CHAPTER 26

BREADTH OF ORIENTATION: INDIVIDUAL DIFFERENCES AND TRAINING [1]

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INTRODUCTION

The concept of metacognition has been used with different meanings. Sometimes in using this term one refers to knowledge about one's own and a third person's cognitive processes (e.g. Flavell, 1976). At other times, the concept of metacognition is used in the sense of steering one's cognitive processes (e.g. Brown, 1980). Though these two (knowledge and steering) might be closely related, it is, in our opinion (compare Lawson, 1984), important to disentangle the two. When we refer to the first meaning we will use the term "metacognition", or "metacognitive knowledge". For the second meaning we will reserve the term "regulation". In this study we will focus on regulations, especially one kind of it called orientations. In our theoretical framework (see Simons, 1989a,b; De Jong & Simons, 1989) there are nine kinds of regulation processes: orientation, planning, monitoring, testing, re-orientation, on-line planning, diagnosing, reflection and evaluation.

Orientation processes can be defined as the preparation of actions by means of an inspection of the learning task and the learning situation, the goals to be reached, the beginning state, strategies that can bridge the

[1] The study reported was executed by M. Daal & M. Liew-On, both studying psychology

differences between the goal state and the beginning state, the possible actions and general characteristics of the person that might be of interest for the execution of the task at hand. Typically, orientation processes can take place before the start of (a series of) actions, or between (sub)actions whenever problems arise (re-orientation). Typical questions learners ask when they are orienting themselves are: "What do I already know about this problem?", "How good am I in these kinds of assignments?", "What exactly is the goal?", "What strategies are available in my repertoire?", etc. We use the term "breadth of orientation" when we mean the extent to which someone orients him/herself, both before and during action. Five subcategories of orientation were discerned (Vermunt, 1984a): 1) Exploration of the task (for instance reading instructions); 2) Asking questions about the meaning of the task and the criteria of effective performance; 3) reflection on one's own characteristics as a learner or problem solver (style, weaknesses, pre-knowledge, etc.); 4) actualizing pre-existing knowledge or skills; 5) searching for information about possible actions in the task instructions; 6) transforming data in a different modality (to get a better overview).

In many theories an extensive orientation of the task to be performed *before one starts* is thought to be important. The most outspoken theories in this respect are the Russian and Eastern European activity theories based on the ideas of Vygotsky and Pavlov. Among these the most extreme hypothesis about orientation was formulated by Galperin (1969). He claimed that - in learning so called mental activities -a complete orientation beforehand forms a necessary condition for learning effectiveness. Only when orientation is complete - in the sense that attention has been paid to the goals and subgoals, the materials to be used, the sequence of activities to be undertaken, an analysis of the learning task and the demands it poses, the criteria of effective performance and the conditions under which activities should be used - is effective learning without errors to be expected. Other and later adherents to the activity theory (Van Parreren, 1983; Van Oers, 1987) weakened this hypothesis in the sense that they stressed only that orientation should occur at some time during learning and that it is complete at the end of a learning process.

Another theory accentuating the importance of orientation processes and its completeness is the one by Kuhl (1983) on mind orientation and activity orientation. According to this theory, in ideal mental states (action orientation) attention is divided evenly between a) the beginning state, b) the goal state, c) the discrepancy between the present state and the goal state, and d) the path that leads from a) to b). In mind orientation, however, attention fixates on one or two of the four components of a fully developed action structure. Kuhl discerned four kinds of fixations (or four kinds of mind orientation): goal fixation, planning fixation, failure fixation and success fixation.

Finally, the importance of orientation processes for learning was stressed in many learning to learn courses. For instance, in the well-known SQ3R method (developed by Robinson in 1946, but in revised form still very popular today) students are taught to orientate themselves thoroughly before starting to read: Survey and Question before Reading.

