THE EFFECTS OF PROLONGED TRAINING ON RT PERFORMANCE AMONG ZAMBIAN STUDENTS

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MASTERS THESIS: 9TH SEMESTER

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It is almost a year ago that I started this research, but the fact that is took a year to finish, was certainly not due to bad co-operation of other. This co-operation was enormous and from this side of the world I would like to thank Mr. Nakwebwa, the head, the deputy and the teachers of Mumbwa Secondary School, for hosting me and the efforts they took to help the experiment to proceed well. Of course I am grateful to the pupils who joined, for their reactions and their motivation, which even after 10 days was still good.
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SUMMARY

In the literature a lot of research is mentioned on reaction time experiments (RT) to discover in what way the results resemble other intelligence measurements or even display general intelligence ('g'). Paper-and-pencil tests display differences between culturally different populations. By measuring the speed of information processing by means of RT tests, this study uses a culturally less dependent measure to come to a reliable measurement.

In this research a group of 32 Zambian Grade Eight students were pre- and posttested and trained for 8 days. The choice to see the subjects for 10 subsequent days was made on basis of earlier research done by Van de Langenberg (1989), where improvement did still occur after 5 days of training. The group was tested on 5 computer-administered RT tasks of increasing cognitive complexity and on a number of school and intelligence measures (RAVEN, vocabulary subtest of the WISC, Grade 7 scores and Examination results).

The group of 32 subjects was divided in 4 training groups, one group of 8 subjects were trained on a 5 choice RT task (Hick). A second group was trained on a cognitively more complex task i.e., responding to one specific figure out of 5 displayed squares. A third group was trained on a cognitively complex task; choosing a figure without a complementary figure out of the 5 displayed squares. Finally a forth group received a training on each of the three tasks mentioned. Influence of specific training on performance was measured and compared.

On all five tasks improvements took place in mean RTs, improvements increased with cognitive complexity of the task; learning effects on the cognitive most complex task were highest.

The absolute correlation between RT and other intelligence scores became slightly stronger with task complexity. Training affected the correlation between intelligence measures and RTs. The group trained on cognitively complex tasks showed correlations increasing in negativity as tasks became more complex. Those trained on the cognitively simple tasks displayed the opposite pattern. Absolute correlations between RT and intelligence measures increased with practice; the measure became more stable over time.

Standard Deviation decreased after training for the cognitively complex tasks and the percentage improvement in SD is comparable with improvements in RT. For cognitively simple tasks even after 10 days of practice this effect was not found; SD and RT improvements were not interchangeable.

Movement times increased as cognitive complexity of the tasks increased. Also, there was a significant effect of day. Movement times decreased with practice.

Inter-trial correlations increased with practice, which means that fluctuations in task performance decreased after training for all training groups and all tasks.

Inter-task correlations also increased after practice and near, similar and method transfer took place. Near transfer was found if subjects improved on isomorph tasks they were not trained on (tasks with the same underlying structure); this transfer was found in the group trained on the cognitively most complex task, not for the group trained on cognitively more simple tasks. Similar transfer is an improvement on the task they were trained on; this was found for all training groups. Method transfer is the test wiseness subjects acquire; it is found in all groups.

From this study little evidence became clear that test-scores correlated with background variables of the subjects tested.

In future studies, to my opinion the facts should be taken into account that RT tests should be sufficiently complex to be comparable with other intelligence measures and prolonged training should be given which makes the RT tests more reliable and stable.

CHAPTER 1 INTRODUCTION

In the first part of this introduction the history of Reaction Time (RT) testing will be discussed. The second topic will be the correlation between RT findings and intelligence after which the use of RT tests in other cultures is discussed. The fourth part will be about gain. The transfer between different cognitive tasks and an introduction on the present study will then be given, followed by a description of the hypotheses.

1.1. HISTORY

The first one who studied the relationship between RT and intelligence was Galton (1822-1911). He defined RT as the interval between the onset of a stimulus and of the response. It was the time needed to take the decision on the right response. The mental processes that happen during this time are difficult to unravel, but the time needed is an indication for the ability to use strategies on solving problems. The ability to develop these mental strategies is correlated with intelligence. Boring (1950) coined the term 'mental chronometry', for this registration of the duration of mental processes. The correlations found between simple reaction time tasks and intelligence, however, were low; the interest in mental chronometry decreased. According to Jensen (1980) there were three reasons for the low interest in 'mental chronometry'. Firstly, other measurements of complex intelligence functions, as the Binet intelligence scale were being developed during that time, so the interest had changed. Secondly, the adequacy of chronometers was insufficient for these observations. And also the facts that RT research was done in poor experimental set-ups and that psychometric validity was low, was a reason for the decrease of the interest in mental chronometry (Jensen, 1980).

Later the RT measurements became more accurate due to technological developments. The work of Hick in the fifties marked the beginning of a new era. He used Choice Reaction Time (CRT)-tasks. He asked his subjects to hold their fingers on 10 buttons. Above each button there was a light. As soon as one of the lights went on, the subject had to press the corresponding button as quickly as possible. He measured the RT, being the time between the onset of the light and the moment a button is

pushed down. Cognitive complexity varied, as the number of lights involved. Hick found a logarithmic relation between mean RT and the number of stimuli.
He described this relation as follows:

$$\text{mean RT} = K\ {}^2\log(n+1)$$

In which K is a constant value, the mean SRT; log is the logarithm (base 2) and (n+1) is the number of uncertainties in the experiment (i.e., the number of lights, n, and the fact if there was a light or not, +1). The relationship between mean RT and the log described, proved to be very strong.

Hick's work turned out to be inspiring; investigators tried to replicate Hick's results and to broaden the theoretical framework (e.g., Carlson & Jensen, 1982; Jensen & Vernon 1986). The logarithmic relation proposed by Hick, has been found in most RT experiments.
Later a distinction was introduced between the time needed to think and the time needed to move. In order to separate these processes. Jensen and Vernon used a different set-up; they introduced the 'home button.' This button made it possible to differentiate between Movement Time (MT) and the real RT. The MT was the time needed to move the finger from the home button to the response button. The RT was the time the subject needed to think; the time the stimulus was visible on the screen till the time the subject left the home button. A trial began with the subject holding down the home button with a single finger of his preferred hand after a preparatory stimulus ('beep') was presented. After a random interval of 1 to 4 seconds, a light (the reaction stimulus) was turned on. The subject's task was to turn off the light as quickly as possible by touching the sensitive microswitch push-button corresponding with the right figure. Welford (1980) proposed that the use of the home button also had some limitations namely: When the movements had to be in very different directions from the starting point, say in a semicircle around it, the response was likely to have been at least partly chosen by the time the subject left the home key. Even if no choice of response to the signal was made before leaving the home key, some elements of decision to respond and elements of imitation of action to leave the home key will have been included with the time required to identify the signal (Welford, 1980). This would imply that if Welford is right, the measurement of RT and MT did not match the difference between decision time and movement time accurately.

1.2. CORRELATION BETWEEN RT FINDINGS AND INTELLIGENCE

In the last few years much research has been carried out into the correlation between reaction time and intelligence (Jensen, 1988, 1989). The results show that the one choice reaction time tasks (= simple reaction time = SRTs) do not have a relation with general intelligence. But the additional time needed to solve RT problems with more than one alternative (CRTs) correlate substantially with general intelligence ('g'). A strong item of evidence for the relationship between CRT and 'g' is the mean difference in RT between groups that differ on average in 'g' or its educational or occupational correlates, as found by Jensen (for a review see Jensen, 1989). Correlations (in absolute value) between 'g' and elementary cognitive processes almost never exceed .30. This value gives rise to different interpretations. For Jensen this correlation is enough evidence for the existence of the relation between CRT and 'g'. But the same value leads Hunt (1982) to the conclusion that there is an only moderate relation between the two.
Some researchers looked for an explanation for the correlation and they propose that practice effects can cause correlations between intelligence and RT and MT slope parameters derived from the Hick paradigm. These correlations ca be taken to reflect a differential speed of executing elementary information processes. However, other interpretations are also possible. In Widaman and Carlson's (1989) terms: 'The correlation between general intelligence and RT slope, may reflect differential practice effects, or differential rates of automatization of psychomotor responding rather than differential speed of executing elementary information processes' (p. 69).

1.3. GAIN

In the literature a lot has been published about improvements on RT tasks of different cognitive complexities, with questions on the relation with general intelligence ('g') and the decline in RT after practice. Ackerman (e.g., 1986) reports re-analyses of earlier studies. His conclusions are first of all, that the data confirm the proposition that individuals convergence on performance as tasks become less dependent on attentional resources with practice. With development of automatic processes the task becomes, what he calls 'resource insensitive.' In this stage fast, effortless and accurate performance is possible. This stage is characterized by stable performance, regardless of the amount of cognitive resources devoted to the task. Second, the re-analyses show that intellectual abilities indeed do play a substantial role in determining individual differences in skill learning (as long as appropriate methodological techniques are used and crucial task characteristics are taken into account). Third, he quotes Reynolds (1952 a, 1952 b) who found two general trends: (a) the intercorrelation of performance scores steadily decline as trials became more separated in terms of the number of intervening trials and intervening time; (b) as practice progressed, the adjacent trial intercorrelations increased; that is, the trend was for individual differences to stabilize as skills developed. The abilities that determined performance on an initial task trial were not identical to those abilities that determine performance on later task trials. The model that underlies the process of inter-trial correlations becoming higher after practice is called a simplex process model (Guttman, 1955; Jones, 1962, 1970).

The analysis of gain in tasks in which there are initial individual differences can be problematic. There can be two competing tendencies in skill acquisition data. The larger gains among low-ability subjects (since they start slow, they are able to improve much after practice) and a general positive relation between intelligence and learning (the faster someone learns, the more intelligent) display two tendencies going in two opposite directions; therefore, it is not surprising that various correlations were found between gain and reference cognitive abilities (e.g., Pellegrino, 1985). A positive relation is found by Cronbach and Snow (1977), between initial and final abilities on a RT tasks, indicating that there must be some relation with intellectual abilities that are constant over time. This is not, however, what Fleishman and Rich found (1963); to be able to analyze intertrial correlations they had to make a division in kinds of tasks. There are skill development tasks, in which initial performance correlates substantially with intellectual abilities; this correlation disappears with practice. On the other hand, there are the motor RT and related perceptual/motor ability measures, for which the initial score hardly correlates with intellectual abilities, but tends to account for more variance as the task practice proceeds. This is called task-specific variance. According to Ackerman (1986), task-specific variance is identified only in tasks with substantial amounts of resource insensitivity after practice (where automatic and controlled processing of the tasks occur), while resource dependent tasks (= cognitive complex tasks) contain little task-specific variance. So, task-specific variance will occur in cognitively simple tasks. The intertrial correlation in these resource insensitive tasks may be initially high, but after practice the inter-trial correlations decrease. In cognitively complex tasks, which are resource dependent, a stable simplex pattern develops over time (inter-trial correlations increasing with practice).

1.4. RT ACROSS CULTURES

For cross-cultural psychological research the use of RTs in the assessment of mental abilities has two advantages in comparison to 'paper-and-pencil' tests. The influence of language, and hence of various abilities in this area, is substantially reduced. The second advantage involves the content of the items. Not uncommonly, paper-and-pencil procedures capitalize on differences in school quality by their measurements of facts learned in school; in CRT tasks, this problem is less prevalent. It has been argued by Eysenck (1986) and Jensen (1987) that in comparison to IQ batteries (paper-and-pencil-tests), RT measures contain little 'crystallized intelligence' and more 'fluid intelligence.' This means that RT tasks are less influenced by the familiarity with the task; they constitute a very suitable method in cross-cultural research.

Kendall, Verster and Von Mollendorf (1988) made some restraints on the testing of groups with different backgrounds. A Western researcher should bear in mind that an insufficient diet has its effect on the school results. Education systems throughout Africa are often inadequate and the quality of teaching can vary markedly from school to school. Furthermore, the pupils emerge as rote learners, handicapped in their ability to apply their knowledge to solutions of complex problems. The western-type cognitive abilities will develop slower in African countries because socialization practice is focussed on different issues.

To determine whether a test is (relatively) independent of background, such as cultural factors, it is important to see if initial differences in scores on RT tasks, are the same after some training. The training is a method to see if the initial scores were influenced by test (un)wiseness. If after a period of training the differences between two cultures are still the same and the slopes of the learning curves are identical, it can be concluded that the task is independent of background. The test can then be said to depend mainly on the complexity of the mental operations required by the items rather than on their content. In Jensen's view, research on ECT's (Elementary Cognitive Tasks, 1987) proves, if nothing else, that it is possible to measure psychometric 'g' by means which depend scarcely at all on individual differences in content. According to Jensen the chronometric variables derived from a variety of RT tasks reflect mainly cognitive processes rather than cognitive content, they would seem an especially valuable technique in the investigation of mental ability differences between populations that vary racially and culturally.

Poortinga (1971) administered a 4 and 8 choice RT task to black and white university students in South Africa (two racially different groups). The two groups differed substantially on both CRTs. The test was administered repeatedly; hence it was possible to compose individual learning curves. Black students responded significantly slower on those cognitively complex tasks than did white students ($p<.01$). For both black and white students there were significant learning effects. But there was no race-learning-interaction found when learning curves were compared. Interpretation of learning effects, however, remains difficult.

1.5. TRANSFER BETWEEN DIFFERENT COGNITIVE TASKS

Van de Vijver, Daal and Van Zonneveld (1986) administered tests of inductive thinking to Dutch, Surinam and Zambian subjects in a training procedure. They analyzed to what extent learned strategies could be generalised from one task to another. They used three tasks, two of which were isomorph (this means that the problems have the same underlying structure) and one was a different task. All subjects were pretested, after that some were trained on one of the tasks. Afterwards, the groups were presented a posttest. When the experimental group improved on the task they were trained on, the authors called it 'similar transfer.' When the subjects also showed an improved performance on the isomorph task, it was called 'near transfer.' In the case that the training would give an improvement on the structurally different tasks, than it would be called 'far transfer.' 'Method transfer' would occur if subjects got more test wiseness. The results indicated the presence of similar and near transfer. Far transfer did not occur, probably because of the short period of training. Only in the Zambian group method transfer appeared to play a role. This was consistent with the authors' hypotheses; their idea was that Zambian subjects had had less contact with tests; therefore, the control group could be expected to show a substantial learning effect (Van de Vijver, Daal & Van Zonneveld, 1986).

In another study (Van de Vijver & Van de Langenberg, 1989) the same number of computerized RT tasks of increasing cognitive complexity were administered to groups of pupils of the first year of secondary schools in Zimbabwe and the Netherlands. The tasks were administered on five subsequent days. It was observed that on the first day the differences in average performance between Dutch and Zimbabwean pupils increased with cognitive complexity. However, differences between the groups tended to decrease after repeated administration of the task. It appeared that cognitive complex tasks gave rise to the largest difference in performance and were most influenced by repeated administration (Van de Langenberg, 1989).

1.6. PRESENT STUDY

In the present study some questions will be answered that arose Van de Langenberg's study (1989).

first, the performance differences between the Zimbabwean and the Dutch subjects tended to decrease after repeated administration of the tasks. Will the differences completely disappear? Is the nature of the tasks the same for the two different groups? And does the nature of the task change over time by training?

There is a learning effect on all the tasks of all different cognitive complexities, the question that remains here is if improvements on one task will be extrapolated to other tasks (transfer). By using tasks of five different cognitive complexities and giving training on three of them, I will try to identify if there is a task specific learning effect or a more general learning effect.

Furthermore it is interesting to determine the asymptote of the RT. In the Van de Langenberg study, subjects were trained for 3 days. In the present study subjects were trained for 7 days in a row to see if subjects reached their limit up to an asymptotic level. Also, it will be determined whether training on a specific task improves or changes the RT results on tasks of different cognitive complexity.

By examining the RAVEN- and WISC-subtest scores and the school results the relation with other intelligence measures will be computed. The cognitive complex RT tasks are supposed to be linked to 'g'; so, a high correlation between Raven, Wisc, school results and the complex RT tasks can be expected.

1.7. HYPOTHESES

1. Learning effects will be larger on cognitively complex tasks than on cognitively easy tasks.
2. Near, similar, method and far transfer will occur.
3. Movement Time shows a positive correlation with the amount of uncertainty in the different tasks.
4. There will be a negative correlation between RT and intelligence scores.
5. Correlation between RT and other intelligence scores will increase with cognitive complexity of the tasks.
6. The Standard Deviation (SD) will be correlated with intelligence scores. In subjects with a higher intelligence, SD's will be smaller.
7. Inter-task correlations will increase with practice, intra-task correlation will increase with practice and will initially be higher for cognitively simple tasks.

CHAPTER 2 METHOD

2.1. SUBJECTS

In Zambia the average percentage of pupils allowed on secondary schools, varied between 10 and 20 % of the primary school subjects per year. Only pupils with scores higher than the regional cut-off are allowed to enter secondary school. Boys from Grade 8 of Mumbwa Secondary School were recruited. Mumbwa is a regional centre, about 140 km from the capital, Lusaka. This school was a school with mainly boarders and a smaller proportion of non boarders from the near surroundings. The boarders usually lived in rural areas of Central Province. Their ages varied between 13 and 19 years. The subjects, all male, can be supposed not having been in contact with any computer equipment before (this was confirmed by a question of the questionnaire). The subjects were free to decide whether or not they wanted to participate. The tasks were usually administered during regular class hours.

2.2. EQUIPMENT

The RT tasks were administered by a BBC (Acorn) micro-computer. The subject was seated behind a monitor and a small response board, a console on top of which two or six buttons could be made accessible by means of removable covers. A schematic presentation of the experimental setup is given in Figure 1. The monitor and response board were connected to the micro-computer. The administration of the tasks and the registration of the responses (in ms) were taken care of by the computer. Both the instructions for the experimental control and the tasks were displayed on the tester's monitor; the subject's monitor displayed only the tasks.

[insert Figure 1 here]

The positions of the buttons on the response board, corresponded with those on the monitor of the subject (as can be seen in Figure 1). The response board was placed right in front of the monitor. In order to facilitate the accessability of the buttons the top was slightly tilted; its angle with the plane of the table was 25 grades. The response board was 29 by 35 centimeters. The buttons were 1.4 by 1.4 centimetre, and were made of red, hard plastic. To activate the microswitches, which were connected to the buttons, the buttons had to be pushed down 0.5 centimetre. Dependent on which task was administered, 2 or 6 buttons were used.

The BBC was connected to the audio exit of the subject's monitor. In order to accompany the visual warning stimulus by an auditive signal. The data (RTs) were first stored in the BBC, in the form of data blocks.

The BBC measured and stored different variables:

- -reaction times
- -movement times
- -random waiting time in between the warning stimulus and the reaction stimulus
- -the position of the stimuli
- -the figure of the stimuli
- -the right and wrong answers

The data were later converted to a mainframe (VAX) for further analyses.

The equipment was placed in such a way that the sun or artificial light did not reflect on the monitor. The tester had an overview over the subject while he was working, both on his monitor and on his movements. Most of the equipment was placed outside the subject's direct view (see Figure 3).

2.3. PROCEDURE DURING TESTING

2.3.1. TASK DESCRIPTION AND INSTRUCTIONS

The subjects were told that the research was about 'how fast they could respond,'and 'how quick they could learn.' No further explanation was given on hypotheses or theories.

The instructions of the tasks were not standardized. The order of the task administration was from simple to difficult.

The subjects first received some general information; the task was then started and information together with the examples on the monitor were presented. Afterwards they got as many examples as needed to get to know the task. The session started as soon as the subject adequately understood the task.

