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TIME STRESS AND KATACHRETICAL BEHAVIOUR

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CONTENTS

1 INTRODUCTION

As automatization in industry increases, one might surmise that the number and the seriousness of accidents should decrease. This is, however, not wholly true, and we might suggest for two reasons.

The first is that in an automatized plant human operators work on important positions in the process. A wrong decision here has more serious consequences than in more primitive manual work because the interdependence between operator and machine and between the operator and his colleagues has been grown. A wrong decision by an operator may have bad effects in one or more other links of the system. For example: if a traffic control operator on an airport does not select the best solution for some traffic problem, or if he takes this decision too late, this will lead immediately to very serious complications.

The second factor is that even in modern plants primitive ways of dealing with tasks remain: e. g. machines are often transported by rolling them over cylinders or wooden rollers just as heavy objects were transported some thousands of years ago (Winsemius, 1969 a).

In many instances these or other kinds of improvisations can be seen in industrial situations. These improvisations may sometimes give rise to accidents. The present experiment was designed in order to study one specific kind of improvisation as a potential source of accidents.

1.1 Theoretical starting-point

The experiment that will be described in this paper is based on Winsemius' theory of task structures (1969 b). Fundamental to this theory is the concept of anticipation: someone performing a task is continuously conceiving the phases through which he will have to proceed in order to attain his goal. This process of conceiving phases is called anticipation, for the worker is projecting his ideas concerning his task into the future. This process is made up of fleeting images that represent coming parts or phases of the job. The images are described in the theory as if they were discrete units, although in reality they are not always sharply distinguishable (as a little introspection makes clear).

In the ideal case of a smoothly running job, without interference of unanticipated events, everything turns out to be just as the subject expected. Yet everyone knows from experience that these ideal conditions are seldom met in reality; in many instances there is some disturbance: a drill breaks down, the electrical fuse blows out, a wrenche suddenly appears not to fit, etc.

Sometimes a tool is led down and when it is needed again the worker cannot find it because he has forgotten where he put it.

In all these cases the worker has to take action which was not foreseen in order to ascertain the attainment of his goal. This action of recovering disturbances is called 'recuperation'. In recuperation it may be seen that the worker uses an already available tool for ends for which it is not quite suited, e.g. he hammers with a wrench, cleans an object with a chisel, turns a nut by means of a pair of pincers. This phenomenon of employing less appropriate tools for the working phase at hand is called 'katachresis'. Katachreses differ in magnitude; the katachresis is greater when the actual use of the tool is more remote from the use for which it is originally meant.
It stands to reason that katachreses may lead to accidents.

1.2 An earlier experiment

In an earlier experiment De Winter (1969) had subjects transport several kinds of objects by means of modified pincets. The three pincents were of different utility for transporting the three kinds of objects (steel balls, iron rings and glass beads) so that for any task a less suited pincet might be chosen, in which case one could speak of a katachresis. Subjects were free to pick any pincet for a given task and they determined their own speed of working.

After selecting a pincet the subject had to walk a distance of about 3.5 metres to arrive at the place where the work had to be done. Now disturbances could be introduced by canceling the original task and giving another task instead when the subject was on a fixed point on his track.

In one group of subjects this happened when the subject was halfway between start and finish, in another group when the subject was 0.5 meter from the goal.

If such a change happened the subject was completely free in his decision to proceed with the originally chosen but less proper pincet in which case one could see a katachresis or to go back and exchange the first pincet for a better one.

One third of all tasks was changed in this way, the place of the subject on the moment the change occurred was the independent variable. In this way it was shown according to the hypotheses that:

- if the distance between the subject and the not-chosen (but better) pincet was greater, the chance that the subject might go back for getting this better tool was smaller
- if the distance was greater the subject tended to show greater katachreses (smaller katachreses occurred more frequently than greater ones)
- if the distance was greater the subject developed a tactics of choosing a 'universal' tool which was of at least some use for any task or counter-task that might occurr.

These findings led to the idea of repeating the experiment in a somewhat modified way; new laboratory equipment enabled us to make exact time measurements which could be recorded automatically. This also gave us the possibility of varying the time elapsed between first and second stimulus for one task as independent variable. The disadvantage of this design was that subjects contrary to the instruction had the possibility to wait until the moment after which he knew no counter stimulus would appear. In fact we observed this kind of behaviour in very few instances: the design as such functioned in the same satisfactory way as the one of the earlier experiment.

2 HYPOTHESES

Two hypotheses will be tested. The first is borrowed from Winsemius (1969 b).

1. A katachresis will occurr more easily if - other conditions remaining constant - the tool with which the katachresis might be carried into effect is more available.

The second is more directly related to safety.

2. Katachreses lead to more frequent exceeding of available time than other modes of executing a task.

Accidents are of many kinds and their causes are even more diverse. In many instances, however, there is a certain amount of time available for a certain task. If this time is exceeded, the normal development of the task is disrupted, things do not show up as they were anticipated and the chance that a dangerous situation results is very real.