In our department, several empirical studies have been done searching for evidence that orientation processes are indeed important for text-learning, paired-associate learning and problem solving. In most of our thinking-aloud-studies, however, we failed to find this evidence (see Breyman, De Jong & Vermijs, 1984; De Jong, 1987; De Jong & Simons, 1988; De Jong & Simons, 1989; Simons, 1989b; Van der Sanden et al., 1985; Vermunt, 1984a; Simons & Lodewijks, 1987): students in the beginning phase of secondary education did not orientate beforehand at all; the number of re-orientation processes was very small in most of the tasks studied; better performing students did not orientate themselves more than weaker performing students. It was only in problem solving tasks that the frequency of occurrence of (re-)orientation processes was somewhat greater and that some individual differences in the number of orientation processes showed up: better performing students orientated themselves more fully then weaker problem solvers.

Other investigators reached similar conclusions. Jansweyer, Elshout & Wielenga (1985), for instance, showed that beginning problem solvers differed from expert problem solvers in that they failed to orientate themselves in the beginning phase of problem solving. Only when they encountered problems did they start thinking, proceeding from one blockade to another.

Orientation processes then seem to occur rather seldom with young and inexperienced students, at least with most of the tasks studied. They even seem to hate orientation (see Nelissen, 1980). Individual differences only showed up in problem solving tasks (Vermunt, 1984a). An important question is whether these differences can be broadened by changes in the task environment, using different research techniques. Instead of relying on thinking-aloud-protocols we might try deducing orientation behaviour from task performance (see Meichenbaum, Burland, Gruson & Cameron, 1985). When we construct a task in such a way that orientation is very necessary and profitable, will the number of orientation processes then increase? Another question underlying the research reported here is whether there is some individual consistency in breadth of orientation. Do individual differences in breadth of orientation predict learning performance and orientation processes during other tasks? Finally, we were interested in the relation of breadth of orientation and the dimension impulsivity-reflectivity, because this cognitive style seems to have some overlap with our conception of breadth of orientation.

Although there were few students who orientated themselves extensively, this does not mean that orientation thus is not important. Perhaps students should be trained to do so, possibly resulting in better performance. Our training studies, however, (see Simons, 1989a; Vermunt, 1984b; De Jong & Simons, 1989) failed to show such effects. Training students to orientate themselves more extensively, had only effects on the number of testings, but not on the number of (re)orientations. One reason for this might be that we used rather general isolated training programs that were not embedded in normal domain specific training (cf. Perkins & Salomon, 1989). Other researchers did find effects of embedded training on orientation processes. Mals'kaja & Il'jasova (cited in Van Oers, 1987) succeeded in training psychology students to orientate themselves more fully. Better performance in making research designs resulted. Miloradova (in Van Oers, 1987) reached similar results in teaching students how to identify and classify minerals. Mettes (1987) showed that it is possible to teach university students to orientate themselves more fully in solving chemical and science problems. Thus, training in orientation can be successful, but age and or task variables seem to be important determinants.

The research questions studied were:

1) Is it possible to develop a testing procedure that measures breadth of orientation?

2) Do the individual differences measured through this testing procedure predict orientation processes and learning performance of students in a computer-aided program?

3) Is it possible to train orientation processes through an embedded training program?

PILOT STUDY

Method

Subjects

The subjects in the pilot study were 20 students, ages ranging from 14 to 17. There were 10 boys and 10 girls. They all attended the third grade of a secondary school (Higher general education (HAVO)).

Materials

Breadth of orientation test

In a computerized game (run on an Olivetti M-19) students had to guess what the average of a series of 5 randomly generated numbers between 1 and 99 would be. Time constraints (15 seconds, 30 seconds and unlimited) and error ranges (within 2, 4, or 6 from the arithmetic mean) were varied, creating 9 different game conditions and permitting several kinds of guessing strategies. Students could choose the sequence in which they wanted to try the game. Under some conditions arithmetic strategies were possible. The game was constructed in such a way that with the longer time limits and a strict error range, one could better turn to arithmetic. With the stricter time limits and the permissive error range, however, one could better use a guessing strategy, or a combination of guessing and arithmetic (for instance taking the mean of the largest and the smallest number, or taking the middle number of the series). The test procedure registered how students tried to explore this game, taking into account the questions they asked, the extent to which they read the instructions, the kinds of strategies they used, the tuning of strategies to time constraints and error range allowed, their evaluations of the game, the answers given to questions about the game and the sequence in which they wanted to try the different conditions of the game. The students were asked to fill in an evaluation form consisting of the following 6 questions:

1 Were the instructions clear?
2 What are the differences between the different game-conditions?
3 What condition was the most difficult? Why?
4 Why did you choose this game-condition as the first one?
5 What strategies did you use in the different conditions (arithmetic, guessing, gambling, combined strategy, other)?

6 Did you have special reasons why you chose the sequence you took? What were they?

The data were analyzed, using both live and video observations as well as student evaluations, according to six aspects of orientation. A good orientation was defined as one where the student:

1. Read the instructions more than once.
2. Posed questions about the game.
3. Understood that the game-conditions had to do with both the time-constraints and the error range allowed.
4. Started with a game-condition without time-limit.
5. Used strategies that were tuned to the time and error constraints.
6. Chose a sequence from easy to difficult.
7. Chose a different strategy after an error.

A weak orientation was defined as one in which the student:

1. Skipped the instructions.
2. Did not pose questions about the game.
3. Did not understand the game conditions.
4. Chose only the most difficult game-conditions.
5. Used wrong strategies, not tuned to the game conditions.
6. Chose only the difficult conditions.
7. Persisted in too difficult strategies after errors.

Training program

The computer-aided training program (written in PC-Pilot, run on Olivetti M-19 and on IBM PC systems) consisted of three components: awareness training (making students aware of different kinds of executive control possible), executive control training (suggesting and training different kinds of orientation) and domain-specific information. The awareness training consisted of a description of the strategies of two fictitious students (Frank and Ben) in learning mathematics. Frank orientates himself better than Ben. He writes the most important instructions down. Frank does not work as hastily as Ben. Frank checks his calculations, Ben does not. Frank revises his errors, Ben does not even notice them. Frank evaluates his approach, Ben does not. Ben, however, is described as a popular, optimistic student. The students are then asked to compare the two approaches and to relate them to their own approach. Orientation processes were suggested by the experimenters orally, whenever they noticed a lack of adequate orientation during learning. Domain specific topics treated were: statistics, frequencies, average, median and mode. In total the training program took 29 screen pages of 25 lines (40 - 80 characters per line). The program consisted of 8 parts: a) Overview of the program (3 pages); b) Instructions (how to use the program)(2 pages); c) Calculator (1 page) (to make calculations for the assignments); d) Scratch-pad (1 page) (to make notes); e) Introduction (7 pages) (where the approaches of Frank and Ben were described and compared and questions were posed about the subjects' own approaches); f) Frequencies (3 pages)(information about Statistics and frequency distributions); g) Basic concepts (5 pages) (treating the concepts Mean, Median, and Modus); h) Assignments (6 pages) (5 application assignments). Subjects thought aloud during the learning sessions. Their verbalizations were tape recorded and analyzed in combination with student responses to questions with reference to the orientation processes, using the categories developed by Vermunt (see Vermunt, Lodewijks & Simons, 1986). The answers students gave to the 5 assignments at the end of the program and within the program were treated as an achievement test, having 16 items.

Reflectivity test

The Matching Familiar Figures Test (Children version) was used to measure the dimension of impulsivity- reflectivity.

Mathematics achievement

The school supplied the average Mathematics grade-point of all the students. They ranged from 5 to 8.

Procedure

There were two kinds of individual sessions: in the first sessions (75 minutes), the breadth of orientation game was played by all 20 students. In the second kind of sessions of a half day ten subjects were selected to go through the training program, thinking aloud all the time. One subject failed to cooperate during the pretests. Therefore only the data of 19 subjects were analyzed (10 trained and 9 untrained). All sessions were video and audio recorded. After the training the Matching Familiar Figures Test was delivered individually.

