting results emerge from this, and the earlier, study, results that serve to guide future work in the field.

The first is that experts and novices seem to perform the task given to them in different ways, at least when little time is available for inspection of the scenarios. One possible interpretation of this result is that the experts found the scenarios used in these experiments easier than the novices do, and that the novices, but not the experts, have to perform analysis to arrive at the interpretation that the experts could see by a "coup d'oeil". This is a question that can only be answered by future experimentation, perhaps by employing experimental procedures where interpretation of scenarios which experts and novices perform equally well under normal conditions is studied under conditions where the analytical processes are otherwise engaged by subsidiary tasks, or the like.

The second interesting result is that both novices and experts seem to be affected by the manner in which the scenario develops in the same way. Although officers outperform the novices at recall, both perform better when the scenario develops without violating constraints than when it does violate constraints. This result cannot be predicted from the chunking, or pattern matching, hypothesis, but in is consistent with the constraints hypothesis, under the assumption that novices rely on only the more general constraints that do not require very much military experience. The difference in level of performance between officers and novices would then be due to the number of constraints that they are able to rely upon. This suggests that the next step should be to investigate in more detail which constraints are used by experts and novices in their understanding of what goes on in a military scenario, and that the chunking, or pattern matching, hypothesis should be put aside for the present time.

References

Brehmer, B. & Kuylenstierna, J. (2010). *Towards an understanding of the commander's "coup d'oeil*. Paper presented at the 15th International Command and Control Symposium, Santa Monica. Calif. June 22-24, 2010.

Chase, W. G. & Simon, H. A. (1973). Perception in chess. *Cognitive Psychology, 4*, 55-81.

Clausewitz, C. von (1834/1989) *On war*. Edited and translated by M. E. Howard & P. Paret. Princeton: Princeton University Press.

Norman, G. R., Books, L. R. & Allen, S. W. (1989). Recall by expert medical practitioners as a record of processing attention. *Journal of Experimental Psychology: learning, Memory and Attention, 15*, 1166-1174.

Vicente, K. J. & Wang, J. H. (1998). An ecological theory of expertise effects in memory recall. *Psychological Review, 105*, 33-57.

Williams, M., Davids, K., Burwitz, L. & Williams, J. (1993). Cognitive knowledge and soccer performance. *Perceptual and Motor Skills, 76*, 579-593.