Here the pressure of time is seen as a special kind of disturbance.

3 METHOD

3.1 Task

The tasks consisted in transporting objects by means of pincets. The objects were of three kinds, steel balls with a diameter of 9.5 mm, iron rings 1 mm thick with an outer diameter of 11 mm and an inner diameter of 5.5 mm and glass beads with a diameter of about 5 to 6 mm. The tools (see appendix I) were modified pincets that were 12 cm long. The first pincet that was most suited for transporting balls had pierced jaws and a bolt was soldered to the inside of one of the legs so that the minimum opening was 6 mm. The next pincet that was suited for transporting rings, had needle-like extensions 0.75 mm thick and with a protruding length of 9 mm. The third pincet was provided with a bush that was fixed on the inside of one of the legs. The height of the bush was 5 mm, it was fixed 8 mm from the end of the leg. This pincet was most useful for transporting beads. In the quoted experiment (De Winter, 1969) it was shown that each pincet had different utilities for the three tasks, while no pincet was completely useless for any task.

The objects were put into metal cans, one pair of cans for each kind of objects. The cans were mounted on a board (see appendix II).

So the number of ways in which the pincet could be used was limited and the distance over which the objects had to be transported was constant.

In a console behind the board and some 20 cm higher there were three lamps, corresponding with the three pairs of cans. These lamps were used as signals for the subject. Subject was instructed to put five objects fromthe one in the other can, during the time the indicator light was on (see for instruction appendix IV)

3.2 Arrangement of apparatus

At one side of the room there was a board on which the pincets when not in use, had to be hung. On the other side, at a distance of 3.50 m was the board with the cans that was described in 3.1.

The starting-point of the subject was always at the pincet-board. When a stimulus appeared, that is: when the subject saw that one of the three lamps glew up, he selected an appropriate pincet and went on his way to perform his task. Sometimes, however, a counter-stimulus was given when the subject was on his way and then he could choose between two courses of action: going on with the pincet or going back and getting a more appropriate one.

3.3 Disturbances

As indicated in 3.1 it is necessary to introduce disturbances in a task in order to induce katachreses. In this case disturbances were realized by presenting a counter-stimulus some time after the original one. Half of all stimuli was changed, the order of all 36 changed and unchanged stimuli was randomized.

3.4 Conditions

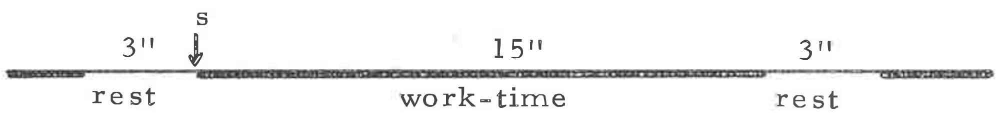
Our first hypothesis concerns availability of tools. Now, if one had a tool in his hand and an alternative tool is somewhere on a table, the relative availability of the tool in the hand is dependent on the distance between the person and the other tool. When this tool is further away, the tool in the hand is relatively more available. Otherwise said: the availability of the chosen tool in relation to the availability of the not-chosen tool is proportional to the distance. This distance was influenced in the present experiment by varying the time that elapsed between the presentation of the first stimulus and the presentation of the second, or counter-stimulus (c.f. also 1.2).

In some preliminary trials it was established that if the second stimulus occurred after 1.5'' the subject had just finished picking a pincet and he had just begun his walk. If the second stimulus was given 2.0'' after the first, the subject had covered about half or two thirds of his road on the moment the counter-stimulus was given. This was a satisfying difference. The two conditions will be referred to in the remaining part of this paper as 'condition 1.5' and condition 2.0'.

If there was no counter-stimulus, the available work-time was 15'' and the resting interval was in every case 3'', see fig. 1.

Figure 1

Resting- and work-times, no counter-stimulus



If a counter-stimulus was given, it was necessary to allow extra time, because, if the subject should go back, he needed some time for doing so, exchanging the pincet and walking to the place where he had received the counter-signal. After this cycle of action the situation is equal to the situation on the moment in which the counter-stimulus was given, except that the subject now has the proper tool. It was decided to allow 1.5'' extra for this chain of action in both conditions (see figs. 2 and 3).