Results and discussion

Breadth of orientation game

Overall, the students liked the game very much and tried to reach good results. Some of the pictures and animations, however, were evaluated negatively

TABLE 1
Overview of the Number of Subjects Showing the Different Orientation Activities

	yes 0p	? 1p	no 2p
1.Reading instructions twice	10	7	2
2.Pose questions	19	-	-
3.Recognize game-conditions	12	6	1
4.Start with easy games	9	2	8
5.Adequate tuning of strategies to conditions	5	10	4
6.Sequence from easy to difficult	7	5	7
7.Re-orientation after errors	11	8	-

Table 1 presents the results with reference to the different aspects of orientation during the game. Ten subjects read the instructions twice or more, whereas 9 of them read them only once. Two of these started reading the instructions after starting the game on a trial and error base. All subjects posed questions about the game to the experimenter. Twelve subjects were able to formulate the differences between the game conditions, mentioning both the time constraint and the error-allowance. Six of the subjects thought erroneously that the game became more difficult when the error allowance became greater. They did not recognize the influence of time. One subject thought that the easiest game (no time constraint, high error-allowance) was the most difficult one. Nine subjects started with an easy game without time constraint, 6 chose a starting game with an average difficulty level and some time limit. Eight subjects chose the most difficult game-conditions for a start. Only five of the students adequately tuned their strategy to the difficulty level of the game (75 % or more adequate), 10 chose between 25 % and 75 % adequately tuned strategies and 4 reached only 25 % adequately tuned strategies. Seven subjects chose a sequence from easy to difficult, five followed a sequence that was predominantly from difficult to easy and seven only chose the difficult conditions. Finally, 11 subjects changed their strategy after errors, while 8 persisted in the same strategy.

In order to see whether the 7 aspects of orientation formed one concept and one measurement scale, the alpha coefficient of homogeneity was calculated (excluding item 2 that had no variance). No points were given when a certain aspect fulfilled the criteria described before and 2 points were given when they did not. In case of the middle category 1 point was given. The resulting breadth of orientation scale proved not to be homogeneous (alpha=.26). This was caused by item 5. Skipping item 5 raised the alpha to .53. One possible cause of this might be that item 5 was based on a post-hoc description of the strategies used by the students that might not be reliable, probably involving some misunderstandings by the students. The inter-item correlations are presented in Table 2.

TABLE 2
Inter-Item Correlations for the 6 Items of the Breadth of Orientation Test

Item	2	3	4	5	6	7
1. Reading instructions twice	-	-.22	.38	-.11	.07	.06
2. Pose questions	-	-	-	-	-	-
3. Recognize game-conditions	-	-	-.05	.07	.12	-.07
4. Start with easy games	-	-	-	.03	.56	.39
5. Adequate tuning of strategies	-	-	-	-	.10	-.15
6. Sequence from easy to difficult	-	-	-	-	-	.51
7. Re-orientation after errors	-	-	-	-	-	-

The conclusion to be drawn from these results is that there seem to be individual differences involved, but that the reliability of the scale is still unsatisfactory. This may have to do with the test and scoring-procedure. In the main study therefore, these were changed: the registration of item 5 was changed by replacing the ad hoc registration with an on-line one. The questions posed to the students afterwards were reformulated. Several new measures were added: on-line registration of strategies, correctness of the calculations and guesses, registration of notes students make, registration of re-reading of the instructions, registration of wrong input produced by the subject and corrections students try to make.

Training program

The training program proved to need several changes: the text should become easier to read, the instructions led to some misunderstandings that should be prevented in the final version, the calculator and the scratch-pad can be removed since students did not use them, the students should get more opportunities to participate and to be active themselves. Especially, the metacognitive part of the training should be extended and improved. From the reactions of the students and several expert judges, many suggestions were received on how this might be done. Apart from changes in the texts, especially the feedback and stimulations should get more attention.