TASK A

You see an empty screen now, but in a few moments you will hear a beep and there will appear a small square on the screen. When you hear the beep and see that square, you have to push this button (experimenter points to the home button). After some time you will see that the square becomes black. As soon as you notice that, you move your finger as quick as possible to that button there (tester points to the upper button). You can choose any finger to push the buttons, as long as you use the same finger. The tester starts the task. Okay, I will show it to you (moves the finger in the right way and repeats the instruction, with some examples). After these examples the subject was asked to do the same.

TASK B

The task is started then and the explanation follows together with the first examples. You see 5 squares now. They correspond with the buttons of your response board. One of the squares will become black. I would like you to press the button that corresponds with the position of the black square. Again, you have to do it as fast as possible. As many examples as needed for understanding the task, are given.

[insert Figure 2 here]

TASK C

The sheet with the different figures is shown (see Figure 2). In the next task, 5 squares will again appear on the screen. One square will be like this one here (points to number 8), a white square with a black triangle in top. The other four squares can be any of the other figures, but all four are the same. I would like you to push the button corresponding with figure number 8. The task is started, and tester responds himself and points to the screen while explaining the task one more time.

TASK D

Again five figures are displayed. The five squares consist of two times two figures that are the same and one figure that is different. So, there are two couples of identical figures and one single figure. You should push the button of the square that is single. Again a demonstration, a second explanation and sample items follow.

TASK E

Tester shows the paper with figures (see Figure 2). Look at this paper carefully, this figure has a black triangle in top, and this other one of the same pair has a white triangle in top, the rest of the square being black. When you would put these two figures together, they would form a black square; together they form a pair. On the paper you see that there are 8 pairs of squares. In the next task there will be two pairs on the screen and one figure that is single, that does not belong to a pair. You should press the button of the figure that is single.

When the subject had done 3 to 4 items right by himself, the test items were administered. On day 1, 4 and 10 all subjects got some examples before they started a new task. On the training days, they got some trials, before the first task started to get used to the situation again. The sets of trials on day 1,4 and 10 were identical. The sets on the days of training were different, drawn randomly from 10 sets. Therefore, it was almost impossible to memorize the order in which items occurred. In each set of task C a different target figure was chosen on the training days; the new target figure was presented before each set of 12 items.

2.3.2. EXPERIMENTAL SITUATION

The tests are administered by two testers, one male and one female. Both testers were affiliated to Tilburg University (the Netherlands). The testing language was English, Zambia's national language.

[insert Figure 3 here]

The set up used during the testing sessions, is shown in Figure 3. The small rooms used for the test were in the school. They were not totally free from sounds from outside, because the rooms were surrounded by classrooms.

2.3.3. DESIGN

The tests were administered on 10 subsequent days. On the first day, the tasks were administered in the order A-B-C-D-E. By administration in increasing order of complexity, problems with the explanation were minimized. Day 4 was a 'half-training' posttest, the tasks were presented in a counterbalanced order of the first day: task E, D, C, B and A, respectively. On day 10, this same order was used again for the final posttest. A distinction was made in four training groups: training group B (N=8), trained on task B; training group C (N=8),
trained on task C; training group E (N=8), trained on task E; training group All (N=8), trained on the tasks B, C and E.

An overview of the scheme of the test sessions is given here.

day 1: pretest (task A,B,C,D,E)
day 2: training (on task B or task C or task E or on B+C+E)
day 3: training
day 4: 'mid-training' (task E,D,C,B,A)
day 5: training
day 6: training
day 7: training
day 8: training
day 9: training
day 10: posttest (task E,D,C,B,A)

On the pre-posttest days, 20 items of task A, 20 items of task B, 24 items of task C, 24 items of task D and 24 items of task E were presented.

On the training days of task B: 5 series of 20 items were presented,
task C: 10 series of 12 items were presented,
task E: 10 series of 12 items were presented
task B+C+E : in a random order 2 series of 20 items of task B, 3 series of 12 items of task C and 3 series of 12 items of task E.

Other measurements all took place on different times. The vocabulary subtest of the WISC, a simple and complex tapping task, a Digit Span and a personal inventory were administered on one of the training days. The Raven's Progressive Matrices was administered 2 to 4 weeks after the experimental training.

The subjects got a small daily reward. Furthermore, they could earn a solar pocket calculator if they were the fastest out of a group of 4. They were told their own averages on the training days and so could see their own improvements.

2.4. REACTION TIME TASKS

The research had both simple and complex RT tasks. Starting from a one-choice RT task (task A), to a 5-choice RT task (task B), to cognitively more complex tasks (task C, D and E) developed in our laboratory.

In our test we also used the 'home button' to separate RT from MT. When the test started the screen changed from black to white. The subject was asked to press the home button on the response board as soon as he heard the warning stimulus, and depending on the task, saw 1 or 5 empty squares appearing on the screen. The position of the buttons on the response board corresponded with the positions of the squares on the monitor (see Figure 1). The foreperiod varied randomly between 2000 and 4000 ms. The subject was asked to lift the home button as soon as he knew the answer and to move to one of the response buttons. In order to ensure that the right answer was known before the subject lifted the home button, the figures disappeared from the screen and the monitor became totally white after the home button was released. Immediately after the response button was pressed, the intertrial interval began. The sequence of the specific events per trial are shown in Figure 4.

[insert Figure 4 here]

For every item, the BBC computer registered the random waiting time, the position of all figures involved, the RT, the MT, the numbers of the presented figures (varying from 0 to 15, see Figure 2), the position of the chosen answer, the position of the right answer and the time and day the test took place. The maximum RT for task A and B was 4096 ms, for task C, D and E the maximum time was 51200 ms. When this maximum time expired without a response, the figures disappeared from the screen and the next item was presented.

In task C, D and E the figures which appeared were fixed for day 1, 4 and 10, while the position in which they appeared was randomised. For the training days of task C, a randomised set of target figures was used, differing every set of 12 items.

2.5. TAPPING TASKS

In this study two kinds of tapping tasks were used. A simple tapping task, in which there was only 1 button on the response board also used for the other tasks. The subject was asked to push that home button as many times as possible in 45 seconds. He was allowed to use only one finger of his preferred hand. The subject was told that it was important that the button was pushed deep enough and that the button could come up enough in between the subsequent pushdowns. The tester demonstrated it and the subject practiced. The subject could decide when to start, and the tester told him when to stop. The task was administered twice with a substantial recovery period in between.

The second tapping task, was more complex; there was a home button and 9 other buttons, in the configuration as shown in Figure 5.

[insert Figure 5 here]

The subject was asked to start pushing the home button, moving to button 1, coming back to the home button, moving to button 2, home button, button 3, home button, etc... After button 9, he had to go to the home button, from where to start all over again. The subject was told that he should try not to miss any button and if he missed one, he should try to continue as fast as possible. Again it was the subject who could decide when to start and the tester who told the subject when to stop. Immediately after finishing, the subject could see on the monitor what his score was. Again, the task was administered twice for 45 seconds.

2.6. INTELLIGENCE MEASURES

The Raven's Progressive Matrices, the WISC Vocabulary Test and a computerised version of the Digit Span test were administered. Grade 7 Examination results and the results of examinations made in June 1989, were also available.

The WISC vocabulary subtest was administered individually on one of the training days; a sheet with the words of the subtest was presented to the subject. The subjects could read the words and the tester pronounced them simultaneously. The question was: Can you tell me what the word means. The tester wrote down the answers. There was no time limit; the words that subjects did not know were left open. The total list of 40 words was administered.

The Raven's Progressive Matrices was administered groupwise, in groups of 6 subjects. The normal instruction (as indicated in the manual) was given and again, there was no time limit.

A computerised version of the Digit Span, was administered twice. The screen was white with 9 empty squares (see Figure 5). The subjects viewed a series of squares which briefly became black. Firstly, one of the squares became black for a part of a second, after a second another square briefly became black. The first two series were strings of 2 squares, the third and fourth series consisted of 3 squares in a row, the fifth and sixth series had 4 squares, etc. The subjects had to remember in which order the squares had become black. After a signal (a beep), they should press the buttons in the same order as the squares had become black. They got as many examples as they needed to get the meaning of the task. The examples were series of 2 and 3 squares. The real task started with a series of 3 squares. The instructions they got were that they had to repeat after the beep the order in which the squares had become black. The subject had to push the buttons in the same order. It was also said that the task became more difficult later on. The serial positions in the task were identical to those used in the Digit Span forward of the WISC.

2.7. CONTEXT VARIABLES

The context variables referred to a number of aspects of the social-demographic environment of the subject. To measure context variables, the subjects were interviewed using a standard questionnaire (see Figure 6).

[insert Figure 6 here]

As context variables we measured the following aspects:

1. Date of birth;
2. Father's education;
3. Mother's education;
4. Father's profession;
5. Mother's profession;
6. Number of books in the home;
7. Longest distance ever been away from home;
8. Student's preferred future profession;
9. Subjects in school preferred most by the student;
10. Subjects in school liked least by the student;
11. Hobbies with a academic interest;
12. Grade 7-scores;
13. Examination results of the second semester (June 1989);
    (The following two question were asked for each of the five CRT tasks separately).
14. How difficult were the tasks?;
15. How interesting were the tasks?;

2.8. ANALYSES OF THE DATA

2.8.1. RT AND MT

In the analysis we used the daily means of the RT and MT's. Both the mean and the median were computed, but there was no meaningful difference in between them. We used the Hawkins outlier procedure (1980) to adjust for outliers; scores outside a 0.95 reliability interval were eliminated. All errors (trials with incorrectly pushed buttons) and outliers were treated as missing data.

2.8.2. WISC AND RAVEN

The WISC vocabulary and the RAVEN'S Progressive Matrices were scored as mentioned in the manuals.

2.8.3. DIGIT SPAN

In the computerised Digit Span, the subject got two times a string of figures of the same length (2 times a string of 3 figures, 2 times a string of 4, etc...). If one of these strings of figures of the same length was repeated well, the subject could continue to the next, longer string. This procedure was repeated until both strings of the same length were reproduced incorrectly. The score was the longest string which was correctly repeated. The test was administered twice; the scores were added.

2.8.4. TAPPING

Both the simple and complex tapping task were administered twice. Again, scores of the two administrations were added. The scores were the number of times a button was pushed in 2 times 45 seconds.

2.8.5. GRADE 7 SCORES

Grade 7 scores were the scores on the nationwide Grade 7 Examination on the basis of which they were admitted to Secondary school. From the school records Grade 7 results were copied. Pupils got scores on different subtests, namely English, Social Studies, Mathematics, Science, Zambian Languages, Special Paper One, Special Paper Two. The latter two were reasoning tests. All subtest scores were added for our calculations.

2.8.6. AGE

Age was computed by subtracting the year of birth from 1989.

2.8.7. EXAMINATION RESULTS JUNE 1989

The results of the second semester of Grade 8 were collected. The following subjects were involved: English, Mathematics, Geography, History and Civics. The scores were added to get a mean examination result.

2.8.8. SOCIO-ECONOMIC STATUS (S.E.S.)

The factor S.E.S. consisted of 6 separately measured variables that were combined in a factor analysis, namely father's education, mother's education, father's profession, mother's profession, number of books in the home, longest distance ever been away from home. A single factor was extracted, explaining 37 percent of the variance (see Table 1).

*** Education from both father and mother were scored as 0 if they had no formal education; a score of 1 when they had gone to primary school, if they finished this school, they got a 2. 3 Points were given if they did go to secondary school, if they finished secondary they got 4 points. The factor loading of education mother was .87 and for father it was .79.

*** Profession was scored according to the scores in the ARBVO, a profession scale developed by the Directorate General of Employment. The maximum score was 7, the minimum was 1. Score 7 stood for a profession of a high academical level. Father's profession had a factor loading of .64 and mother's profession a loading of .48.

*** The number of books in the home, was a multiple choice question, the possibilities and scores were as followed:

1 = less than 10 books in the home
2 = between 10 and 25
3 = between 25 and 50
4 = between 50 and 100
5 = more than 100

This variable had a factor loading of .40.

*** The longest distance ever been away from home was measured in kilometers, the subjects mentioned the place and the tester estimated the distance in kilometers. The actual measure was the logarithm of this number. The variable had a low factor loading of .23.

[Insert Table 1 here]

2.8.9. ACADEMIC

The Academic factor consisted of student's preferred future profession, subjects in school preferred most by the student, subjects in school liked least by the student, hobbies with an academic interest. The profession the student wanted to occupy is scaled on the same scale as the parent's profession (with a minimum of 1 and a maximum of 7). This Academic interest factor explained 50,3 % of the variance in RT scores. This future profession had a factor loading of .73. For each academical subject liked by the student, 1 point was added, a non-academical subject got 0 points. The same procedure was followed for the scoring of the hobbies. In Table 1 factor loadings and explained variance on the factor 'Academic Interest' are shown (N=32). We see that subjects liked most and liked least by the subject had an opposite loading on this factor and that it was equally strong in both directions (.85 and -.87, respectively). Hobbies did not have any impact. Factor loading for hobbies was only .02.

2.8.10. DIFFICULTY AND INTEREST

On a 5-point scale the subjects were asked to rate the tasks. There were two questions:

1. How difficult did you find the tasks?
2. How interesting did you think the tasks were?

The scoring was as follows:

very difficult	1 point	very uninteresting	1 point
difficult	2 points	uninteresting	2 points
moderate	3 points	undecided	3 points
easy	4 points	interesting	4 points
very easy	5 points	very interesting	5 points

The results for the two questions and the five tasks were combined in a factor analysis (N=32). The correlations between the perceived difficulty and interest were strong. The more difficult the task, the more uninteresting the task was found to be (task D and E had the highest loadings). A one factor solution was extracted. The eigenvalue of this factor was 3.14, explaining 31% of the variance. The factor loadings are presented in Table 1.

2.8.11. COGNITIVE FACTOR

The cognitive measures used in this research are combined to a cognitive factor in a factor analysis. The variables used are the WISC vocabulary score, the RAVEN score and time, the Examination results of June 1989 and the Grade 7 scores. Factor loadings are presented in Table 1.

RESULTS

3.1. MEANS AND STANDARD DEVIATIONS

[insert Table 2 here]

In Table 2 the mean RTs are given (N=32); no distinction was made between the 4 different training groups. It was obvious that the mean RT declined over the period of training. The results on task A and B were based means of 32 subjects, those means were based on observations of one day, on blocks of (2 x 10) trials. The results of task C, D and E were based on 32 subject means. This subject mean was based on observations of one day (2 x 12 items) per block.
Mean RTs on Task A decreased from 292 ms to 268 ms. For task B the difference between the first and the tenth day was approximately the same: 400 and 370 ms, respectively. It appeared that the learning effects for cognitive simple tasks were (more or less) stable. For cognitive more complex tasks, this was not true as can be concluded from Table 2. The improvements on task C were from a mean of 897 ms on the first day to 657 ms on the tenth day, which was an improvement of 26.7%, whereas the improvements on task A and B were not more than 8% (see Table 3).

[insert Table 3 here]

The mean RT of task D improved substantially, from 2560 ms to 1783 ms, an improvement of 29.3%. As might be expected the difference in mean RT between the first and the tenth day was largest on task E: RT decreased from 4530 to 2512 ms, an improvement of 44.5 %. So, gains were positively related to cognitive complexity. The results are represented graphically in Figure 7.

[insert Figure 7 here]

Mean RT declined after practice; the same was found for the SD; changes in SD's are presented in Figure 8. Figures per task are given, divided in 2 blocks a day. Task A and B were administered in blocks of 10 items each, the tasks C, D and E in blocks of 12 trials. The decision to make a division between the first and second block was taken because of the large differences between the first and the second block, particularly for the cognitively more complex tasks (see Figure 8).

[insert Figure 8 here]

The decline in SD (see Table 2) was merely due to a decline during the second block of the task. Table 4 presents the percentage decline in SD per task.

[insert Table 4 here]

Large SD's were caused by a large difference in average scores between the first and second block, as can be seen in the Figures 8c and 8e. When changes in percentages of the mean and SD were compared, it could be observed that these were not related to cognitive complexity. The easiest and most complex task yielded the largest change. (Figure 7 and 9).

[insert Figure 9 here]

From a comparison of Table 3 and Table 4, it could be gathered that after sufficient practice the decrease of the SD and RT were comparable on cognitive complex tasks but certainly not on cognitive simple tasks (as task A and B demonstrated).

3.2. TRAINING EFFECTS AND TRANSFER

The impact of training on test performance is given in Table 5, in which the average RTs per day, task and training group are presented.

[insert Table 5 here]

From this Table we can see that the initial group differences were sometimes considerable; the small sample size on which the mean RTs were computed (N=8), should be taken into account here. In order to make the RTs more comparable, they are also expressed as percentages of improvement.

[insert Figure 10 here]

In Figure 10 it is easy to see that groups trained on a task improved more than any of the other groups on that task. Training gave rise to task-specific improvement. Furthermore, the group trained on tasks B, C and E was second fastest (except on task B). This could also be observed in Table 5: the group with the largest improvement was the group trained on the task, the second one was the group trained on all tasks, followed by the task that most resembled the measured task in cognitive complexity. Last in this sequence was the task that differed most in cognitive complexity from the task measured. For task B this implied most improvement for training group B, followed by training group All, training group C and finally training group E. For task C this meant: training group C, All, E and B respectively. And for task E it implied that training group E had the largest improvements, followed by training group All, C and B.

A test of significance of this pattern was computed in a MANOVA. The Greenhouse-Geisser adjustment (univariate analysis) was used. The dependent variable in this calculation was the mean RT of a day (of day 1, 5 and 10). There were three different training conditions.

1. trained on the task
2. not trained on the task
3. trained on task B, C and E

Group 3 was combined with the group trained on one specific task. N=16 for subjects trained on the task and N=16 for subjects not trained on a task (Note: these numbers were 15 if training group C was involved). The results are shown in Table 6. The first part of Table 6 represents the group effects, which shows that training on task B or C or E had a significant impact on the RT results. It should be realized however, that to training group All a smaller number of items was presented daily. It can be seen that training on task E produced a significant improvement on task D, which was a cognitively less complex task than E, but the underlying structures were comparable. This meant that problem solving strategies acquired by practice on a cognitively complex task, were transferred to other cognitively complex tasks (near transfer).

[insert Table 6 here]

The second part of Table 6 is a representation of day effects. Mean RTs differed significantly on day 1, 5 and 10 (only task A was not significant with p = 0.07, p =

0.06 and p = 0.07 for respectively training group B, C and E). From this Table it could not be derived however whether most was learned on the first 5 days or in the second half of the sessions. This trend, however, is shown in Figure 10. For task B, most improvement took place between the fifth and the tenth day. This was different for task C. There seemed to be two clusters, one cluster with the groups with training on task C. This group improved most in the first 5 days. The other cluster consisted of two groups without training on task C. This group improved most in the last 5 days. For task E this division in clusters could not be made. All subjects learned most in the first 5 days, with or without training.

Finally, we see that the day by group interactions were significant for three variables. Two of these were expected. Training on task C made this group perform significantly better on task C, at the pre-, mid-training and posttest. The same for training group E; they performed better than others on task E during these days. Furthermore, there was one other cell that was significant. Training on a cognitively complex task (task E) made this group significantly slower on a cognitively simple task (task B). Note that this was not the case for task A, possibly because none of the groups had training on A. In Figure 10 we can also see that both training groups All and E did not improve on task B, whereas training group B and C improved substantially.