Figure 2

Resting- and work-times, condition 1.5''
(s = first stimulus, s' = counter-stimulus)

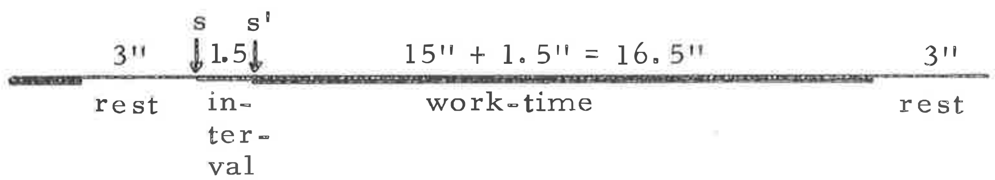
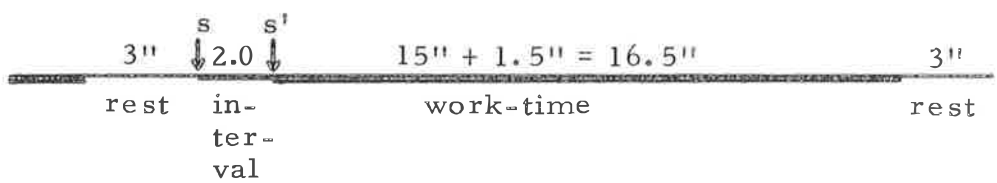


Figure 3

Resting- and work-times, condition 2.0''



3.5 Series of stimuli

The stimuli for both conditions were punch tape programmed. If we designate the tasks as follows:

transporting balls = 1
transporting rings = 2
transporting beads = 3

we can give the sequence of stimuli in table 1.

Table 1

Series of stimuli presented to subjects in two conditions

stimulus number	cond. 1.5	cond. 2.0
1	32 *	23
2	11	21
3	11	22
4	21	33
5	12	31
6	33	13
7	33	11
8	22	32
9	31	22
10	33	32
11	11	13
12	23	33
13	13	12
14	22	11
15	22	23
16	11	12
17	31	33
18	21	22
19	22	21
20	33	31
21	12	11
22	23	22
23	11	22
24	12	13
25	33	23
26	13	11
27	32	33
28	22	31
29	32	22
30	11	33
31	13	33
32	31	12
33	33	21
34	22	11
35	21	11
36	23	32

* the first digit represents the first task, the second the second task: e.g. 32 means that the original task was 'transporting beads' and the counter task 'transporting rings'.
If the digits are equal, the task was not changed.

The reader may remark that the sequence of the second series is the reverse of the sequence of the first. It is the experimenters' opinion that there will be no more transfer of training than if there were no relation whatsoever between the two orders.

Changed stimuli had to have the same probability as unchanged ones. In a series of 36 there have to be 18 of each. The series of stimuli meet this requirement as table 2 shows.

Table 2

Frequencies of combinations of stimuli found in the series of table 1

unchanged		changes	
st.	freq.	st.	freq.
11	6	12	3
		13	3
22	6	21	3
		23	3
33	6	31	3
		32	3
total	18		18

Table 2 shows that unchanged stimuli were just as probable as changed stimuli and within both groups any combination was as probable as any other.

3.6 Apparatus

The punch tape was fed into a tape reader that triggered an electronic clock, on the moment a new stimulus appeared.

The clock was stopped when the subject pushed a button-type switch and the clock reading was written down by a teleprinter. In the case of a counter-stimulus the reaction time was measured from the second stimulus on. At the same time the tape reader activated the stimulus lamp during the predetermined time (see 3.4). The pincets when not in use were hung on a special board each on its own place. When a pincet was on its place it established electrical contact between a peg and a rail. There were three such pegs, connected to a voltage divider. The voltage at the output of this divider was dependent on the pincet or combination of pincets that was taken from the board. This voltage was used as a signal for one channel of a polygraphic recorder, that converted its input signals into readible signs. A second channel of the recorder was employed for registrating the time the lamp was glowing (that is the permitted work-time) and the time the subject was actually working (subjects had to push a button during their work performance).
In short, the following measurements were available:

- reaction time (= decision time + walking time)
- work-time (= time spent in transporting objects)
- total time available
- time worked with i^{th} pincet.

If a subject continued with a task after the lamp extinguished, it was technically not possible to registrate how long he went on with the task.

3.7 Subjects

The data are based on the observation of ten subjects, ranging in age from 20 to about 50 years. There were five men and five women. The order of presentation of the two experimental series was randomized:

Table 3

Sex, estimated age, profession and the order of presentation of the two experimental series for ten subjects

subject nr.	sex	estimated age	profession	order of series 1st	2nd
1	f	25	student	2.0	1.5
2	f	25	secretary	2.0	1.5
3	f	40	secretary	1.5	2.0
4	m	25	chem. analyst	1.5	2.0
5	f	35	chem. analyst	2.0	1.5
6	f	25	chem. analyst	1.5	2.0
7	m	35	audiometrist	1.5	2.0
8	m	20	fitter	1.5	2.0
9	m	20	student	2.0	1.5
10	m	20	student	2.0	1.5

4 RESULTS

4.1 Learning period

Before starting the experiment a training session was arranged: each subject was given an opportunity to get acquainted to the situation and the handling of the pincets. Afterwards subject was asked to judge the pincets on their relative utility for the different tasks (see for the instruction appendix IV).