Twelve aspects of orientation were deduced from the protocols and responses to questions and scored 0 or 1. The first two (exploration of the task and asking questions of the experimenter) had no variance: all subjects explored and asked questions. The remaining ten consisted of two measures of reflection about pre-knowledge, 7 measures of "actualization of knowledge or skills" and 1 measure of re-orientation. The scale had an alpha coefficient of .75. The inter-item correlations are presented in Table 3.

TABLE 3
Inter-Item Correlations of the Orientation-Scores During The Training Program

Item		R1	R2	A1	A2	A3	A4	A5	A6	A7	O1
Reflection about	R1	-	.22	.67	.10	.61	.17	.33	1.0	-.25	.00
preknowledge	R2	-	-	.51	.36	-.09	.22	-.52	.22	.22	.22
Actualization of	A1	-	-	-	.41	.41	.11	.22	.67	-.17	.33
Knowledge	A2	-	-	-	-	-.25	.27	.09	.10	.61	.41
	A3	-	-	-	-	-	.27	.53	.61	-.41	.00
	A4	-	-	-	-	-	-	.51	.17	.17	.33
	A5	-	-	-	-	-	-	-	.33	-.22	.22
	A6	-	-	-	-	-	-	-	-	-.25	.00
	A7	-	-	-	-	-	-	-	-	-	.00
Re-orientation	O1	-	-	-	-	-	-	-	-	-	-

Intercorrelations

Table 4 presents the intercorrelations between the various measures. None of the correlations were statistically significant. Taking into account the small number of subjects and the low coefficient of homogeneity, the breadth of orientation score predicted the performance on the training program reasonably well (r=-.53). Therefore, we decided to go on with the revised breadth of orientation test in the final experiment.

TABLE 4
Intercorrelations Between The Measures

Measure		BO (N=19)	OR (N=10)	MA (N=19)	PF (N=9)
Breadth of orientation score	BO	-	.16	-.12	-.53
Orientation during training	OR	-	-	-.37	-.14
Average maths achievement	MA	-	-	-	.10
Performance during training	PF	-	-	-	-

MAIN STUDY

In the main study the breadth of orientation test was used as pre- and posttest in a training experiment. The research questions were the same as for the pilot study.

Method

Subjects

The subjects in the main study were 131 students, ages ranging from 14 to 17. There were 47 boys and 84 girls. They all attended the second (N=10) or third grade of three secondary schools (Higher general education (HAVO)).

Materials

The materials were the revised Breadth of orientation test (see above), a parallel version of it, the revised Training program, and two parallel versions of a newly developed computerized Matching Familiar Figures Test for adolescents. In the parallel version of the Breadth of orientation test subjects had to guess or calculate what a fifth number would be, given four of five numbers and their arithmetic mean. The two parallel versions of the two tests were constructed in such a way that the version delivered last was more difficult than the one delivered first.

Procedure

The Breadth of orientation test was delivered in groups of 10-25 to 131 subjects (as was the reflectivity test). This took about 1 hour. The 49 lowest scoring subjects on the breadth of orientation test and the reflectivity test were selected for further study, a few days later.Twenty-three subjects were trained with the revised embedded metacognitive program and the other 26 formed the control group. The control subjects were trained with the same domain specific materials, but without the metacognitive part of the program. The training took about 1 hour. Some days later, the parallel version of the BOO test and the reflectivity test were delivered (1 hour).

Design

The design was a pretest posttest control group design with random assignment to the two conditions (trained and control group).

Results

The homogeneity of the breadth of orientation test at the pretest session (N=131) was .54. Leaving out the adequate tuning or strategies criterion raised the alpha to .59, as was the case in the pilot study. At the posttest session (N=49) the alpha was .42. Leaving out the tuning criterion again raised the alpha to .58. Thus, the tuning criterion again proved to be measuring something different from the other items, in spite of the fact that now a different measurement technique was used. It was decided to skip this item. The reflectivity test proved to be homogeneous, both as to reaction time scores and with reference to errors (alphas of .89 and .62 respectively).