3.3. CORRELATIONS BETWEEN TASKS

The total sample could only be considered to be homogeneous at the first day. Starting from the second day, the sample was split in four groups, each of them receiving a different training procedure.
Due to technical problems one subject was excluded from the calculations; he belonged to training group C. This group had 7 instead of 8 persons in all further calculations.

Correlations between tasks were expected to increase after practice. Looking at Table 7 we see that the inter-task correlations on the last day were significantly higher than on the first day (as found by Van de Langenberg, 1989). The mean inter-task correlation .21 on day 1, .45 on day 5 and .52 on day 10 (one tailed $p<.05$). Correlations were higher after training, which supported the expectation.

[insert Table 7 here]
[insert Table 8 here]

Table 8 gives a matrix on the intra-task correlations compared on the first and the tenth day. The total intra-task correlations between the first and the last days showed a mean of 0.35. Between day 5 and 10 however it was much higher, $r= 0.69$. This is also conform the seventh hypothesis.

In Table 7 it can be seen that the in the matrix the further away the correlation is from the main diagonal, the lower the correlation. This 'simplex pattern' was already found on day 5, more clearly on day 10, but it was not yet visible on day 1 (Guttman, 1955; Jones, 1962, 1970) On the first day the nature of the measurements seemed to be different from day 5 and 10. Test wiseness might have been interfering here. When cognitive complexity increased, the 'simplex pattern' became stronger and had less outlying values. A prediction of the results on day 10 was more accurate on the basis of the fifth day results than on those of first day. Also the prediction was better for the cognitively simple tasks than for the cognitively complex. For example task A, the correlation between the performance of the first and the fifth days was 0.33, day 5 with day 10: 0.76. The explained variance is 58 %, when the performance on the tenth day was predicted from day 5. For task E, the correlation was higher between day 1 and 5 than for task A. But it was not as high between day 5 and 10, $r = 0.69$. (This explained 48 % of the variance). Lower correlations between the performances of the first and the fifth days in comparison with the fifth and the tenth days can be taken to be caused by, among other things, the learning processes which differ across the individuals. Unexplained variance is larger in the cognitively complex tasks, task specific variance is larger in the cognitively simple tasks.

3.4. CORRELATIONS BETWEEN DAYS

[insert Table 9 here]

Correlations between day 1 and 5, day 1 and 10 and finally day 5 and 10 in the 4 different training groups, are shown in Table 9. Correlations between day 5 and 10 were always larger than between day 1 and 10. This, again, demonstrated that the tasks of the first and the last day were not equivalent. On day 5 most 'interfering variables' already had disappeared. The mean correlation between day 5 and 10 was 0.68 (for all tasks and training groups). It was remarkable that the correlations between day 5 and 10 were smallest on the task the group was trained on. For example, in training group B the correlation was .66 between the RT scores on task B on day 5 and the RT scores on task B day 10. In this same training group the mean correlation between scores on 4 other tasks day 5 compared with day 10, were higher (mean: .81). This is displayed in Table 10.

[insert Table 10 here]

Training reduced the inter-task correlations of the task which was trained. The reason behind these differences was probably the fact that by getting training individual differences in learning potential could be much more reflected in the more overtrained tasks. As a consequence, the inter-individual performance differences observed during the first days were most threatened on these tasks. The inter-individual differences could become larger than for subjects that did not receive a training on the task. The fact that for training group E on task E the correlation was lower than for training group B was probably due to the learning potential going by task E.

[insert Table 11 here]

Table 11 shows the inter-task difference between training groups in inter-task correlations on the first, fifth and tenth day (N=16 for the group trained on the task, a combination of training group All and the specific training group). Mean inter-task correlations decreased more if training was given on cognitively more complex tasks. For groups not trained on the task the opposite trend was found.

3.5. GAIN AND TRANSFER

[insert Table 12 here]

The 'Hick coefficient,' which is a regression coefficient that reflects the steepness of the line connecting mean RT on task A with mean RT on task B, was found to be unstable. After training it became more stable .65 (the correlation between day 5 and 10; N=31). The stability was rather poor in the beginning and seemed to increase with practice (see table 12).

Another gain measure is the regression of day on mean RT. The independent variables were day (1, 5 and 10) and the dependent variable was mean RT per person. A high regression coefficient implied that 'day' was a good predictor for RT on that task. High correlations between A and B regression as measured by their regression coefficient would mean that the improvement on A correlated high with improvement on task B. In Table 13 the results of the correlation (for N=31) are given. The pooled mean is the mean of the concatenated results of the specific training groups.

[insert Table 13 here]

Correlations for task A with B and A with D were positive; so were those of task C with D and D with E. The untrained tasks, task A and D, were the only ones between which the correlation was highly positive (r=.31). We see that there was not a simplex structure. Gains on cognitive simple tasks did not correspond with gains on complex tasks; overall, the correlations between the regression coefficients were rather low.

A third gain measure was the regression of task complexity on mean RT; independent variable was task complexity (Task A=1, Task B=2, Task C=3, Task D=4, Task E=5), dependent variable was mean RT. The correlation of this measure was predominantly influenced by the results on cognitively complex tasks. Correlations with the mean RTs on these tasks were highest. Correlation of the regression of complexity on mean RT correlated with task A .10, task B .29, with task C .31, task D .66 and with task E .84 (on N=31, pooled for training groups). The results of these coefficients strongly resembled what was found for task E. The results replicate the findings of Van de Langenberg (1989).

Our last gain measure was the percentage of gain per task (Table 14).

[insert Table 14 here]

Mean correlations were somewhat higher than the regression coefficients, but still not very high. It appeared, in sum, that gain measures overall were moderately correlated. Also, the 'Hick coefficient' is rather unstable in the beginning and has in terms of cognitive complexity a restricted reach.

3.6. CORRELATIONS OF RT WITH CONTEXT VARIABLES

The results from our questionnaire, the vocabulary of the WISC and the Raven score and time, have been correlated with mean RTs. With the interpretation of the results we should bear in mind that the group contained only 31 subjects selected on the basis of their high scores on the Grade 7 examinations; correlations should be interpreted with care. We know from the introduction that day 1 could be measuring something different than we intended to measure, there could be a lot of interfering variables. If the cognitive complex tasks measured something like general intelligence, then the correlation between RTs and the Raven score, the WISC vocabulary, mean examination results and the Grade 7 Examination scores, would have been highest (on day 10). The correlations are being presented in Table 15. Correlations were not very strong. On the tenth day the values were; 0.24 (Raven), 0.18 (WISC vocabulary), 0.16 (mean examination results) and 0.16 (Grade 7 scores). So, the relations, most of them in the expected directions, were not strong (cf. Hunt in Vernon, 1987).

[insert Table 15 here]

We saw that correlations between tapping (both simple and complex) and RT became stronger after practice. The motor component had a greater impact on the tasks after training. This could have been a sign that the cognitive component decreased in importance (cf. Fleishman, quoted in Ackerman, 1986). This was not true for the WISC vocabulary, since these correlations remained constant. It could be seen in the correlations of RT with Digit Span scores; the absolute correlations went down from 0.27 on day 1, to 0.14 on day 10. The cognitive component in Grade 7 scores remained constant over days. The Raven score did show a slight decrease in importance of the cognitive component.

In Table 16 the correlation between context variables and tasks, averaged over the first, fifth and tenth day, are presented.

[Insert Table 16 here]

It is remarkable to see that average absolute correlations of the **WISC vocabulary** with the different tasks, seemed dependent on the fact whether pupils were trained on the task. Task A and D were not part of any training conditions, their correlation with the WISC were 0.08 task A and 0.09 task D, which was minimal, for task B, C and E correlations were .21, .24, and .24 respectively. Random group differences could play a role. The absolute correlations of RT with the WISC, did not increase with cognitive complexity of the tasks, as found by Van de Vijver and Willemse, 1989.

Digit Span correlations did not change much as the difficulty of the tasks increased. Apparently, individual differences in short term memory abilities did not affect the RT results on tasks with different cognitive complexities.

The correlations between **tapping** results and RT were more pronounced for the simple tapping tasks; The correlations decreased with increasing cognitive complexity as might be expected.

Results of **examinations** administered in the same semester as the tests were taken, showed correlations with the tasks, shown in Table 16. Correlations were strongest with task A (r=.41), followed by task E, task C, task D with respectively correlations of .22, .20, .15 and .05. These results indicated that correlations between the cognitive complexity of tasks and school results were not strong and not systematic.

There was a positive correlation of RT with **age**. The correlation increased as cognitive complexity of the tasks increased. This implied that younger pupils were faster on the cognitively complex task than older ones. For the cognitively simple tasks this was not evident (correlation was only 0.11). The pupils differed substantially in age. The youngest participant was 13 and the eldest was 18 years old. The median was 17 years. An explanation might be that brighter children finished Primary School faster and therefore were younger when they entered Grade 8.

Raven's score did not differentiate between the different CRT tasks. These results could be due to the restriction of range in the Raven. The scores were above the usual Raven's results for Grade 8 students (highest score was 56, lowest was 36, median was 49 points out of 60). **Raven time** on the contrary was correlated with task complexity. The time needed to finish the Raven Standard Progressive Matrices, had a relatively high correlation with RTs on cognitive simple tasks (r=.24) and a low correlation on cognitive complex tasks (r=.08). The direction of the correlation was negative. The longer the time needed to finish Raven, the faster subjects were on task A. Absolute correlations between task E and Raven time was slightly positive (r=.08). It could be concluded that the CRT for cognitively complex tasks was unrelated to the time needed to finish the Raven's.
The **difficulty-interest factor** had high correlations (.31) with RT, which did not differ much across tasks (except for task A where a low correlation was found). We found the same correlations of approximately .30 of Grade 7 scores with cognitively complex tasks, Jensen (1989). On cognitively simple tasks the correlations were much lower. This is in line with Van de Vijver and Willemse (1989).

[insert Table 17 here]

In Table 17 we see that correlations between context variables and tasks slightly increased after training. Mean absolute correlation is .18 the first day, .21 on day 5 and .23 the last day. With practice, the predictability increased. Yet, the increase is small. The most important conclusion of this section is that the correlations between reaction time tasks and the context variables were low.

3.7. CORRELATIONS OF GAIN WITH CONTEXT VARIABLES

The correlations between the Hick coefficients on the first, fifth and tenth day are presented for each training group separately in Table 18.

[insert Table 18 here]

It could be expected that the correlation on day 10 would be the strongest. We see that for training group B there was a high negative correlation with the computerized Digit Span task, the simple and complex tapping task and with the Raven score and time. A negative correlation meant that if the regression coefficient (b) was small, (i.e., the line connecting the two mean RTs was flat) this corresponded with high scores on the context variables. The subject who reacted fast on task B, had high scores on Raven, tapping and digit span. For the WISC, the opposite was observed (r = .34). High scores on the WISC (high word knowledge) corresponded with a high Hick coefficient (i.e., a large difference in performance between the A and B task). This phenomenon was found in all training groups.

A second gain measure was the regression of day on the mean RTs, an indication of the improvement after practice. The higher b (in absolute values), the steeper the slope, the more improvement was made. Correlation of this regression coefficient with context variables are also presented in Table 18. In the training groups the pattern of correlations were somewhat complicated. In the pooled group (N=31), there were some trends visible. There was an increase in correlation between WISC and cognitive complexity of the tasks, from r= -.26 task A to r=.20 task E. This positive correlation implied that on task E the high RTs corresponded with high scores on the WISC. Persons with high verbal ability were not the fast problem solvers on task E and they performed better on task A (high WISC score and low RTs). The regression coefficient of task E correlated also positively with grade 7 scores (r=.26).
A negative correlation with task A, B and C between the regression coefficient and grade 7 scores was visible (-.03, -.10 and -.14). For task D and E the correlation was positive (.14 and .26 respectively), a positive correlation meant that persons with high grade 7 scores were fast on cognitively complex tasks.
For the Raven score the results gave a trend in the opposite direction. The correlations were all positive, but became less strong as cognitive complexity increased. This implied that high Raven scores corresponded with lots of improvement on task A and less gain on task E. Subjects who improved a lot on task E did not necessarily perform well on the Raven's (r= .16).

The third gain measure was the 'regression of complexity', this was the regression of task complexity on mean RTs, the prediction of mean RT on basis of the complexity of the tasks. The smaller this measure, the flatter the line 'b', the faster subjects were on cognitive complex tasks. We see in Table 18a, a high negative correlation with Raven score for training group B (-.47). For training group C and All there was also a negative correlation (-.53 and -.49); for training group E,

however, this correlation was highly positive (r=.63). These large fluctuations were probably due to the small number of subjects per training group.
For the total number of subjects, correlation between Raven score and the regression coefficient of complexity (fast ones on cognitive complex tasks, had high Raven scores (r=-.22)). The same was true for the correlation with the WISC and grade 7 and the regression of complexity; both context variables correlated -.25 .
Digit Span correlated .20 (N=31) with the regression of complexity. This implied that low RT scores on cognitively complex tasks corresponded with low scores on the Digit Span. The two measures seem to tap different factors.

The last gain measure was the percentage of gain per task. The results were not clear. For training group E, the correlation with Raven is high, going from -.62 to .22 as cognitive complexity increased. The negative correlation with percentage of gain on task A meant that a low gain on task A corresponded with a high score on the Raven test. And a high percentage of gain on task E (r=.22) went together with a high Raven score, which was as could be expected, because Raven measured something like fluid intelligence which was needed more in task E than in task A.
For the total number of subjects (N=31), the percentage gain correlation, decreased in value with cognitive complexity. This implied that subjects with a large improvement on task A had lower Raven scores than those with a large gain on task E (r = -.32 for task A and -.08 task E). Correlations (N=31) with Raven time seemed very strong for this gain measure; The ones with a large gain on task E were fast on the Raven. The ones with large gains on task A needed a lot of time to finish the Raven. Raven time seemed to be correlated with the ability to solve problems fast (task E). The 'learners' on task A, seemed to work slow on the paper and pencil test, where speed constituted only a marginal aspect.
In sum, the correlations between gain measures and context variables were moderate, at best.

3.8. CORRELATIONS OF RT AND COGNITIVE MEASURES

In this paragraph the relation between the RT tasks and other cognitive measures is discussed. It was hypothesized that there will be a negative correlation between RT and intelligence scores; fast responders on the RT task will have high intelligence scores. According to the second hypothesis on this subject, correlations between RT and intelligence scores will increase with cognitive complexity of the tasks. In Table 1 the factor loadings on the cognitive factor are presented. The cognitive factor is dominated by the examination results of 1989 (see Table 1). The relation with RTs are shown in Table 19.

[insert Table 19 here]

We see that task E correlated strongest negatively with the cognitive factor (-.41). This confirmed the hypothesis; however, task A correlated substantially too. All tasks correlate negatively except task C (.08). There is a slight tendency for correlations to increase with practice; day 1: -.22, day 5: -.13 and day 10: -.26. The school results resemble the RT scores most.

So it was found that the cognitive measures were not strongly correlated with RTs, though some tendencies confirming the hypotheses could be discerned.

3.9. RANK ORDERS BEFORE AND AFTER TRAINING

Kendall's tau was used to see if rank orders of RTs changed after practice. A question not yet addressed, involves the influence of prolonged specific training on the individual rank order of the RTs. In Table 20 Kendall's taus are reported. Given are correlations of the rank order on day 1 with the mean of rank orders of the nine other days (day 2 to 10), followed by the rank order of day 2 with the mean of rank orders of the following days (day 3 to 10), etc. The average rank order correlation is the mean of the ranks on the separate days.

[insert Table 20 here]

It could be observed that for cognitive simple tasks, specific training did not differentiate between subjects; the inter-individual rank orders remained more or less the same. For cognitively complex tasks, specific training caused a change in rank orders. This implied that the initially fast subjects were not necessarily fast after training on cognitive complex tasks, the variance in performance was caused by a factor present in the subjects, and not a task specific. For cognitive simple tasks the initial differences remained. This meant that cognitive simple tasks contained more task specific variance, that could not be explained by individual learning processes.

Finally, it can be seen in Table 20 that rank order correlations became higher with training. Rank order on the ninth day was more or less the same as on day 10 and rank order on day 1 was different from day 10 (lower correlations). The fifth day was (usually) not in perfect sequence with the rest of the days. It could have been because it was the 'mid-training-day' and instead of just training on one task (or 3 tasks in training group All), subjects got tested on task E, D, C, B and A. There was an influence of order in which tasks were presented, on rank orders, especially in training group All.

Conclusion: It appears, in sum, that rank order correlations increased after training and decreased with cognitive complexity.

3.10. ERRORS

[insert Table 21 here]

[insert Table 22 here]

From the Tables 21 and 22, it appears that the overall proportion of errors was low. There was a significant day effect; the proportion of errors decreased with practice. There were no significant training group effects, which means that training did not have a significant impact on the number of errors made on all tasks. In Table 21 could be seen that the number of errors increased with cognitive complexity, which was as could be expected; the task-effect was significant at .00. The group by task effect however was significant, meaning that training did affect the number of errors made on the task they received training on. This effect however was task specific and did not lead to fewer mistakes on other tasks than the one trained on. Block effects were not significant. Some of the person interactions were significant, indicating that some people made an unexpectedly small or large number of errors in some circumstances. The pattern of significance was difficult to interpret.

3.11. MOVEMENT TIMES

Did the movement times (MT's) decrease after practice, as did the RTs and was there a difference between MT on cognitively complex tasks and the cognitively simple tasks?

[insert Table 23 here]

In the literature it is mentioned that MT tends to increase as cognitive complexity increases. When we look at Table 23, we see that this was true for our subjects. Yet, we should keep in mind that the training groups were small; all training groups consisted of 8 persons, except training group C which had only 7 subjects.

[insert Table 24 here]

MT on task A, B, C, D and E were respectively 208, 224, 234, 245 and 251 ms; this task effect was significant (see Table 24). A perfect step by step increase of mean MT as cognitive complexity of the tasks increased step by step. A univariate analysis, the Greenhouse-Geisser adjustment was used. The SDs did not differ much over the tasks (ranging from 57 to 66).

[insert Figure 11 here]
[insert Figure 12 here]

In the first part of Table 23 and in Figure 12 we see that training groups (over all tasks) did not differ significantly in mean MT (see Table 24, $p = 0.47$). Training group E was slowest (MT= 244 ms), probably because in the responses of task E the movement time takes a relatively small part of the total movement (careful responding was required). And apparently this was a given effect which affected MT on the other tasks. Training group All was used to tasks of changing cognitive complexities and was fast; MT= 223 ms. For training group C mean MT was 220 ms, which was very fast. After practice MT decreased considerably; a mean of 274 ms on day 1, day 5 it had already dropped to 224 ms and finally on day 10, mean MT was 198 ms. This implied that a strong effect of day was present ($p=.00$, Table 24).
It could be concluded that task effects were substantial; MT on cognitively simple tasks was significantly faster than on cognitively complex tasks. The RT needed to

solve the problems affects the speed of the movement. Day effects were also significant; MT decreased with practice (see Figure 11).

3.12. CORRELATIONS OF MT AND RT

In Table 25 the correlations of MT with RTs are reported per task (N=32).

[insert Table 25 here]

For task A and B the results were based on 32 intra-individual correlations, each of which was based on 60 trials; for task D and E they were based on 32 correlations each of which were based on 72 trials. We see that correlations increased from low negative to low positive values with cognitive complexity of the tasks. This pattern was also found by Van de Langenberg (1989). The negative correlations for the simple task, can be explained by referring to Welford (1980), according to whom the RT may also include a preparation of the movement. Long RT's will then be followed by short MT's.