Appendix III gives the utility marks as given by ten subjects. From this the mean is computed

Table 4

Mean utility for nine combinations of task and tool

		task			
		ball	ring	bead	mean
tool, pincet with:	holes	7.9	4.0	5.0	5.6
	pins	1.8	8.5	5.8	5.4
	bush	4.4	5.8	8.0	6.1
	mean	4.7	6.1	6.3	

Every pincet was optimal for one single task, as the high figures in the diagonal indicate. The marks for both other tasks were much lower for every pincet. An analysis of variance confirmed this finding: a necessary condition for the experiment is fulfilled namely that there are tools of different utilities of which none is completely useless for any task.

Table 5

Analysis of variance of the data of appendix III
(learning period)

	sum of squares	df	mean square	F	p
pincets	7.5	2	3.75	1.82	n. s.
tasks	44.4	2	22.2	10.8	$< .01$
interaction	330.8	4	82.7	40.2	$\ll .01$
subtotal	382.7	8			
within	166.6	81	2.06		
total	549.3	89			

There was no significant difference between the pincets. The significant difference in tasks indicates that the task 'transporting balls' was seen as more difficult than the other two. The variance in tasks is small compared to the 'interaction' variance, which is most prominent. This means that the effect of combining tools and tasks was the cause of the greater part of the total variance. The conclusion is that it is possible to conduct the experiment on the basis of these data.

4.2 Experiment

4.2.1 Coding of reaction modes

In section 4.1 it is made clear that it is legitimate to match tools and tasks in the following way:

pincet with holes and transporting balls
pincet with pins and transporting rings
pincet with bush and transporting beads.

If a subject chose the corresponding pincet for a given task, there was certainly no katachresis. If the task was not changed and the subject worked with the right pincet, this was defined as a type A reaction.

If the stimulus was changed and the subject went back for picking the corresponding pincet, there was also no katachresis. This way of acting was called a type B reaction.

If the task was changed and the subject employed the first-chosen pincet for the counter-task, there was a type C reaction, which is shorthand for a katachresis.

It was also possible that a subject set out for performing a task that would not be changed with a pincet that was less suited for that task (a tool-task combination other than the three listed above). In this case there was a reaction of type (A)C. This is a kind of katachresis that is provoked by selection of the not corresponding pincet.

In total 21 (A)C reactions were counted, 18 of these were observed in one subject. Therefore it was decided to regard this subject as an outlier ($p \ll .01$, test for outliers, De Jonge, 1964); the remaining three cases were conceived as being caused by chance factors.

4.2.2 Number of katachreses in two conditions

In condition 2.0, 45 katachreses were observed, in condition 1.5 20 katachreses were found. In other words: in condition 2.0 there were more than two times as many katachreses as in condition 1.5.

As the total number of observations is 360 (in each condition every subjects did 36 reactions) the proportions katachreses are

$$p_{k\ 1.5} = \frac{20}{360} = 0.056 \qquad p_{k\ 2.0} = \frac{45}{360} = 0.125$$

The 0.05 confidence interval for the difference between proportions is:

$$0.125 - 0.056 \pm 1.96\sqrt{\frac{0.056 \times 0.944 \times 0.125 \times 0.875}{360}}$$

that is from 0.061 ..... 0.077, an interval that does not cover zero.

Therefore, the difference between the two proportions is significant at a 5% level.

As is explained in 3.4, the relative availability of the first chosen pincet is greater in condition 2.0 than in condition 1.5. It may be concluded that this greater availability is related with a greater number of katachreses. This confirms the first hypothesis (see ch. 2).

4.2.3 Difference in number of katachreses between men and women

Splitting the data according to the frequencies of the katachreses by men and women gives:

Table 6

Frequences of katachreses by men and women in two conditions

	condition 1.5	condition 2.0	total
women	0	13	13
men	20	32	52
total	20	45	65

A test for independence (1-test, Spitz, 1961) gives: 1 = 10.948 ($p < .005$). This means there is a striking difference in frequencies for men and women: men show many more katachreses than women, although there were five men and five women and every subject made 2 x 36 reactions.
This difference between men and women may be explained in three ways:

- men are more sensible to the time stress than women
- men are more than women inclined to perform tasks in a risky way
- women are more than men inclined to profit from the information, they gain during the experiment. This means women would show a greater learning effect than men. This will be the subject of the next section.

4.2.4 Learning effect

As was stated katachreses form a source of risk. That is why katachreses may be looked upon as a less effective way of dealing with a task. Now it would be interesting to see if the subjects show a learning effect, i.e. if they perform less katachreses as their information about the task increases.

Every subject performed two series of 36 reactions. If these two series are regarded as one long run, there are 72 reactions. Five subjects had condition 1.5 as the first series and five subjects got condition 2.0 first. So, if the performances of the ten subjects are put together, the effects of the two conditions may be expected to neutralize each other. In this way we come to the following result.

Table 7

Numbers of katachreses as they appeared in four consecutive phases of the total job.