The correlations between the breadth of orientation scores and the reflectivity scores were low (see Table 5).

There were no differences between the experimental and the control group in the breadth of orientation test scores (Mc=21.0, Sd=3.7; Me=21.0, Sd=4.3, t=.0, n.s.) delivered at the pretest session. After the training at the posttest session there were also no significant differences in the scores on the breadth of orientation test (Mc=19.3, Sd=4.4; Me=20.3, Sd=4.7, t(48)=-.76, n.s).

TABLE 5
Intercorrelations Between the Reflectivity Measures and the Breadth of Orientation Test

Measure	RT	Errors	BOO
Reaction time reflectivity test	--	-.31	.14
Errors reflectivity test	--	--	.08
Breadth of orientation score			

There were significant differences between the trained and the control group in the reaction time on the reflectivity test (Mc=352.7, Sd=110.2; Me=439.8, Sd=155.1, t(48)=-2.25, p=.03) at the pretest session. There were, at that time, no differences between the two groups in error scores of the reflectivity test (Mc=10.6, Sd=4.1; Me=11.6, Sd=3.4; t=-.85, n.s.). There were also differences on these measures between the experimental and control group at the posttest session: the reaction times of the experimental group on the reflectivity test were again higher (Mc=359.1, Sd= 125.0; Me=494.7, Sd=265.5, t(separate variance estimate)=-2.33, Df=36.5; p(one tailed)=.03). There were no significant differences in error scores (Mc=5.4; Sd=2.5; Me=4.3 Sd=2.9; t=1.4, p(47, one tailed)=.09). Because the experimental subjects both thought longer and made somewhat fewer errors when pretest and posttest were compared and the control subjects did not, a combined time-error score was calculated. During the pretest session the control subjects performed better than the experimental subjects (Mc=7.3, Sd=2.7; Me=5.8, Sd=1.7, t(48)=2.41, p=.01). After the training these differences disappeared (Mc=11.7, Sd=4.0; Me=11.9, Sd=3.6, t=-.17, n.s). The improvements in the combined scores (difference scores) were not significantly higher in the experimental group than in the control group (t(48)=-1.6, p(one tailed) <.10).

Finally, the experimental and the control group were compared with a test measuring arithmetic skills taught in the domain specific part of the computer program (calculating means). During the pretest the scores did not differ (Mc=.30, Sd=.31; Me=.19, Sd=.25, p= 1.14, n.s.). After the training there were significant differences between the two groups in favour of the control group (Mc=.89, Sd=.81; Me=.52; Sd=.53, t=1.87, p=.03).

CONCLUSIONS

The main conclusion to be drawn from the two studies is, in our view, that it seems more possible to measure individual differences in breadth of orientation through a test-like procedure than through thinking- aloud-protocols. Now we found the differences in orientation processes we failed to find through thinking-aloud-procedures in previous research. There were some indications that these differences predict performance in a learning situation, whereas on-line orientation measures did not. The new concept of breadth of orientation did not coincide with the concept of reflectivity - impulsivity. Thus, there is discriminant validity.

The training program did not change the breadth of orientation scores. It did lengthen the reaction times on the reflectivity test while at the same time the error rates decreased somewhat. One probable cause of these differences in results between the two dependent measures might be that the relative short metacognitive part of the training may have interfered with the domain specific part (compare McKeachie, 1987). The experimental subjects had to learn two things: how to orientate and how to deal with statistics and averages. The control group indeed learned better how to calculate means than the experimental subjects. In the Breadth of orientation game exactly this kind of domain specific skills may help.

Further research should focus on the validity of the test procedure and on the effects of longer training programs, using a domain of knowledge in the training that differs from the contents of the Breadth of orientation guessing game.

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