CHAPTER 4 DISCUSSION

With the results in the preceding chapter the hypotheses will be discussed. The first hypothesis stated that learning effects will be larger on cognitively complex tasks than on cognitively easy tasks. This hypothesis is strongly corroborated. As we saw in Table 3 the percentage of performance improvement on the cognitively simple tasks A and B were 8% and for task C, D and E these values were 26.7%, 30.4% and 44.5% respectively. According to Ackerman (1986), the cognitively simple tasks contained more task-specific variance than cognitively complex ones. On the cognitively simple tasks, little task-specific variance is left. The learning effect for task B is small and can be attributed to the amount of individual difference in the development of automatic and controlled processing of the task. On cognitively complex tasks the learning effect was large and could be attributed to individual differences in learning. Cognitively simple tasks do not allow for the formation of individual strategies which can give rise to large individual differences; individual variation is small.

Here we come immediately to the fifth hypotheses: stating that the correlation between RT and other intelligence scores will increase with task complexity. If the learning effect on the cognitively complex tasks is dependent on the skills to develop problem-solving strategies, the correlation with intelligence measures will be larger in that case than with the cognitive simple tasks where no such skills are needed. Table 16 shows the results; it was not found for the more verbally oriented subtest of the WISC. The RAVEN score showed a trend in the direction of increasing correlations for the cognitive more complex tasks with RTs (but task A is an exception). For the mean score of this years examinations the hypotheses must be rejected. On the other hand, the correlations of the RTs with the Grade 7 scores increased with increasing cognitive complexity. But overall, the correlations of intelligence measures with RTs were not strong. Mean correlation of all intelligence measures with RTs are for task A, B, C, D and E respectively .23, .16, .17, .17 and .26. One explanation possible here is what Eysenck (1986) has suggested that 'there is a central core to IQ tests which is quite independent of reasoning, judgment, problem solving, learning, comprehension, memory, etc'(pp.285-296). This could explain the .23 correlation of task A with other intelligence measures. Another explanation can be that the group of N=31, is not homogeneous anymore after the different training conditions they were in. Correlations will have been affected by this phenomenon.

According to the fourth hypothesis, the RTs will be negatively correlated with intelligence scores. In the previous section we saw that absolute values of the correlations of RT with the WISC vocabulary, the RAVEN, the examination results of June 1989 and the Grade 7 scores, did not all display this pattern. These correlations were very much affected by the training some pupils got. Those trained on task E had a correlation of RT and intelligence measures increasing in negativity as the task became more complex. Those trained on task B displayed the opposite, correlation between RT and intelligence measures were negative on RTs of task A and became gradually positive as tasks became cognitively more complex. So, training on task E made the correlation between RT and intelligence measures become stronger and more negative as task complexity increased (also found by Willemse, 1989). Apparently training explored the individual learning differences and those differences correlated negatively with other intelligence scores. Definitely much research can be done on the question why training influences these correlations in this way.

When we compare mean RTs of this research with mean RTs of other research done by van de Langenberg (1989), the results after 4 days of training on all tasks, mean RTs on the first and the fifth day are given in Table 26.

[insert Table 26 here]

We see that the means of Dutch subjects for cognitive simple tasks did not differ significantly from the means of Zimbabwean subjects, but that Zambian subjects were much faster in responding to task A and B. Mean on task C is the same for Zambian and Dutch subjects, the Zimbabweans had higher RTs on this task. On cognitive complex tasks Dutch subjects were fast and both Zimbabwean and Zambian subjects responded slower.
We have to keep in mind that training for the Zimbabwean and Dutch subjects consisted of all tasks on the four training days. For Zambian subjects it was task A, B, C, D and E on day 1 and for day 2, 3 and 4 it was one of the four training conditions. Eight Subjects were trained on task B, 8 subjects got a training on task C, 8 on task E and 8 subjects were trained on task B, C and E. In Table 5 we could

see that the Zambians trained on task B, C and E (the condition that resembled the situation of the other research most), mean RTs were 357, 684 and 2269 ms for task B, C and E respectively. It can be concluded that this training group responded as fast as the Dutch subjects.
The percentages show us that even if mean RTs in the Zimbabwean and Zambian groups were higher, the percentage of learning that occurred during training, were more or less the same for all nationalities. One remarkable thing is the fact that Van de Langenberg did not find a learning effect for the cognitive simple tasks A and B, in the present research however there was an improvement on these tasks. And in Table 3 we could see that this learning continued to take place after day 5. Even after 10 days of training, it cannot be said that pupils reached their lowest possible RT. To discover what their minimal RT is, more training should be given in a research in the future, although problems of motivation and concentration could occur than.

We will continue with the sixth hypothesis, stating the SD that will correlate with intelligence scores; the higher intelligence scores, the smaller SD's will be. We saw that the decrease of the SD was comparable with mean RT on the cognitive complex tasks after sufficient training; for the cognitively simple tasks this is not true, not even after 10 days of training. Correlation of SD with RTs on task E was high; for N=31 the correlation was .78. Correlation of SD with scores on the WISC vocabulary, the RAVEN, the examination scores of June 1989 and the Grade 7 results are presented in Table 27.

[insert Table 27 here]

It can be seen that task C correlated positively, even on day 10. This means that high scores on the intelligence measures corresponded with slow responding on task C. No explanation is available. The confusing results of Table 27 could be due to the different training conditions, which had an enormous influence on RTs and probably also on SD's. It can be concluded that correlations between RTs and cognitive measures were not strong.

The third hypothesis stated that MT should show a positive correlation with the amount of uncertainty in the different tasks. This hypothesis is accepted since there is a significant task effect; MT increased with cognitive complexity of the tasks. Day-effect was significant; MT decreased with practice.

Inter-trial correlations were expected to be initially high for cognitively simple tasks and to decrease with practice (e.f., Ackerman 1986). In our sample, the inter-trial correlation for task A and B were higher after practice than before (see Table 8). Therefore the hypothesis must be rejected. The inter-trial correlations of cognitive complex tasks became higher after practice which confirmed the hypothesis. The difference between the task-specific variance found in cognitive simple tasks and the cognitive complex tasks is not clear in our results.

What kind of transfer took place is postulated in the second hypothesis; near, similar and method transfer will take place. Inter-task correlation did increase after practice. The influence of training on one of the tasks on RT improvements of isomorphic tasks (tasks with the same underlying structure) is called near transfer. Training on E will make these subjects faster on task E and D. As can be seen in Table 6, the group-effects of near transfer were significant. Near transfer between task B and A for training group B was not significant, but was higher than for training group C and E which were further away in cognitive complexity than training group B. Similar transfer was significant for all training groups; improvements on the task they got trained on. On all tasks this transfer was found. Method transfer refers to the fact that subjects got more test wiseness. This is found, since intertrial correlations increased with practice. In a country as Zambia, where computers were unknown to the subjects, this effect is not surprising.
We know far transfer as the improvement on structurally different tasks than the one trained on. Substantial improvements took place but not significantly. The further a task was away in cognitive complexity from the task trained on, the lower the correlation (see Table 6 part one). Hence it can be said that far transfer did not occur.

Improvements on RT were compared in several ways: RT correlations, declines in SD's, rank order correlations and gains. The conclusion to be drawn from these different measures were given in the preceding chapter. Some differences and similarities will be given here.
RTs increased gradually with task complexity and training amplified this effect (confirming the hypotheses).

Gain measures as the Hick coefficient, regression coefficient, regression of complexity and the percentage of gain, all differed somewhat in their effects. Hick regression coefficient became more stable after practice. For the regression coefficient inter-task correlations were positive for tasks that were similar in cognitive complexity and became negative if cognitive complexity was more distant. For the percentage of gain the same effect was found, only somewhat stronger. The gain measures resembled the RT improvements, but not very strong.
Inter-individual rank order correlations displayed a difference in cognitive simple and complex tasks. Rank orders did not change significantly (even after training on task B) and this can be attributed to task-specific variance. For cognitively complex tasks, rank orders did change substantially; the learning potential between subjects could be explored. This conclusion is important for further research; apparently, training on cognitively complex tasks had a significantly different result for rank orders than training on cognitively simple tasks.

Finally, the differences and similarities between the RTs and gain measures and their correlations with intelligence measures will be discussed. For RTs was found that correlations with the cognitive factor increased with cognitive complexity of the tasks (see Table 19). Especially training on cognitively complex tasks increased this correlation. The gain measures displayed inconsistent and not very strong correlations with cognitive variables. The RT results were not a reflection of the intelligence scores pupils got on different measurements (RAVEN, WISC vocabulary). For future research I would suggest to give the instruction on the computer to make the tasks totally independent of language or the experimenters influence. This could be done by means of a learning session to see if the task is well understood and some simple examples. Another suggestion I would like to make is to adjust the tasks, maybe make them more difficult, in that way learning potentials for problem-solving strategies, will be distinguished and correlations with other intelligence scores will probably increase. A long training, minimal 10 days is necessary to make the results stable (and reliable).

REFERENCES

Ackerman, P.L. (1986). Individual differences in information processing: An investigation of intellectual abilities and task performance during practice. Intelligence, 10, 101-139.

Boring, E.G. (1950). A history of experimental psychology (2nd ed.). New York: Appleton-Century-Crofts.

Carlson, J.S., & Jensen, C.M. (1982). Reaction time, movement time, and intelligence: A replication and extension. Intelligence, 6, 265-274.

Cronbach, L.J., & Snow, R.E. (1977). Aptitudes and instructional methods. New York: Irvington.

Directoraat-Generaal voor de Arbeidsvoorziening (unannotated). ARBVO Beroepenindeling. The Hague: Ministry of Labour, Public Health and Culture.

Eysenck, H.J. (1986). Intelligence and reaction time: The contribution of Arthur Jensen. In S. Modgil & C. Modgil (Eds.), Arthur Jensen: Consensus and controversy (pp.285-296). Barcombe, England: Falmer Press.

Fleishman, E.A., & Rich, S. (1963). Role of kinesthetic and spatial-visual abilities in perceptual-motor learning. Journal of Experimental Psychology, 66, 6-11.

Guttman, L. (1955). A generalized simplex for factor analysis. Psychometrika, 20, 173-192.

Hawkins, D.M. (1980). Identification of outliers. London; Chapman and Hall.

Hunt, E. (1987). The next word on verbal ability. In P.A. Vernon (Ed.), Speed of information-processing and intelligence (pp. 347-392). New York: Norwood.

Jensen, A.R., & Vernon, P.A. (1986). Jensen's reaction time studies: A reply to Longstreth. Intelligence, 10, 153-179.

Jensen, A.R. (1987). Process differences and individual differences in some cognitive tasks. Intelligence, 11, 107-136.

Jensen, A.R. (1988). Speed of information processing and population differences. In S. H. Irvine & J.W. Berry (Eds.), Human abilities in cultural context (pp. 105-145). Cambridge University Press.

Jensen, A.R., Cohn, S.J., & Cohn, C.M.G. (1989). Speed of information processing in academically gifted youths and their siblings. Person ability and Individual Differences. 10, 29-33.

Jones, M.B. (1962). Practice as a process of simplification. Psychological Review, 69, 274-294.

Jones, M.B. (1970). A two process theory of individual differences in motor learning. Psychological Review, 77, 353-360.

Kendall, I.M., Verster, M.A., & Von Mollendorf, J.W. (1988). Test performance of blacks in Southern Africa. In S.H. Irvine & J.W. Berry (Eds.), Human abilities in cultural context (pp. 299-339). Cambridge University Press.

Pellegrino, J.W. (1985). Individual differences in skill acquisition: Information processing efficiency and development of automaticity. Unpublished manuscript, U.S. Air Force Human Resources Laboratory, San Antonio, TX.

Poortinga, Y.H. (1971). Cross-cultural comparison of maximum performance tests: Some aspects and some experiments with simple auditory and visual stimuli. Psychologia Africana (Monograph Supplement No. 6).

Raven, J.C. (1965). Advanced Raven's Progressive Matrices: Manual. London: Lewis.

Reynolds, B. (1952a). Correlations between two psychomotor tasks as a function of distribution of practice on the first. Journal of Experimental Psychology, 43, 341-348.

Reynolds, B. (1952b). The effect of learning on the predictability of psychomotor performance. Journal of Experimental Psychology, 44, 189-198.

Van de Langenberg, G. (1989). Prestatieverbeteringen op reactietijdtaken van uiteenlopende cognitieve complexiteit. Een cross-cultureel onderzoek. Doctoraalscriptie, Tilburg University, Tilburg, The Netherlands.

Van de Vijver, F.J.R., Daal, M., & Van Zonneveld, R. (1986). The trainability of formal thinking. International Journal of Psychology, 21, 589-615.

Welford, A.T. (1980). Choice reaction time: basic concepts. In A.T. Welford (Ed.), Reaction times (pp. 73-128). New York: Academic Press.

Widaman, K.F., & Carlson, J.S. (1989). Procedural effects on performance on the Hick Paradigm: Bias in reaction time and movement time parameters. Intelligence, 13, 63-85.

Willemse, G. (1989). Keuze-reactietijdtaken in multi-culturele context. Doctoraalscriptie. Tilburg University, the Netherlands.

FIGURES

Figure 1: The monitor and the response board with the configuration of the buttons.

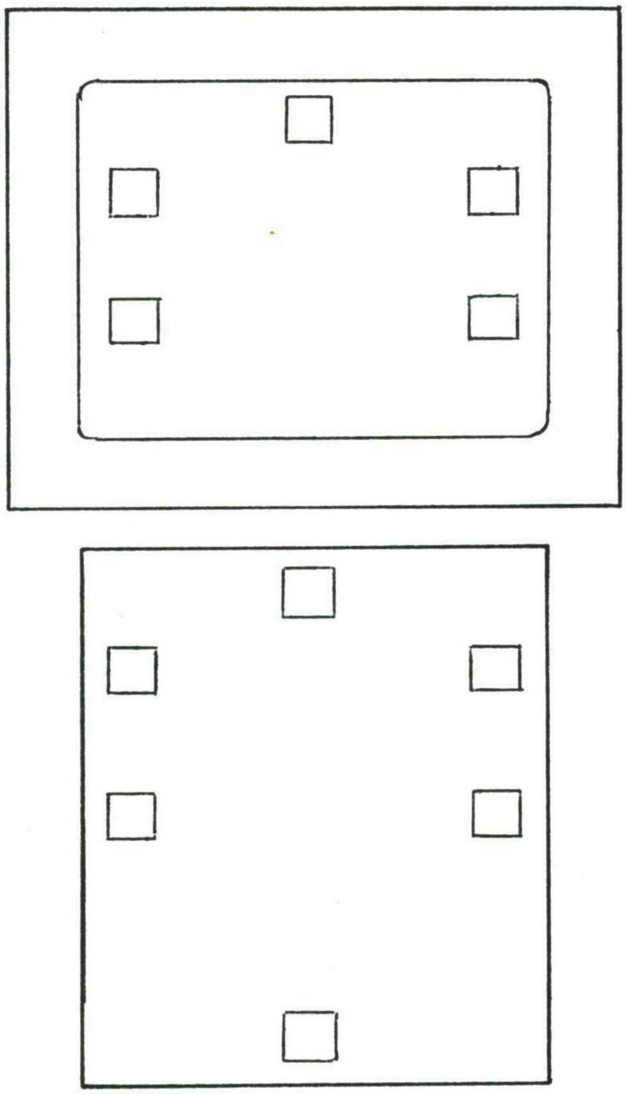
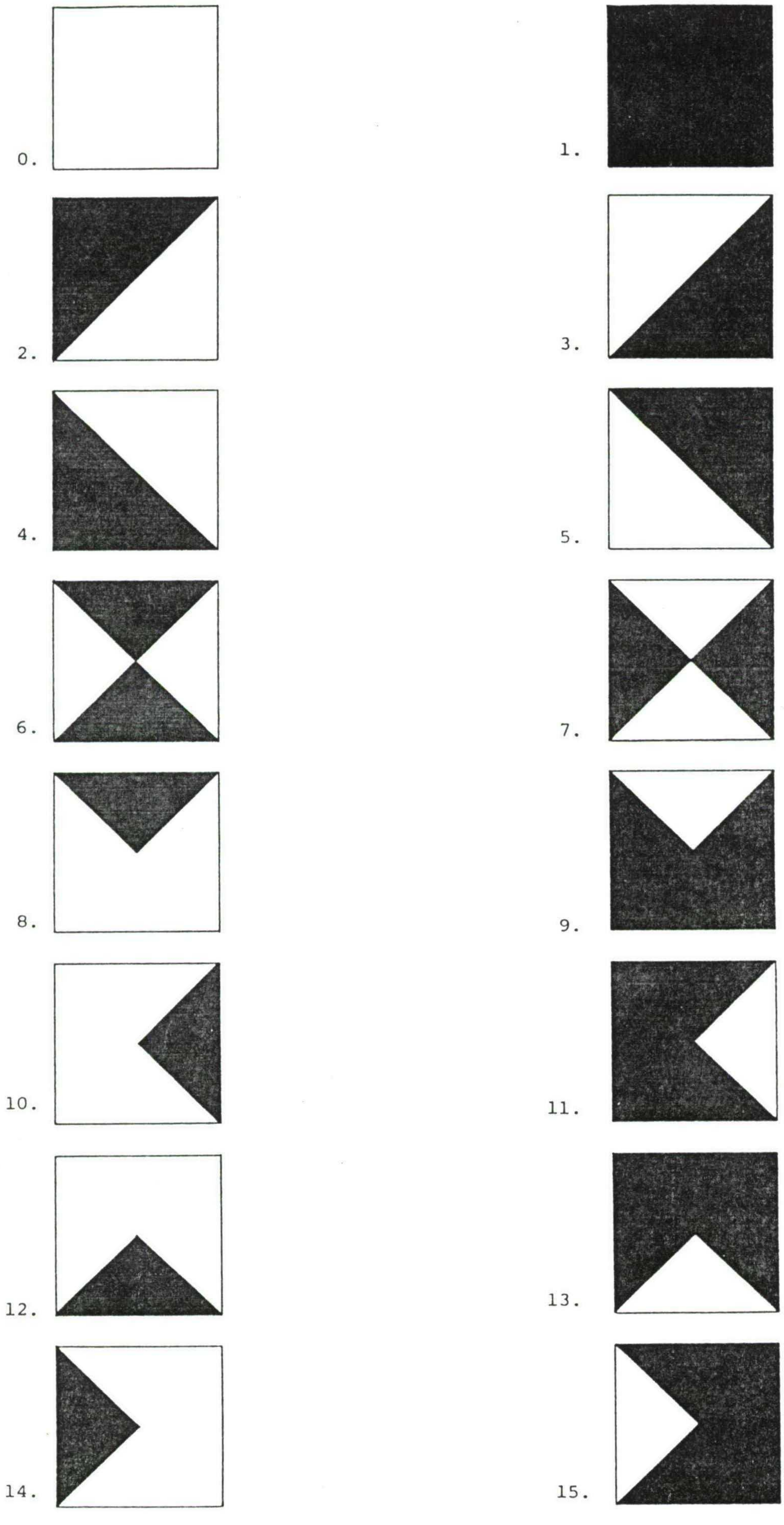
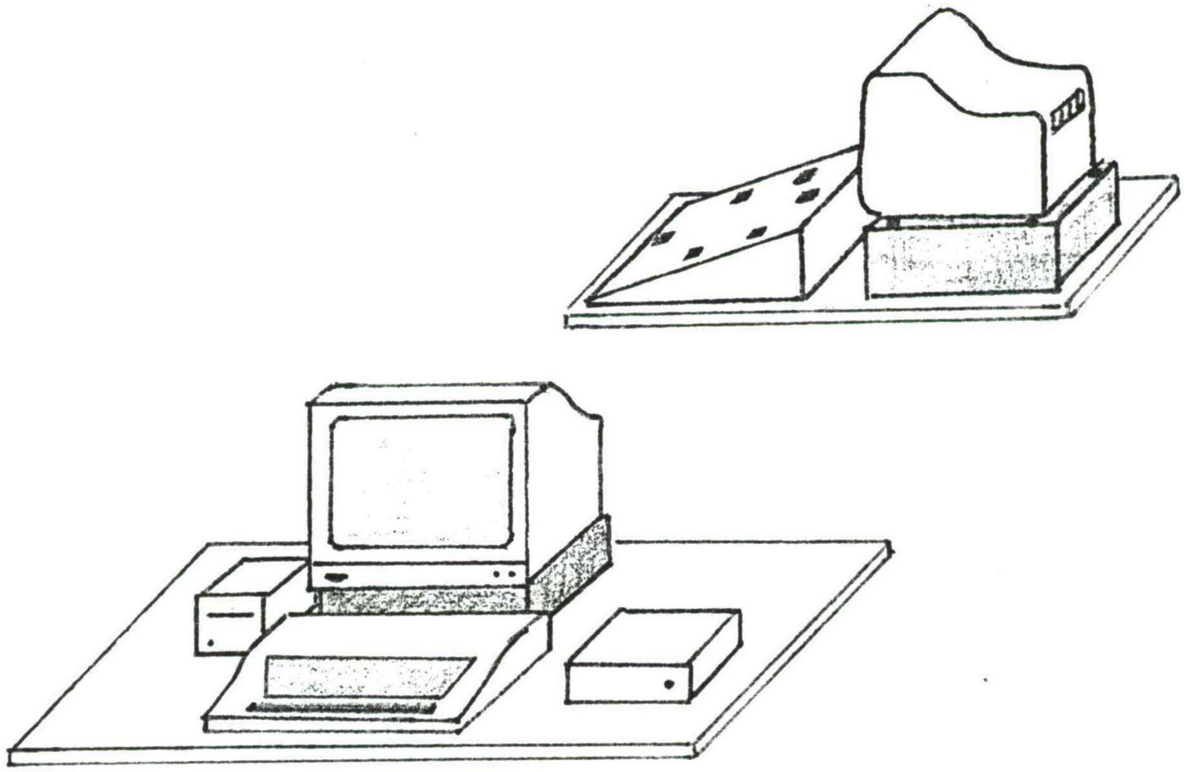


Figure 2: The 16 figures, used in the experiment.