	Phase				
	I(1-18)	II(19-36)	III(37-54)	IV(55-72)	Total
men	14	12	14	12	52
women	7	5	0	1	13
total	21	17	14	13	65

The total numbers for the four phases form a monotonously decreasing series, which suggests that there is a learning effect. The more information the subjects get, the less katachreses they perform. It seems as if they learn to assess the katachresis as a poor way of dealing with the task. The women contribute the greater part of this effect.

A test for trend (De Jonge, 1964, part II, p. 642-3) gives: $z = -1.66 (p \leqslant .05$ one tailed) for men and women together. The same test for the women separately did not give a significant result, because of a too small number of observations. Yet we are inclined to estimate the contribution of the women greater than that of the men.

4.2.5 Comparison of time measurements

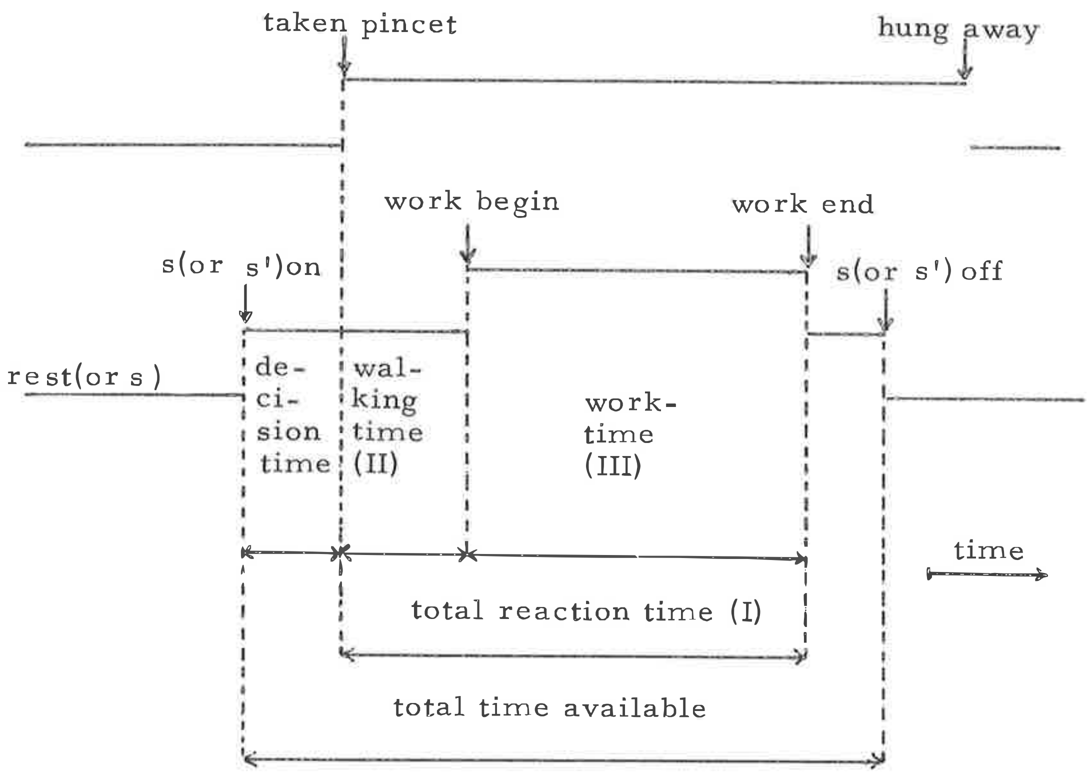
Walking- and work-times were compared in different conditions for men and women, in the first and second series. In the instruction (appendix IV) it is stated that subjects were free in their choice either to perform or not to perform a katachresis. As a consequence the number of the different kinds of reactions was different from subject to subject. Besides, some reactions were omitted or not performed in an acceptable way. In any case, the data could not meet the criteria in order to perform an analysis of variance. Now it was decided to compare each pair of sets of data by means of separate Student's t-tests. As a significance level of 5% was adopted, it may be expected that 5% of these comparisons may be a result that seems significant, but which is not significant in reality. This is an imperfection inherent in the design of the experiment.

The time measurements compared were divided in three categories. The total reaction time was defined as the time elapsing between the moment in which the subject in response to the stimulus lamp took a pincet and started walking and the moment in which he finished his task.

This total reaction time is called "I"; it was divided into the 'walking time', "II", and the 'work-time', "III". When a subject finished the task within the available time, indicated by the glowing lamp, the sum of the periods II and III was always smaller than the total time available. If a subject needed more time than he was allowed to spend, the measurement of period I and period III was impossible.

Figure 4

Scheme of time measurements



4.2.5.1 Comparison of first and second series

As was stated in 3.4 there were two conditions. Every subject was confronted with both series of stimuli and the order of presentation was randomized. Five subjects began with condition 1.5 and the other five had condition 2.0 as first series. It is possible that there are learning effects or sequence effects which will be reflected in differences in the time measurements in the first and second series.

As can be seen in table 8 reaction time in the second series was shorter than in the first series. This difference was statistically significant for reactions of type A and B but not for type C reactions which is due to the small number of observation.

Table 8

Differences in time measurements (in seconds) of first and second reaction series

time measure	reaction type	mean time series		t	df	p
		1st	2nd			
	A	10.1	9.7	2.06	289	$<.01$
I	B	10.1	9.6	2.95	259	$<.01$
	C	13.7	12.1	1.15	14	n.s.
	A	2.3	2.2	3.19	328	$<.01$
II	B	2.3	2.1	2.92	284	$<.01$
	C	3.1	2.9	0.80	62	n.s.
	A	7.8	7.2	3.12	298	$<.01$
III	B	8.0	7.6	1.66	259	$<.05$
	C	10.9	9.3	1.09	14	n.s.

This result can be interpreted as indicating an increase in efficiency during the experimental session.

4.2.5.2 Comparison of men and women

Comparison of men and women indicated no significant differences except in the 'total time' (I) measurement in condition 1.5 for reaction type A: 10.4 for men and 9.5 for women, $t(134) = 2.16$ ($p < .025$)

In the type B reactions only one significant difference could be observed between men and women, and this difference was the opposite direction: the 'work-time' (III) measurement in condition 1.5 for type B reactions is shorter in men: 7.4 sec. for men and 8.1 sec. for women, $t(134) = 2.46$ ($p < .01$).

These results suggest that there is no sufficiently clear difference between men and women in their use of the available time.

4.2.5.3 Comparison of the two conditions

There were three types of reaction and in every kind of reaction three measurements were made (I, II and III), so there were nine combinations of which a matrix was made. Comparison between the conditions was realized by looking for significant differences between corresponding cells in the two matrices for the two conditions. No significant differences were found.

4.2.5.4 Comparison of A and B reactions

It was interesting to see if there were systematic differences between time measurements in type A reactions (in which no counter-stimulus was given) and in type B reactions (in which the subject returned after a counter-stimulus). In both conditions the available time was sufficient for executing the task: 15.0'' in condition A and 16.5'' in condition B (cf. 3.4).

When a counter-stimulus was given, the subject got 1.5'' more as allowance for walking back and taking the new pincet,* but the subject himself did not know about this allowance, it was not mentioned in the instructions.

So although objectively there was no need for the subject to speed up his walking, we can expect that subjectively the subject experienced time stress. This might induce an acceleration of movements.

Table 9

Comparison of time measurements in A and B reactions, difference in conditions neglected. Measurements in seconds

time measurement	mean time		variance		t	df	p
	A	B	A	B			
I	9.87	9.82	7127	6597	0.44	550	n.s.
II	2.27	2.18	482	613	1.79	613	$< .05$
III	7.66	7.69	6180	5946	0.21	551	n.s.

* according to preliminary observation

Table 9 shows that the 'walking time' in type B reactions is shorter than in reactions of type A. The psychological basis of this phenomenon may be twofold:

1. In general the sudden change of the stimulus makes the subject afraid not to be able to finish the task in time. His decision to return moreover gives him the ambiguous feeling of winning security by taking the right pincet, but on the other hand loosing time by removing from the goal. This ambiguous feeling increases the experienced time stress: the subject gets the impression of being late on his time schedule. All this results in a speeding up of his walking.

   This working hypothesis might also explain the psychological mechanism underlying katachretical behaviour. The ambiguity of the situation increases the inclination of choosing the katachretical strategy. On the other hand the subject get more experience during the experiment. He learns that 'losing time' by returning and change the pincet is more profitable than going on with the wrong pincet ('winning time' in case of adopting the katachretical strategy). The data of table 10 illustrate that working in a katachretical way more often leads to accidents (defined as not finishing work within the time available) than working with appropriate tools.

Table 10

Percentage reactions 'out of time' in three reaction modes and two conditions

reaction time	condition		total
	1.5	2.0	
A	15.7	11.2	13.4
B	11.5	12.8	12.1
C	56.8	46.4	50.5

From this table it is evident that the percentage reactions 'out of time' is much higher in type C reactions than in A and B reactions, while the difference in the corresponding percentages between A and B reactions is very small. C reaction or katachreses appear to be very ineffective way of dealing with the tasks.

In the beginning of the experimental session the sibjects have no information about this fact. Only after some time they learn that katachreses are less effective, and they react less in a katachretical manner (see 4.2.4). When the amount of information the subject has about the task, increases, he begins to realize that even if the stimulus is changed, it is possible to finish the task in time, if not a A but a B type reaction is made. This is connected with a decreased feeling of time stress.

In section 4.2.4 it was established that with increasing experience, the number of katachreses decreases.

Thses findings support the psychological explanation of the mechanism underlying the choice of the katachretical strategy.

2. It might be expected that the change of the stimulus to which the subject started to react has an excitatory effect on the psychoneural mechanism that is responsible for maintenance of a certain level of vigilance and ability to perform. This is called the 'arousability force' of the stimulus (in this experimental situation the change of the stimulus is a stimulus itself) which may have some facilitatory effect on the motor behaviour of the subject.