<u>Figure 3:</u> The experimental set-up; at the table in the front is the disc-drive, the testers monitor, the BBC computer and the Co-processor. On the table in the back is the subject's monitor and the response board with 5 buttons plus the home button.



<u>Figure 4</u>: An overview of the elapse of time per trial.

ITI	=	Intertrial- Interval
WS	=	Warning Stimulus
FP	=	Foreperiod
S	=	Stimulus presentation
R1	=	Release of the home button
R2	=	pushing of the response button
RT	=	Reaction Time
MT	=	Movement Time

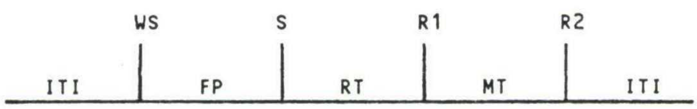


Figure 5: The response board used for the complex tapping task.

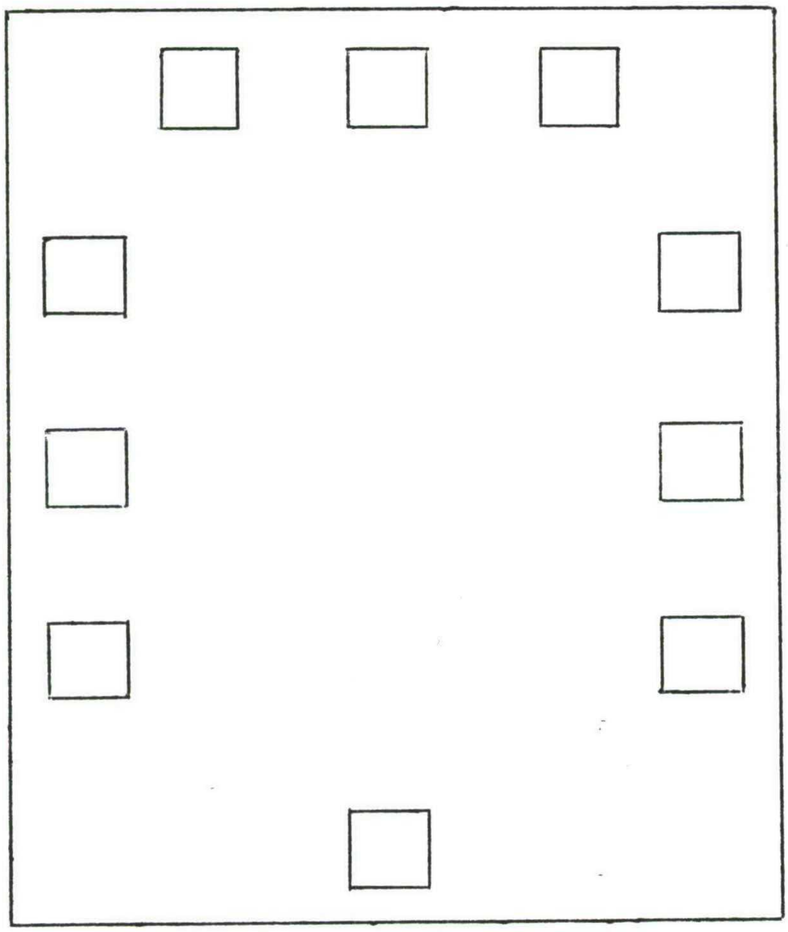


Figure 6: The questionnaire used to measure context variables.

PERSONAL INVENTORY OF THE CRT EXPERIMENT VAN DE VIJVER - VERHOEVEN
April 1989

1. Name?

3. When were you born?

4. Where do you live?

5. Did your father go to primary school?

6. Did your father finish primary school?

7. Did your father go to secondary school?

8. Did your father finish secondary school?

9. Did your mother go to primary school?

10. Did your mother finish primary school?

11. Did your mother go to secondary school?

12. Did your mother finish secondary school?

13. What is your father's profession?

14. What is your mother's profession?

15. How many books does your family have in the home?
    - less than 10
    - between 10 and 25
    - between 25 and 50
    - between 50 and 100
    - more than 100

16. What are your plans after secondary school (profession)?

17. What is the largest distance you ever traveled in your life?

18. Name three subjects in school which you prefer the most.

19. Name three subjects in school which you prefer the least.

20. What are your hobbies?

21. Did you ever participate in a psychological test?
    If so, how many times?

22. Did you ever participate in an individual examination?
    If so, how many times?

23. Did you ever work with computers?
    If so, how many times?

24. From doing the tasks with the computer I learn a number of things.
    - this is true
    - I don't know
    - this is not true

25. It is uninteresting to carry out the tasks with the computer.
    - true
    - I don't know
    - not true

26. When a friend would ask me whether he or she should join the experiment, I would tell him not to join.
    - true
    - undecided
    - not true

27. Difficulty of the five tasks.
    Make a choice out of:
    - very difficult
    - difficult
    - moderate
    - easy
    - very easy

    Task A was:..........................
    Task B was:..........................
    Task C was:..........................
    Task D was:..........................
    Task E was:..........................

28. Interest of the five tasks.
    Make a choice out of:
    - very uninteresting
    - uninteresting
    - undecided
    - interesting
    - very interesting

    Task A was:..........................
    Task B was:..........................
    Task C was:..........................
    Task D was:..........................
    Task E was:..........................

<u>Figure 7</u>: The learning effect in percentages of day 1, over day 1, 5 and 10 for task A, B, C, D and E.

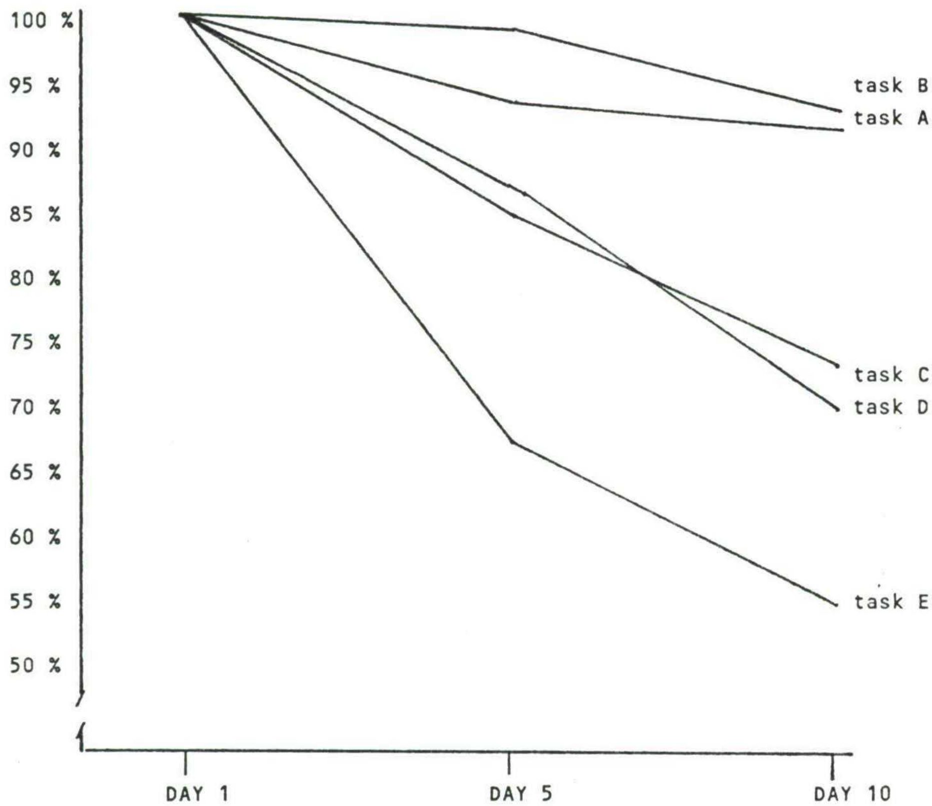


Figure 8A: Mean RTs with 95% confidence interval for task A on day 1, 5 and 10, for N=32, two blocks are given per day.

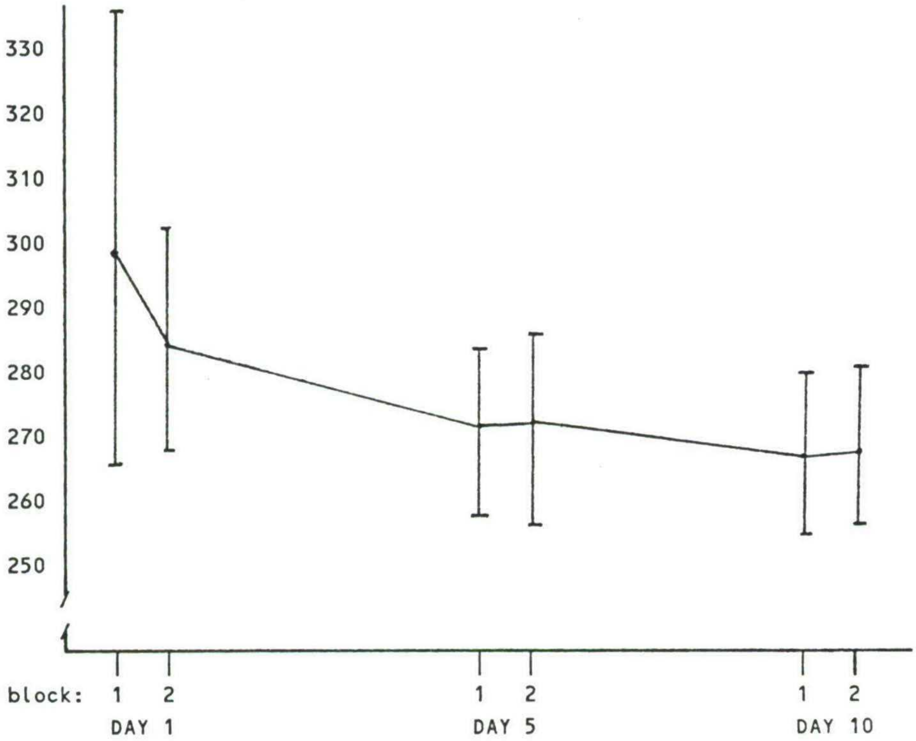


Figure 8B: Mean RTs with 95% confidence interval for task B on day 1, 5 and 10, for N=32, two blocks are given per day.

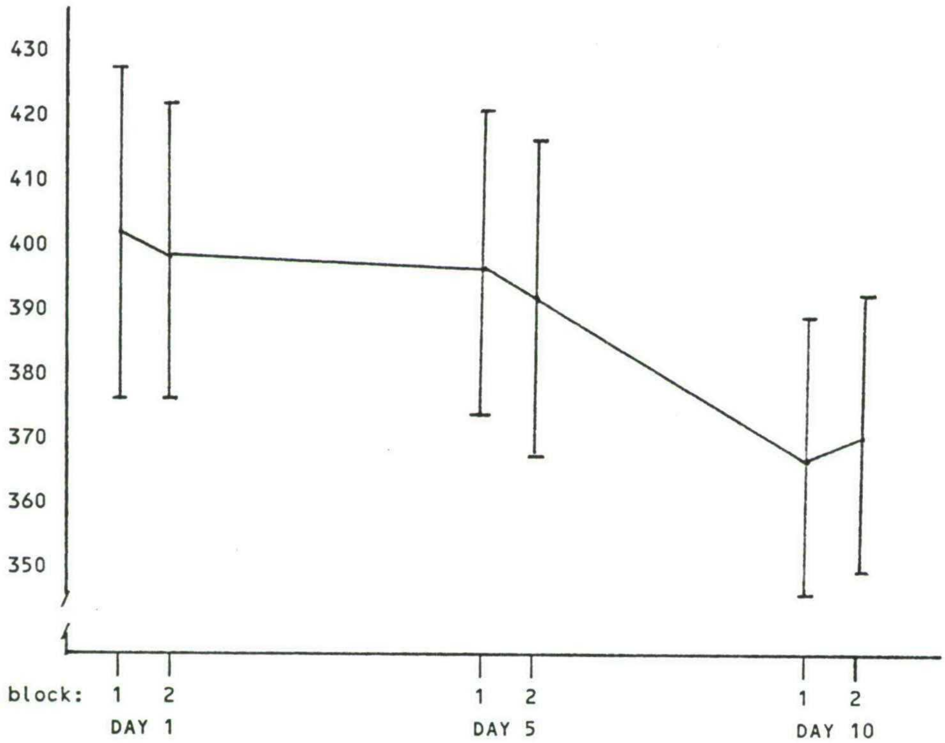


Figure 8C: Mean RTs with 95% confidence interval for task C on day 1, 5 and 10, for N=32, two blocks are given per day.

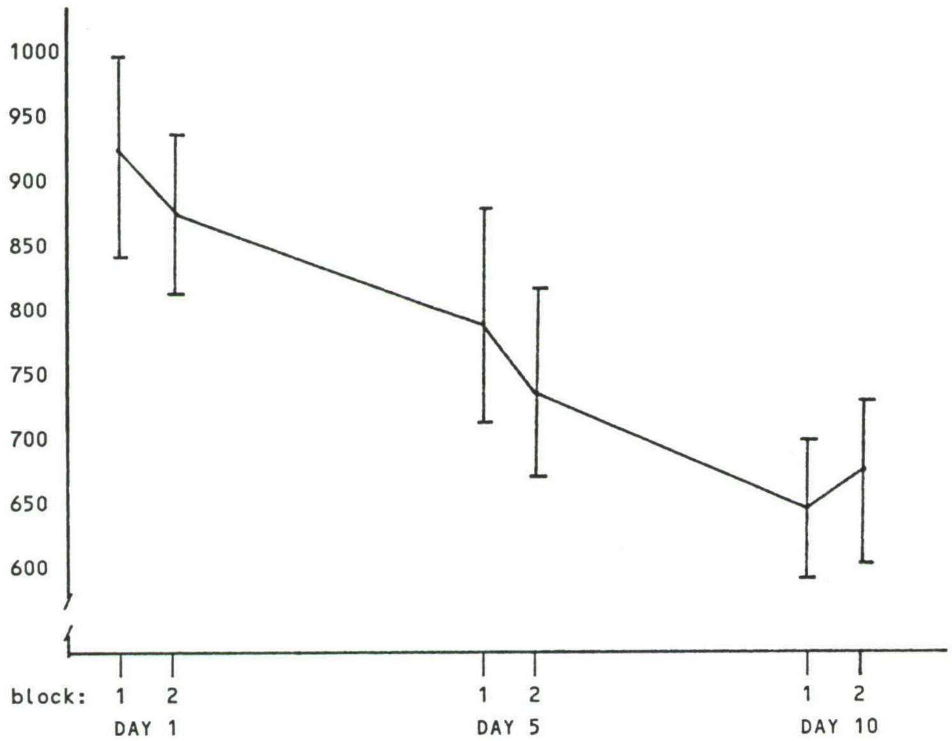


Figure 8D: Mean RTs with 95% confidence interval for task D on day 1, 5 and 10, for N=32, two blocks are given per day.

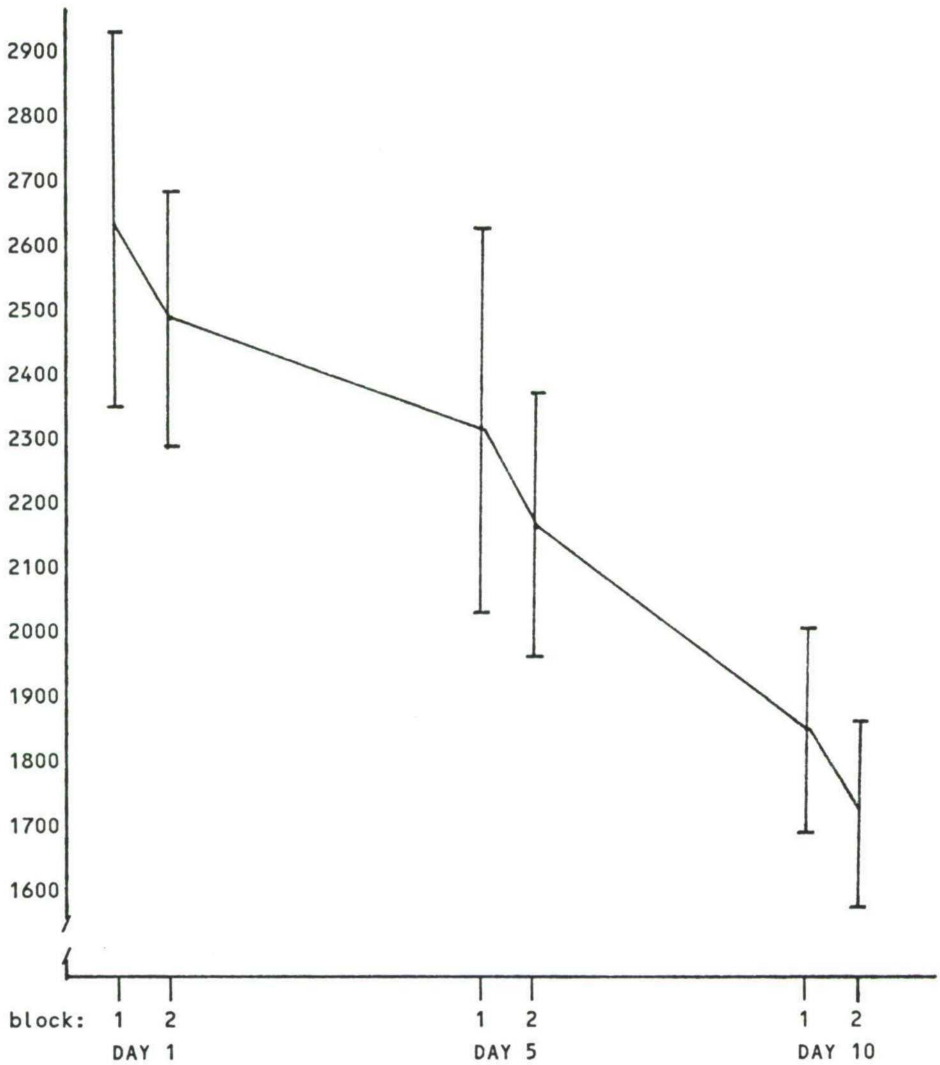


Figure 8E: Mean RTs with 95% confidence interval for task E on day 1, 5 and 10, for N=32, two blocks are given per day.