Both explanations may contain some truth.

5 CONCLUSIONS AND SOME PRACTICAL CONSEQUENCES

Our findings may have consequences for real working situations. In many tasks the goal may be achieved in more than one way. Then the worker has to choose among the alternative methods.

Our experiment consisted of simple manual tasks and the essential feature was that a subject had to choose between two mutually exclusive strategies. This choice is also found in practice in simple motor tasks as well as in mental tasks. It was shown that the katachretical strategy more often leads to exceeding of the available time than other reaction modes. This means that in specific working situations in which the worker is obliged to finish sometasks in time, katachretical ways of working are dangerous. Under these conditions the work has to be organized so, that the possibilities to act katachretically are restricted as much as possible.

This supposes knowledge of the objective and subjective causes of katachreses. One objective cause is the absence of the right tool on the moment the worker needs it. Often a worker has to walk a certain distance (which takes time) for reaching the tool or he has to borrow it from a colleague (which takes even more time). If there is little time available, the worker may prefer to work in a katachretical way, rather than to walk and to fetch the right tool.

In the experiment more time had to be spent in condition 2.0 in order to get the right tool after a change of stimulus than in condition 1.5 . So it was expected that in condition 2.0 more katachreses would occur than in condition 1.5 and this result was found indeed. The practical implication of this is that all tools and other necessary objects should be given on the optimal place in relation to the task structure.

Things must be arranged so that it has to be easy to grasp anything that is needed. If for some task special tools are necessary, these tools have to be situated near the place where they are to be used. (An example is the fire-extinguisher that is sometimes mounted in passenger-cars. It is very often placed so that it is not immediately and easily graspable, e.g. under a seat, in the rear. Here the accessibility of the place of the extuinguisher is sacrificed to the near appearance of the interior of the car.)

These conclusions hold all the more when there are phases in a job in which the worker has to react promptly to some event. For example when a worker has to take action because a machine breaks down and the worker knows that this leads to financial losses or other complications. (In the experiment it was indicated that when a subject feared to come in time stress (especially in condition 2.0) he preferred to adopt the katachretical strategy which was in reality less effective and more time-consuming.)

Another conclusion is that it is necessary to provide workers with all necessary tools, and with more tools of the same type if the task makes this necessary, and to allow borrowing tools from colleagues only if the tools are very expensive or if they are not very important and seldom used.

Another (subjective) cause of katachreses is the lack of experience which leads to lack of knowledge of the relative utility of the different possible strategies. Unexperienced workers are inclined to choose the katachretical strategy. The probability that the katachretical strategy is chosen decreases as the experience in the work increases, as our results indicate. Because of this it is our opinion that special attention should be paid to apprentices and workers with little experience.
Workers with much experience must supervise apprentices intensively.

In safety propaganda no general advice should be given but the content of the propaganda should be adapted to the particular working situation in a plant. Special attention should be given to the right use of tools.

In the experiment women showed much less katachreses than men. This does not imply that this paper is a plea for selecting women for risky jobs.

It was shown that as a subject proceeded in the experiment his experience grew and his skill was augmented. Therefore it was expected that the risk inherent in katachreses diminished.

Because of this one might expect that the number of katachreses should increase during the two subsequent experimental series. In fact the contrary was found: the number of katachreses diminished as the experiment progressed. This is an argument for creating a specific training. By this training a 'dynamic stereotype' of good working habits is established.

The fact that the 'walking periods' in B reactions were shorter than the same periods in A reactions proves that the change of the stimulus acted as a stressor. The result of this stress is an unexpected acceleration of the reaction. This acceleration was objectively unnecessary because the time available after the second stimulus was as sufficient as the time available after an unchanged stimulus. As is mentioned before it is possible that this acceleration took place as a result of time stress experienced by the subject.

Time stress increases the probability that the risk taking strategy shall be chosen and has a negative effect upon some psychophysiological and performance parameters (Danev, 1969). Work problems producing time stress must be obviated as much as possible in the practical working situation.

The sudden changes in the working process may lead to deviations from the anticipated time schedule and to katachretical behaviour, that is why they have to be also restricted,

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Acknowledgement

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6 SUMMARY

An experiment was conducted in order to see if under certain circumstances (time stress experience when sudden disturbance in the based structure occurs) subjects who had to perform a manual task would do so with less appropriate tools. The use of inappropriate tools is called 'katachresis'. A second question was whether acting in a katachretical way would be more time-consuming than other reaction modes.

The tasks were very simple, they consisted of transporting objects from one canister into another by means of modified pincets. There were three such tasks and three corresponding pincets. In a preliminary session the subjects expressed their evaluation of the utility of every pincet for performing every task. In this way every subject gave nine evaluation marks, one for every combination of pincet and task. The evaluation marks ranged from 1 (extremely bad) to 10 (extremely useful). An analysis of variance on these data proved that there was enough differentiation in utility to execute the experiment.