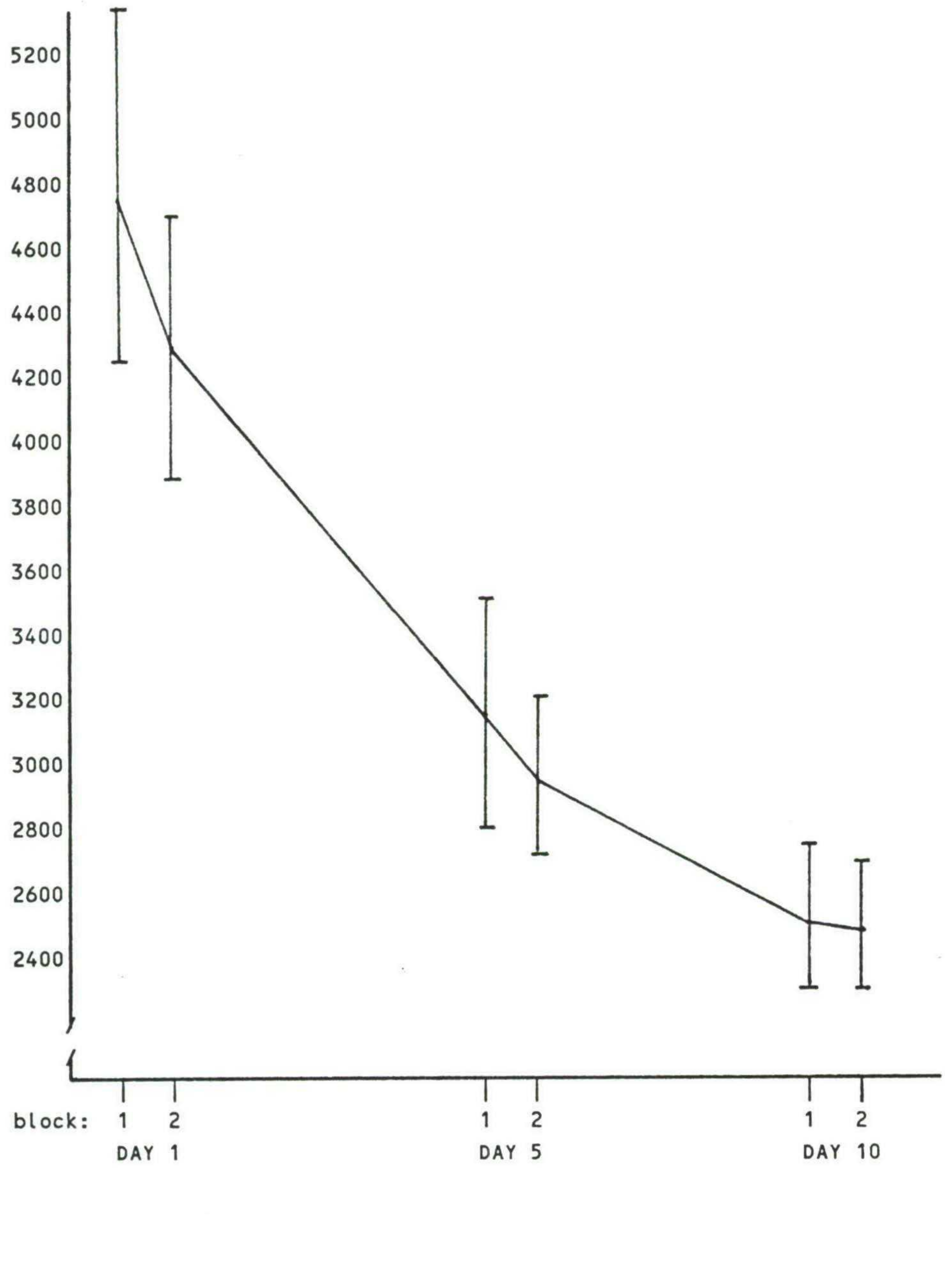


Figure 9: Change in SD's over days 1, 5 and 10, day 1 is 100%, N=32.

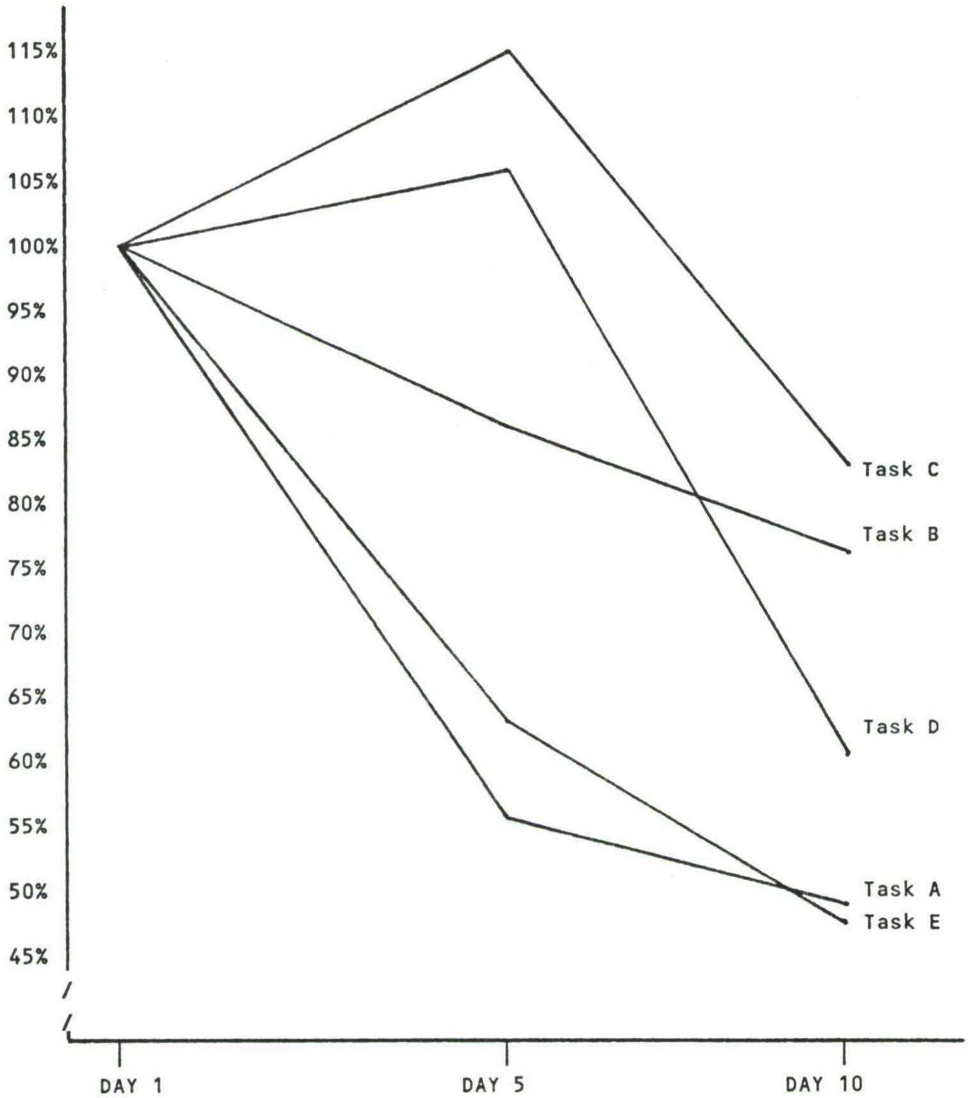


Figure 10: Training groups compared on task B, C and E. RTs in ms. on day 1, 5 and 10.

Figure 10A: TASK B

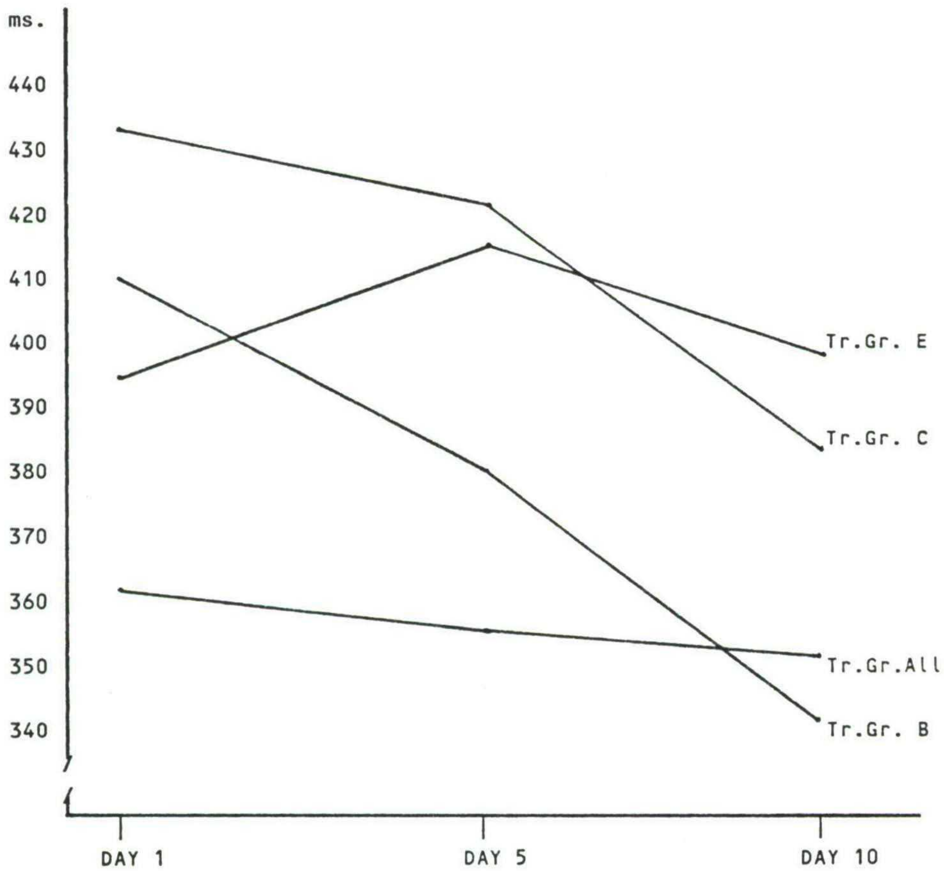


Figure 10B: TASK C

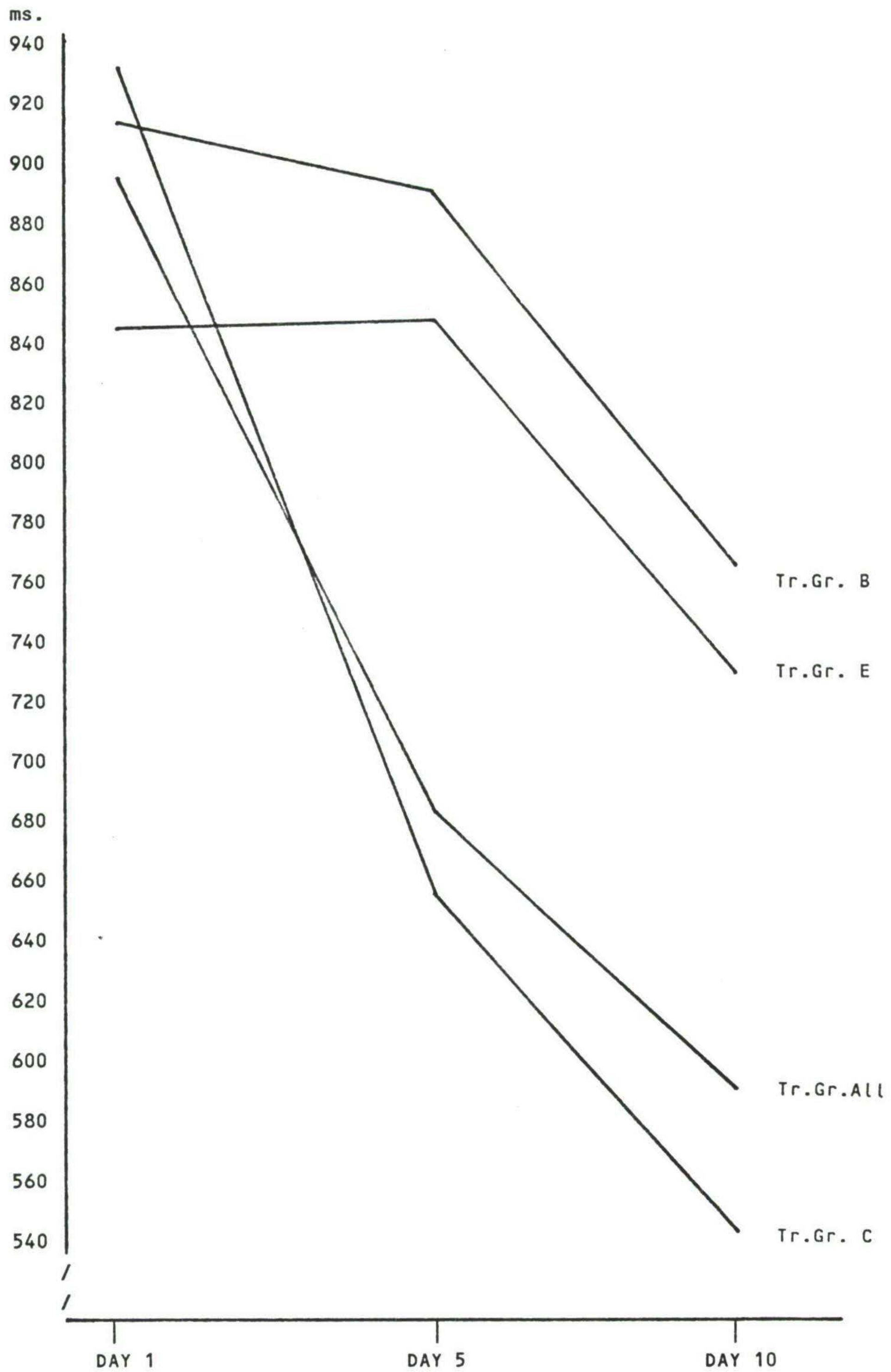
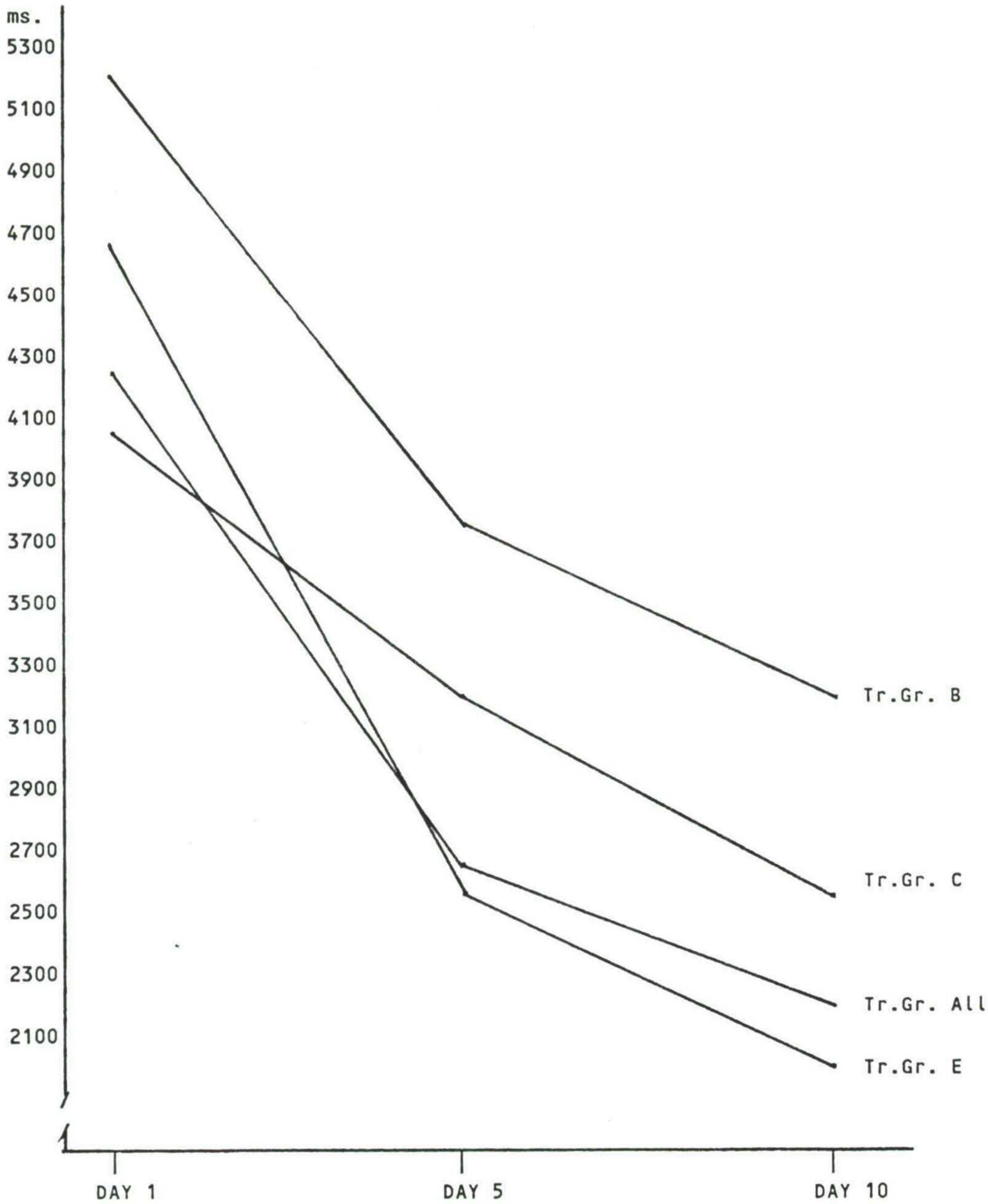


Figure 10C: TASK E



<u>Figure 11A:</u> The improvements of MT in percentages, on task B divided per training group

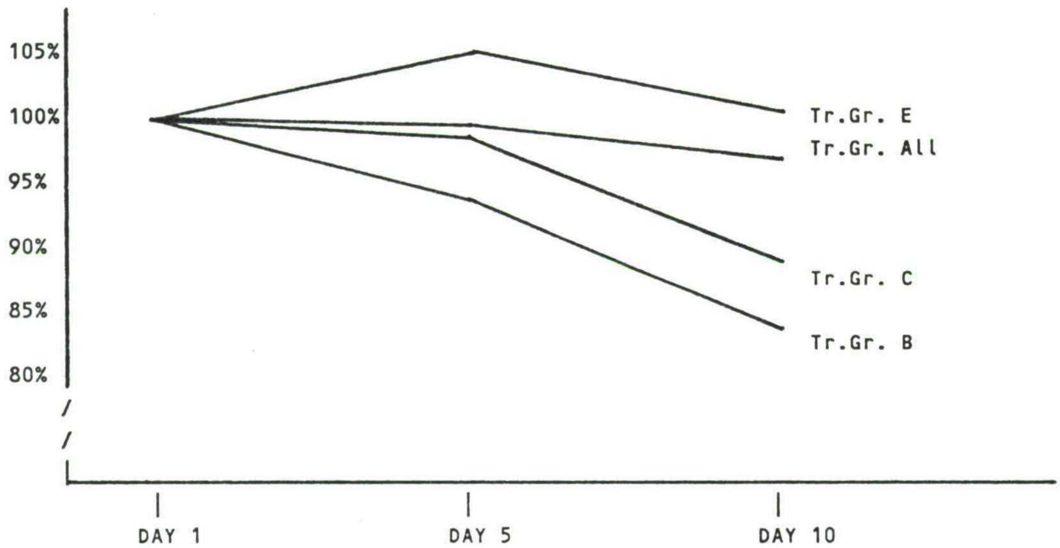
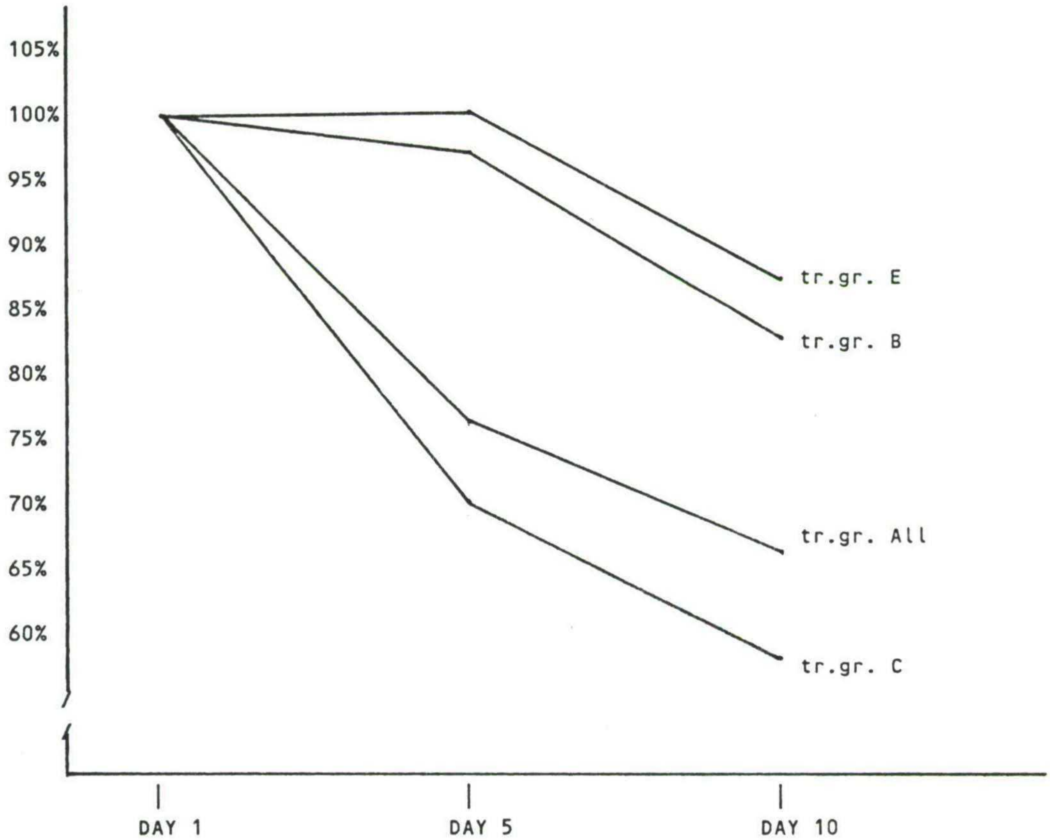


Figure 11B: The improvements of MT in percentages, on task C, divided per training group



<u>Figure 11C:</u> The improvements of MT in percentages, on task E, divided per training group

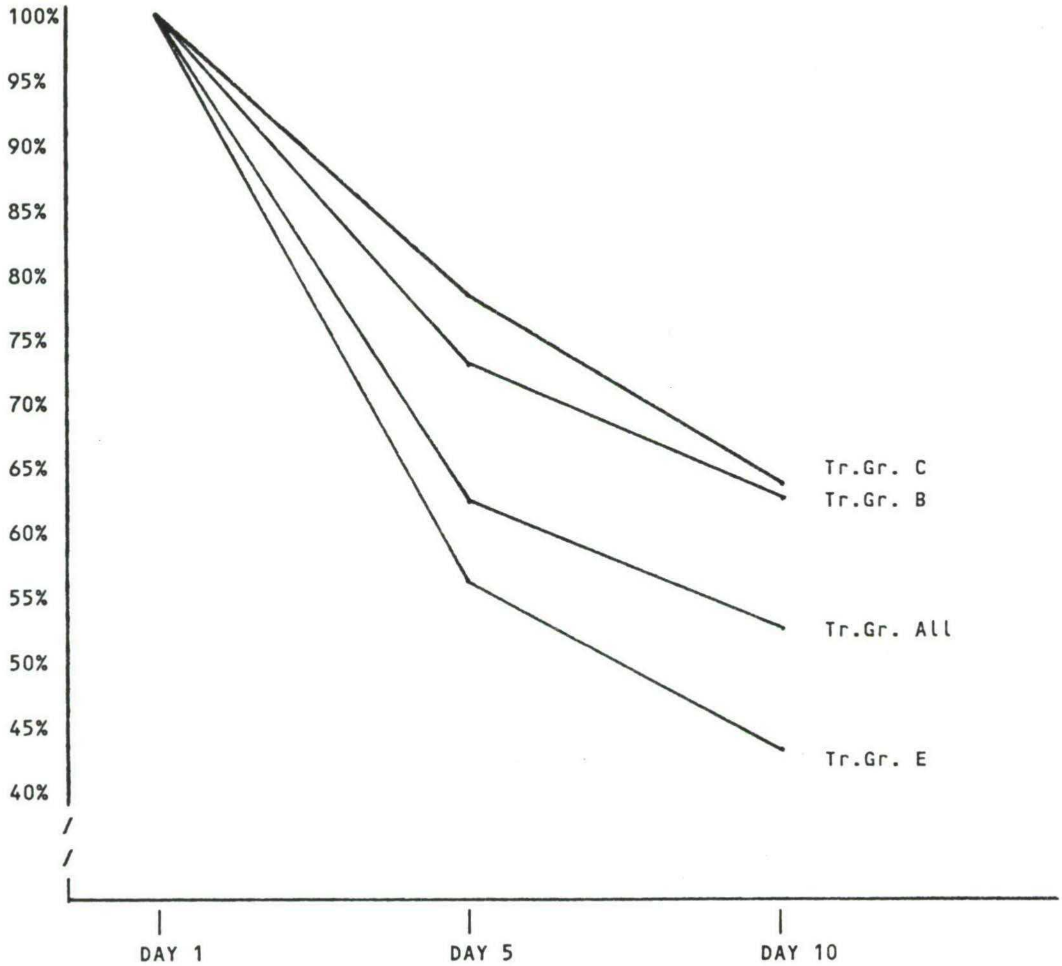
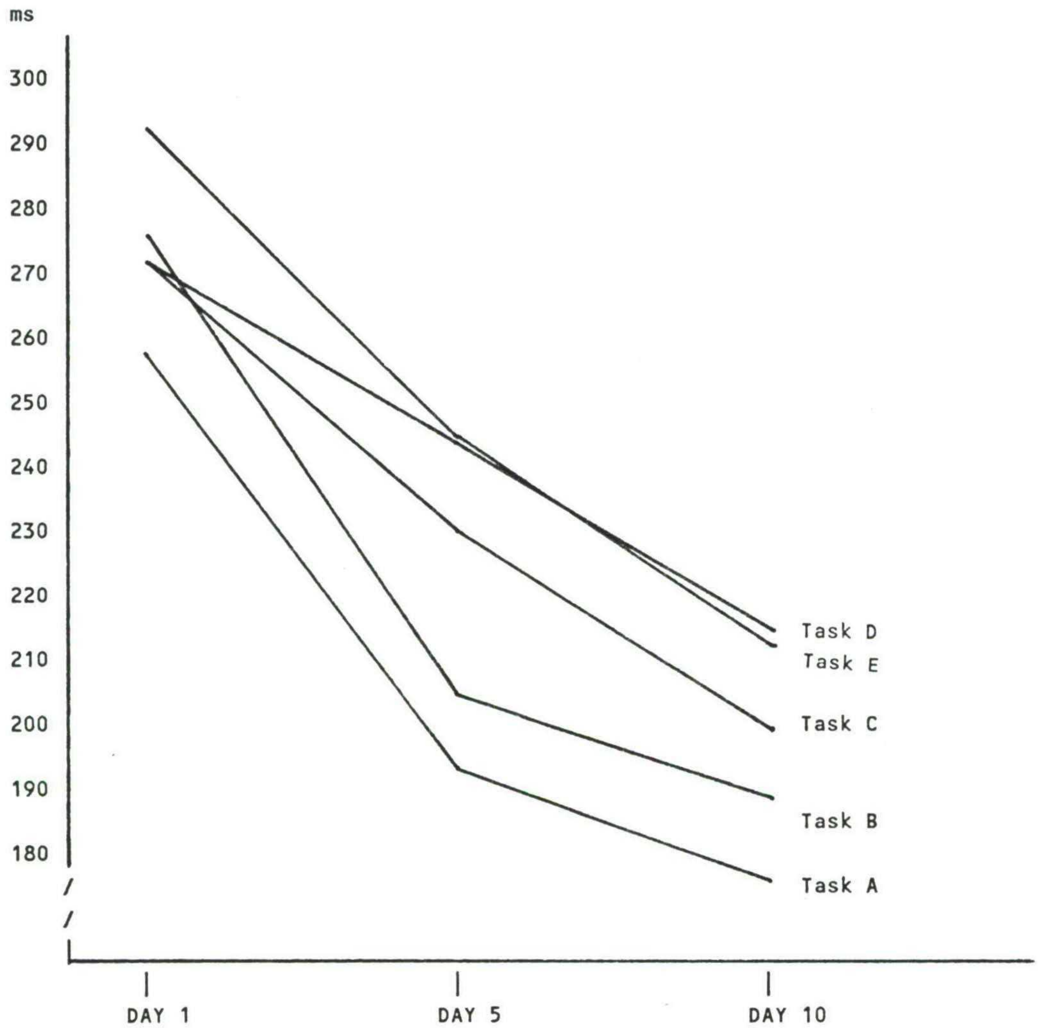


Figure 12: Comparison on day 1, 5 and 10 for MT per task. (N=32)



TABLES

Table 1 Factor loadings, Eigenvalues and % explained variances, for the factor Socio-economic Status, Academic interest the difficulty and interest of the tasks and for the cognitive factor.

SOCIO-ECONOMIC STATUS		**ACADEMIC INTEREST**	
Eigenvalue:	2.24	Eigenvalue:	2.01
% Explained variance	37 %	% Explained variance	50.3 %
Context variables:	Loadings:	Context variables:	Loadings:
Education father	.79	Subjects liked most	.85
Education mother	.87	Subjects liked least	-.87
Profession father	.64	Hobbies	.02
Profession mother	.48	Own future profession	.73
Number of books	.40		
Distance been away	.23		

DIFFICULTY AND INTEREST OF THE TASKS		**COGNITIVE FACTOR**	
Eigenvalue:	3.14	Eigenvalue:	1.90
% Explained variance	31 %	% Explained variance	38 %
Variables:	Loadings:	Variables:	Loadings:
Difficulty of task A	-.01	Mean Examination results	.92
Difficulty of task B	.67	WISC vocabulary	.63
Difficulty of task C	.33	Grade 7 scores	.37
Difficulty of task D	.75	RAVEN score	.63
Difficulty of task E	.72	RAVEN time	.33
Interest of task A	.11		
Interest of task B	.46		
Interest of task C	.42		
Interest of task D	.77		
Interest of task E	.72		

Table 2: Mean RT (in ms) and Standard Deviation for all subjects (N=32) independent of training group on the first, the fifth and the tenth day.

		DAY		
TASK		DAY 1	DAY 5	DAY 10
TASK A	MEAN	292	271	268
	SD	72	40	35
TASK B	MEAN	400	395	370
	SD	78	67	59
TASK C	MEAN	897	768	657
	SD	187	215	156
TASK D	MEAN	2560	2243	1783
	SD	660	695	400
TASK E	MEAN	4530	3051	2512
	SD	1305	828	623

Table 3: RTs on the pre-, mid-training- and post-test (N=32, the numbers between parentheses represent the percentage of performance as compared to the first day).

	DAY		
TASK	DAY 1	DAY 5	DAY 10
TASK A	292	271 (92.8%)	268 (91.6%)
TASK B	400	395 (98.5%)	370 (92.4%)
TASK C	897	768 (85.5%)	657 (73.3%)
TASK D	2560	2243 (87.6%)	1783 (69.6%)
TASK E	4530	3051 (67.4%)	2512 (55.5%)

Table 4: Changes in the Standard Deviation of RT, on day 1, 5 and 10 in percentages of day 1 (N=32, day 1 = 100%).

		DAY	
	DAY 1	DAY 5	DAY 10
TASK			
TASK A	72	40 (55.5%)	35 (48.6%)
TASK B	78	67 (85.9%)	59 (75.6%)
TASK C	187	215 (114.9%)	156 (83.4%)
TASK D	660	695 (105.3%)	400 (60.6%)
TASK E	1305	828 (63.5%)	623 (47.7%)

Table 5: Mean RTs divided per training group and the progress made on day 1, 5 and 10. RT in percentages of the first day.

	TRAINING GROUP			
TASK	TRAINING ON B	TRAINING ON C	TRAINING ON E	TRAINING ON B + C + E
TASK B				
DAY 1	410	435	396	361
DAY 5	381 (93%)	424 (98%)	417 (105%)	357 (99%)
DAY 10	341 (83%)	385 (89%)	400 (101%)	353 (97%)
TASK C				
DAY 1	916	932	843	896
DAY 5	889 (97%)	657 (71%)	849 (101%)	684 (76%)
DAY 10	763 (83%)	542 (58%)	734 (87%)	591 (66%)
TASK E				
DAY 1	5121	4057	4683	4250
DAY 5	3740 (73%)	3200 (79%)	2597 (56%)	2669 (63%)
DAY 10	3213 (63%)	2576 (63%)	2006 (43%)	2257 (53%)

Table 6: Results of the Manova (N=16 per cell).
Two groups: 1. trained on the task including trained on B, C and E.
2. not trained on the task.
Effects of group, day and day x group interaction effects.

GROUP-EFFECTS	TRAINING ON B	TRAINING ON C	TRAINING ON E
ALL TASKS	.09	.25	.07
TASK A	.30	.85	.40
TASK B	.05 *	.33	.81
TASK C	.48	.01 *	.79
TASK D	.25	.19	.01 *
TASK E	.20	.15	.03 *

DAY-EFFECTS	TRAINING ON B	TRAINING ON C	TRAINING ON E
ALL TASKS	.00 *	.00 *	.00 *
TASK A	.07	.06	.07
TASK B	.02 *	.02 *	.01 *
TASK C	.00 *	.00 *	.00 *
TASK D	.00 *	.00 *	.00 *
TASK E	.00 *	.00 *	.00 *

DAY X GROUP INTERACTION	TRAINING ON B	TRAINING ON C	TRAINING ON E
ALL TASKS	.68	.28	.20
TASK A	.61	.34	.63
TASK B	.48	.74	.02 *
TASK C	.84	.00 *	.50
TASK D	.29	.40	.14
TASK E	.70	.16	.05 *

Note: * p <.05 one tailed

Table 7: Inter-task correlations (N=31, pooled) at the first, fifth and the tenth day.

DAY 1	TASK A	TASK B	TASK C	TASK D	TASK E
TASK A	1.00				
TASK B	0.59 *	1.00			
TASK C	0.21	0.12	1.00		
TASK D	0.18	0.12	0.07	1.00	
TASK E	0.12	0.24	-0.20	0.22	1.00

DAY 5	TASK A	TASK B	TASK C	TASK D	TASK E
TASK A	1.00				
TASK B	0.51 *	1.00			
TASK C	0.22	0.59 *	1.00		
TASK D	0.28	0.49 *	0.81 *	1.00	
TASK E	0.14	0.17	0.50 *	0.74 *	1.00

DAY 10	TASK A	TASK B	TASK C	TASK D	TASK E
TASK A	1.00				
TASK B	0.64 *	1.00			
TASK C	0.48 *	0.75 *	1.00		
TASK D	0.45 *	0.55 *	0.54 *	1.00	
TASK E	0.35 *	0.47 *	0.32 *	0.65 *	1.00

Note: * $p < .05$ one tailed

Table 8: Correlations of mean RTs of day 10 with the mean RTs of the same task on day 1 and 5 (N=31).

	DAY	
TASK	DAY 1	DAY 5
TASK A	0.33 *	0.76 *
TASK B	0.39 *	0.74 *
TASK C	0.13	0.55 *
TASK D	0.23	0.73 *
TASK E	0.66 *	0.69 *

Note: * p <.05 one tailed

Table 9: Correlations between day 1, 5 and 10, per training group, on task A, B, C, D and E.

TRAINING GROUP B

	TASK A	TASK B	TASK C	TASK D	TASK E	MEAN
DAY 1-5	.67	.79	.61	.00	.88	.59
DAY 1-10	.80	.46	.89	.02	.85	.60
DAY 5-10	.85	.66	.75	.84	.80	.78

TRAINING GROUP C (excl. pp 12)

	TASK A	TASK B	TASK C	TASK D	TASK E	MEAN
DAY 1-5	.66	.70	-.47	-.13	.88	.57
DAY 1-10	.25	-.08	-.80	.07	.71	.38
DAY 5-10	.79	.51	.36	.95	.89	.70

TRAINING GROUP E

	TASK A	TASK B	TASK C	TASK D	TASK E	MEAN
DAY 1-5	.60	.32	.06	.23	.37	.32
DAY 1-10	.30	.47	.29	.19	.51	.35
DAY 5-10	.74	.90	.46	.56	.45	.62

TRAINING GROUP ALL

	TASK A	TASK B	TASK C	TASK D	TASK E	MEAN
DAY 1-5	-.15	.50	.75	.75	.54	.54
DAY 1-10	-.05	.61	.36	.57	.81	.48
DAY 5-10	.60	.87	.50	.62	.51	.62

Table 10: Correlations between day 5 and 10 for the trained and untrained tasks, per training group (N=8).

	CORRELATION BETWEEN DAY 5 AND 10	
TRAINING GROUP B	on task B	.66
	on tasks A, C, D and E	.81
TRAINING GROUP C	on task C	.36
	on tasks A, B, D and E	.79
TRAINING GROUP E	on task E	.45
	on tasks A, B, C and D	.67

Table 11: The average inter-task correlation of day 1, 5 and 10 (N=16).

TRAINED ON TASK B

	A	B	C	D	E
A	-				
B	.33	-			
C	.34	.63	-		
D	.26	.36	.52	-	
E	.09	.50	.58	.72	-

Mean: .43

TRAINED ON TASK C

	A	B	C	D	E
A	-				
B	.60	-			
C	.34	.45	-		
D	.32	.25	.26	-	
E	.28	.25	.10	.68	-

Mean: .35

TRAINED ON TASK E

	A	B	C	D	E
A	-				
B	.65	-			
C	.23	.36	-		
D	.25	.35	.43	-	
E	-.07	.10	.08	.48	-

Mean: .27

NOT TRAINED ON TASK B

	A	B	C	D	E
A	-				
B	.83	-			
C	.13	.23	-		
D	.17	.22	.20	-	
E	.11	.02	-.31	.48	-

Mean: .21

NOT TRAINED ON TASK C

	A	B	C	D	E
A	-				
B	.75	-			
C	.12	.33	-		
D	.02	.14	.41	-	
E	-.11	.07	.28	.62	-

Mean: .26

NOT TRAINED ON TASK E

	A	B	C	D	E
A	-				
B	.72	-			
C	.12	.24	-		
D	.01	.06	.51	-	
E	.12	.17	.54	.65	-

Mean: .31

Table 12: Correlations between Hick's regression coefficient on the first, fifth and tenth day for the four different training groups and the total sample.

	TRAINING GROUP				
	B	C	E	ALL	TOTAL SAMPLE
HICK GAIN DAY 1 - DAY 5	.69	.73	.37	-.04	.23
HICK GAIN DAY 1 - DAY 10	.14	.37	-.60	.03	.04
HICK GAIN DAY 5 - DAY 10	.52	.79	-.20	.50	.65

Table 13: Inter-task correlations of the regression coefficient of day on mean RT (pooled; N=31).

	REGRESSION COEFFICIENT				
REGRESSION COEFFICIENT	TASK A	TASK B	TASK C	TASK D	TASK E
TASK A	1.00				
TASK B	.14	1.00			
TASK C	-.04	-.14	1.00		
TASK D	.31	-.02	.06	1.00	
TASK E	-.16	-.18	-.28	.06	1.00

Table 14: Inter-task correlations for the percentage gain per task for N=31 (pooled).

PERCENTAGE GAIN ON	PERCENTAGE GAIN ON TASK A	TASK B	TASK C	TASK D	TASK E
TASK A	1.00				
TASK B	.33	1.00			
TASK C	.24	.27	1.00		
TASK D	.27	.13	.53	1.00	
TASK E	-.19	-.03	-.24	.13	1.00

Table 15: The average of task A, B, C, D and E correlations (absolute) with context variables, on day 1, 5 and 10 (and an average over all days, N=31).

		DAY		
CONTEXT VARIABLES	DAY 1	DAY 5	DAY 10	AVERAGE ALL DAYS
Vocabulary WISC	.17	.17	.18	.17
Digit Span	.27	.18	.14	.20
Tapping simple	.14	.38	.38	.30
Tapping complex	.24	.25	.35	.28
Age	.10	.29	.22	.20
Examination mean	.21	.13	.16	.17
Grade 7 scores	.15	.11	.16	.14
RAVEN score	.34	.19	.24	.26
RAVEN time	.19	.12	.24	.18
S.E.S.	.08	.13	.09	.10
Difficulty-interest	.15	.36 *	.28	.26
Academic	.12	.13	.21	.15

Table 16: The averages of day 1, 5 and 10 correlations (absolute) with context variables, on the tasks A, B, C, D and E.

		TASK			
	TASK A	TASK B	TASK C	TASK D	TASK E
CONTEXT VARIABLES					
Vocabulary WISC	.08	.21	.24	.09	.24
Digit Span	.21	.28	.18	.15	.15
Tapping simple	.34	.36	.40	.33	.06
Tapping complex	.42	.40	.28	.18	.09
Age	.11	.19	.14	.22	.36
Examination mean	.41	.15	.20	.05	.22
Grade 7 scores	.04	.04	.04	.28	.30
RAVEN score	.39	.22	.19	.24	.26
RAVEN time	.24	.24	.13	.20	.08
S.E.S.	.09	.11	.12	.06	.14
Difficulty-interest	.09	.31	.27	.38	.28
Academic	.11	.12	.22	.23	.13

Table 17: The absolute averages on all context variables correlations with task A, B, C, D and E, on day 1, 5 and 10 (and an average over all days).

	DAY			
TASK	DAY 1	DAY 5	DAY 10	MEAN
TASK A	.19	.15	.23	.19
TASK B	.16	.25	.26	.22
TASK C	.15	.22	.24	.20
TASK D	.21	.22	.22	.22
TASK E	.17	.21	.18	.19
MEAN	.18	.21	.23	

Table 18a: Correlations of gain with context variables for training group B.

TRAINING GROUP B / GAIN MEASURES	Voc. WISC	Digit Span	tapping simple	tapping complex	grade 7	Raven score	Raven time	Exam mean
Hick gain day 1	-.10	.27	.07	-.04	-.06	-.41	.33	-.12
Hick gain day 5	.29	-.13	.07	-.26	-.20	-.34	-.19	.33
Hick gain day 10	.34	-.60	-.49	-.34	.06	-.52	-.61	.02
regr.coeff.task A	-.40	.55	.40	.64	-.64	-.14	-.30	-.22
regr.coeff.task B	.23	-.56	-.38	-.07	-.03	-.11	-.81	.02
regr.coeff.task C	.00	.87	.69	.41	-.87	.28	.06	-.46
regr.coeff.task D	-.08	-.21	-.46	-.50	-.19	-.35	-.58	.13
regr.coeff.task E	-.19	-.01	.06	-.08	.23	.44	.20	.41
regr.of complexity	.12	.18	-.03	-.13	-.39	-.47	-.13	-.36
% gain on task A	.42	-.62	-.38	-.59	.69	.14	.28	.29
% gain on task B	-.26	.63	.49	.25	.02	.22	.84	-.06
% gain on task C	-.14	-.72	-.68	-.32	.86	-.15	.01	.35
% gain on task D	.13	.08	.33	.45	.36	.30	.55	-.04
% gain on task E	.14	.20	.16	.19	-.35	-.26	-.05	-.47

(CONTEXT VARIABLES: Voc. WISC through Exam mean)

Table 18b: Correlations of gain with context variables for training group C.

TRAINING GROUP C / GAIN MEASURES	Voc. WISC	Digit Span	tapping simple	tapping complex	grade 7	Raven score	Raven time	Exam mean
Hick gain day 1	.44	-.55	-.02	.02	.36	-.40	.65	.16
Hick gain day 5	.70	-.61	-.34	.12	.41	.14	.37	.40
Hick gain day 10	.88	-.12	-.19	.39	.06	.61	.22	.49
regr.coeff.task A	-.05	.50	-.43	-.42	-.37	.33	-.81	.23
regr.coeff.task B	.08	.55	-.31	-.13	-.40	.60	-.72	.65
regr.coeff.task C	.34	-.68	-.43	-.70	.37	-.02	-.53	.04
regr.coeff.task D	-.07	-.34	-.50	-.16	.60	.27	-.22	.12
regr.coeff.task E	.85	.08	.03	.31	.46	.64	.33	.86
regr.of complexity	-.55	-.06	-.66	-.49	-.10	-.53	-.26	-.50
% gain on task A	.00	-.50	.42	.41	.31	-.39	.81	-.33
% gain on task B	-.19	-.47	.32	.08	.29	-.71	.69	-.72
% gain on task C	-.33	.61	.46	.67	-.24	-.02	.60	.01
% gain on task D	.22	.28	.65	.17	-.36	-.02	.14	.03
% gain on task E	-.79	-.10	.36	-.05	-.57	-.53	-.22	-.84

(CONTEXT VARIABLES: Voc. WISC through Exam mean)

Table 18c: Correlations of gain with context variables for training group E.

TRAINING GROUP E	CONTEXT VARIABLES							
GAIN MEASURES	Voc. WISC	Digit Span	tapping simple	tapping complex	grade 7	Raven score	Raven time	Exam mean
Hick gain day 1	-.46	.13	-.05	-.09	.69	-.17	-.21	.05
Hick gain day 5	-.42	-.13	-.71	-.47	.76	.18	-.51	-.39
Hick gain day 10	.39	-.68	-.14	-.41	-.67	-.21	-.25	-.47
regr.coeff.task A	-.29	-.04	-.26	.06	.72	.65	-.31	-.17
regr.coeff.task B	.07	-.41	-.27	-.08	.15	.59	-.34	-.39
regr.coeff.task C	-.27	-.71	-.16	-.01	-.45	.13	-.01	-.85
regr.coeff.task D	.30	-.64	-.25	-.46	-.04	.26	-.37	-.40
regr.coeff.task E	.09	.34	-.07	-.41	.18	-.35	-.16	.20
regr.of complexity	-.71	.20	-.21	.74	.19	.63	.60	-.20
% gain on task A	.21	.06	.27	-.02	-.69	-.62	.37	.14
% gain on task B	-.06	.39	.29	.08	-.19	-.61	.37	.37
% gain on task C	.28	.61	.40	-.06	.35	-.28	.06	.80
% gain on task D	-.18	.62	.46	.36	.15	-.27	.24	.48
% gain on task E	-.02	-.28	-.04	.16	.12	.22	-.07	-.03

Table 18d: Correlations of gain with context variables for training group All.

TRAINING GROUP ALL	CONTEXT VARIABLES							
GAIN MEASURES	Voc. WISC	Digit Span	tapping simple	tapping complex	grade 7	Raven score	Raven time	Exam mean
Hick gain day 1	-.20	.21	-.09	-.11	.28	.70	-.53	.31
Hick gain day 5	-.24	.03	.30	-.58	-.47	-.52	-.02	-.19
Hick gain day 10	.01	.17	.42	-.12	.03	.15	.35	.24
regr.coeff.task A	-.31	.02	-.23	-.12	.19	.45	-.48	.16
regr.coeff.task B	-.17	-.24	.16	-.08	-.13	-.36	.56	-.05
regr.coeff.task C	-.56	-.31	.66	.26	.40	.25	.21	.06
regr.coeff.task D	-.31	.28	-.19	.07	.20	.27	-.22	-.23
regr.coeff.task E	.05	.11	-.33	.37	.16	-.08	.40	-.25
regr.of complexity	.16	.49	.14	-.75	-.71	-.49	.26	-.24
% gain on task A	.25	-.06	.28	.21	-.08	-.41	.51	-.11
% gain on task B	.12	.26	-.06	.11	.18	.41	-.55	.06
% gain on task C	.46	.15	-.61	-.14	-.33	-.23	-.24	-.14
% gain on task D	.19	-.48	.25	.05	-.07	-.25	.07	.26
% gain on task E	.20	-.30	-.05	-.05	.16	.24	-.76	.63

Table 18e: Correlations of gain with context variables for N=31.

N = 31	CONTEXT VARIABLES							
	Voc. WISC	Digit Span	tapping simple	tapping complex	grade 7	Raven score	Raven time	Exam mean
GAIN MEASURES								
Hick gain day 1	-.08	.15	-.02	-.05	.32	-.07	.06	.10
Hick gain day 5	-.08	-.21	-.17	-.30	.13	-.14	-.09	.09
Hick gain day 10	.41	-.31	-.10	-.12	-.13	.01	-.07	.16
regr.coeff.task A	-.26	.26	-.13	.04	-.03	.32	-.48	.07
regr.coeff.task B	-.05	-.17	-.20	-.09	-.10	.18	-.33	.06
regr.coeff.task C	-.12	-.13	.19	-.01	-.14	.16	-.07	-.29
regr.coeff.task D	-.04	-.23	-.35	-.26	.14	.11	-.35	-.08
regr.coeff.task E	.20	.13	-.08	.05	.26	.16	.19	.33
regr.of complexity	-.25	.20	-.19	-.16	-.25	-.22	.12	-.33
% gain on task A	.10	-.28	.15	.00	.06	-.32	.49	-.08
% gain on task B	-.10	.20	.26	.13	.08	-.17	.34	-.09
% gain on task C	-.07	.16	-.11	.04	.16	-.17	.11	.23
% gain on task D	.09	.13	.42	.26	.07	-.06	.25	.18
% gain on task E	-.12	-.12	.11	.06	.16	-.08	-.27	-.19

Table 19: Correlation between cognitive factor and RTs for tasks, days and training groups (N=29).

	TRAINING GROUP				
	B N=8	C N=6	E N=8	ALL N=7	N=29
RTs					
RT day 1 task A	.30	-.88	-.68	-.16	-.36
RT day 5 task A	-.31	-.80	-.37	.58	-.23
RT day 10 task A	-.04	-.69	-.49	-.04	-.32
RT day 1 task B	-.03	-.66	-.72	.33	-.27
RT day 5 task B	-.06	.31	-.47	.21	.00
RT day 10 task B	-.17	.16	-.54	.13	-.11
RT day 1 task C	.16	-.09	.43	.27	.19
RT day 5 task C	-.12	-.10	-.19	.50	.02
RT day 10 task C	-.03	.25	-.32	.16	.02
RT day 1 task D	-.08	-.39	-.17	-.08	-.18
RT day 5 task D	-.31	-.33	.00	.07	-.14
RT day 10 task D	-.55	-.34	-.45	-.43	-.44
RT day 1 task E	-.46	-.85	-.03	-.58	-.48
RT day 5 task E	-.49	-.66	.12	-.31	-.31
RT day 10 task E	-.47	-.27	-.28	-.76	-.45
COLUMN MEAN:	-.18	-.36	-.28	-.01	

__Table 20:__ Kendall rank order correlations, for training groups on task B, C E and ALL. Rank order per training group of rank of RTs on day 1 is compared to the mean rank order on all remaining days.

	RANK								
MEAN RANK ON REMAINING DAYS	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	DAY 8	DAY 9
TRAINING GROUP B									
TASK B	.44	.62	.69	.74	.74	.77	.85	.82	.76
					Average Rank order correlation =				.72
TRAINING GROUP C									
TASK C	-.21	.42	.58	.62	.66	.61	.33	.43	.57
					Average Rank order correlation =				.44
TRAINING GROUP E									
TASK E	.23	.45	.30	.30	.53	.50	.43	.46	.50
					Average Rank order correlation =				.41
TRAINING GROUP ALL									
TASK B	.44	.53	.66	.60	.63	.70	.79	.71	.86
					Average Rank order correlation =				.66
TASK C	.34	.42	.44	.24	.51	.54	.52	.46	.36
					Average Rank order correlation =				.43
TASK E	.57	.61	.55	.38	.66	.66	.60	.61	.50
					Average Rank order correlation =				.57

Table 21: Proportion of errors per task and training group.

GROUP	TASK B	TASK TASK C	TASK D	TASK E	MEAN
TRAINING GROUP B	.010	.023	.052	.085	.043
TRAINING GROUP C	.000	.009	.049	.111	.043
TRAINING GROUP E	.031	.028	.056	.078	.048
TRAINING GROUP ALL	.104	.023	.061	.071	.065
Mean	.036	.021	.055	.086	

Table 22: Proportion of errors (N=32).

SOURCE	ERROR TERM	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F-RATIO	PROBABILITY
Group (g)	(g)	0.06433	3	0.02144	1.46	0.25
Day (d)	pd (g)	0.18144	2	0.09072	8.38	0.00 *
Block (b)	pb (g)	0.00760	1	0.00760	1.42	0.24
Task (t)	pt (g)	0.46060	3	0.15353	13.10	0.00 *
gd	pd (g)	0.11999	6	0.01999	1.85	0.11
gb	pb (g)	0.01029	3	0.00343	0.64	0.59
db	pdb (g)	0.00121	2	0.00060	0.10	0.91
gt	pt (g)	0.31070	9	0.03452	2.94	0.00 *
dt	pdt (g)	0.04707	6	0.00784	0.65	0.69
bt	pbt (g)	0.09319	3	0.03106	7.92	0.00 *
gdb	pdb (g)	0.04414	6	0.00735	1.20	0.32
gdt	pdt (g)	0.15178	18	0.00843	0.70	0.81
gbt	pbt (g)	0.05889	9	0.00654	1.67	0.11
dbt	pdbt (g)	0.12964	6	0.02160	4.44	0.00 *
gdbt	pdbt (g)	0.11463	18	0.00636	1.31	0.19

Note: * $p < .05$

Table 23: Mean, Standard Deviation and Standard Error of the Movement Time per group, task and day.

FACTOR	LEVEL	MEAN	STANDARD DEVIATION	STANDARD ERROR
GROUP	training group B	241	77	7.03
	training group C	220	59	5.73
	training group E	244	55	4.99
	training group All	223	56	5.08
TASK	MT on task A	208	57	5.92
	MT on task B	224	66	6.79
	MT on task C	234	60	6.24
	MT on task D	245	58	5.99
	MT on task E	251	66	6.80
DAY	day 1	274	66	5.27
	day 5	224	54	4.31
	day 10	198	41	3.33

Table 24: Results of analysis of variance on MT.

EFFECT	F-RATIO	DEGREES OF FREEDOM		PROBABILITY
Group	0.87	3.00,	27.00	0.47
Task	14.56	2.74,	74.01	0.00 *
Task x Group	1.00	8.22,	74.01	0.45
Day	64.69	1.66,	44.81	0.00 *
Day x Group	1.96	4.98,	44.81	0.10
Task x Day	2.16	4.27,	115.42	0.07
Task x Day x Group	0.75	12.82,	115.42	0.71

Note: * $p < .05$

Table 25: Average of intra-individual correlations between MT and RT per task (N=32).

	TASK TASK A	TASK B	TASK C	TASK D	TASK E
MEAN	-.043	-.018	-.024	.087	.054
SD OF MEANS	.183	.172	.181	.152	.164

Table 26: Mean RTs (in ms), for Dutch, Zimbabwean (van de Langenberg, 1989) and Zambian subjects (Present research), on task A, B, C, D and E.

	CULTURE					
DAY	DUTCH SUBJECTS (N=35)		ZIMBABWEAN SUBJECTS (N=35)		ZAMBIAN SUBJECTS (N=32)	
DAY 1						
TASK A	315		314		292	
TASK B	410		452		400	
TASK C	882		1042		897	
TASK D	1977		2484		2560	
TASK E	3066		4360		4530	
DAY 5						
TASK A	304	(-2.9%)	329	(+5.1%)	271	(-7.2%)
TASK B	444	(+8.4%)	459	(+1.7%)	395	(-1.5%)
TASK C	768	(-12.9%)	881	(-15.5%)	768	(-14.6%)
TASK D	1660	(-16.0%)	2116	(-14.8%)	2243	(-12.4%)
TASK E	2258	(-26.4%)	2837	(-34.9%)	3051	(-33.7%)

Table 27: Correlations of Standard Deviation of the RTs with intelligence measures (N=31).

DAY 1	TASK A	TASK B	TASK C	TASK D	TASK E
WISC vocabulary	.22	-.06	.22	-.19	.07
RAVEN	-.43	-.16	.02	-.17	.01
Examinations (89)	-.07	-.06	.25	-.22	-.06
Grade 7 scores	-.31	-.04	.14	-.08	-.21

DAY 5	TASK A	TASK B	TASK C	TASK D	TASK E
WISC vocabulary	-.09	-.01	.24	-.08	-.32
RAVEN	-.06	-.26	-.10	.04	-.07
Examinations (89)	-.31	-.14	.14	.04	-.34
Grade 7 scores	-.05	-.15	-.18	-.01	-.02

DAY 10	TASK A	TASK B	TASK C	TASK D	TASK E
WISC vocabulary	-.26	.07	.29	-.20	-.04
RAVEN	.17	-.22	.06	-.08	-.05
Examinations (89)	-.11	-.07	.34	-.23	-.05
Grade 7 scores	.22	-.09	.13	-.30	-.17