The tasks to be done were indicated to the subject by means of lamps as stimuli. When a lamp started to glow, the subject selected a pincet, walked a distance of 3.50 metres and performed the task. In half of all tasks a disturbance was introduced by changing the task, the first lamp extinguished and a second began to glow obliging the subject to transport other type of objects. This could happen 1.5 seconds or 2.0 seconds after the first signal (condition 1.5 and 2.0). The subject was free to go on with the first chosen but less appropriate pincet, then he showed a katachresis, or to go back and to exchange the original pincet, for a better one for the task at hand.

It was established that more katachreses were performed under condition 2.0 than under condition 1.5. It was also shown that men are more than women inclined to work in a katachretical way. A probable explanation for this difference is that men are more willing to take risks than women.

Regardless of the difference in conditions and in sex, the number of katachreses decreased as the subject progressed in his series of tasks. This decreasing was more evident in women than in men. This suggests a learning effect that is confirmed by the fact that 'walking times' and ' working times' were shorter in the second half of the total performance of two experimental series (in all reaction modes except the katachretical, in which no difference was found).

There were no appreciable differences between men and women in 'walking time', 'working time' and 'total reaction time'.

When the task was not changed, the decision procedure was simple. When a counter-stimulus was given, that is: when the task was changed, this procedure was more difficult and time-consuming.

It was shown that the walking time in the latter case was shorter than in the former. This was not a consequence of the design of the experiment. The cause of this must be sought in the subject: it may be explained by an increased feeling of time stress and increased level of arousal, caused by the change of the stimulus.

It was found that katachretical task behaviour leads more often to exceeding of the available time than other ways of dealing with the task. Therefore it is thought that in specific working situations katachreses may more often lead to accidents than other ways of working.

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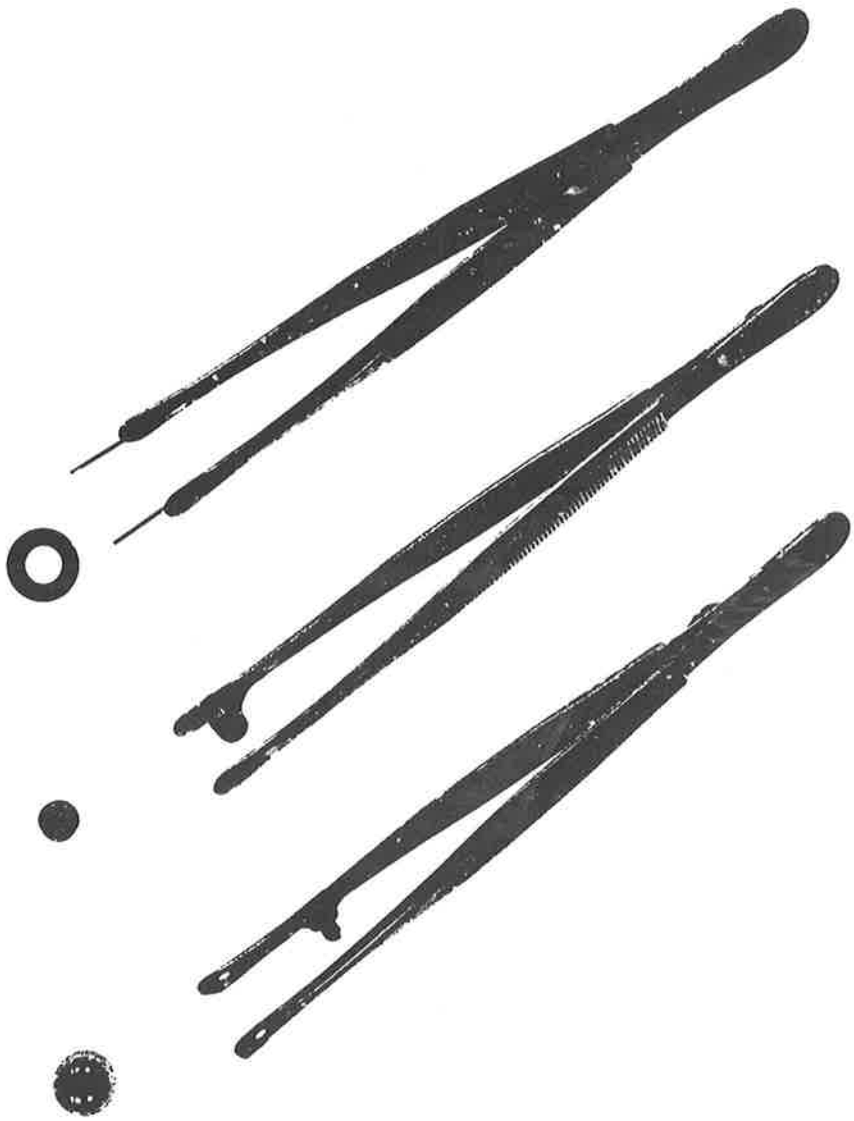
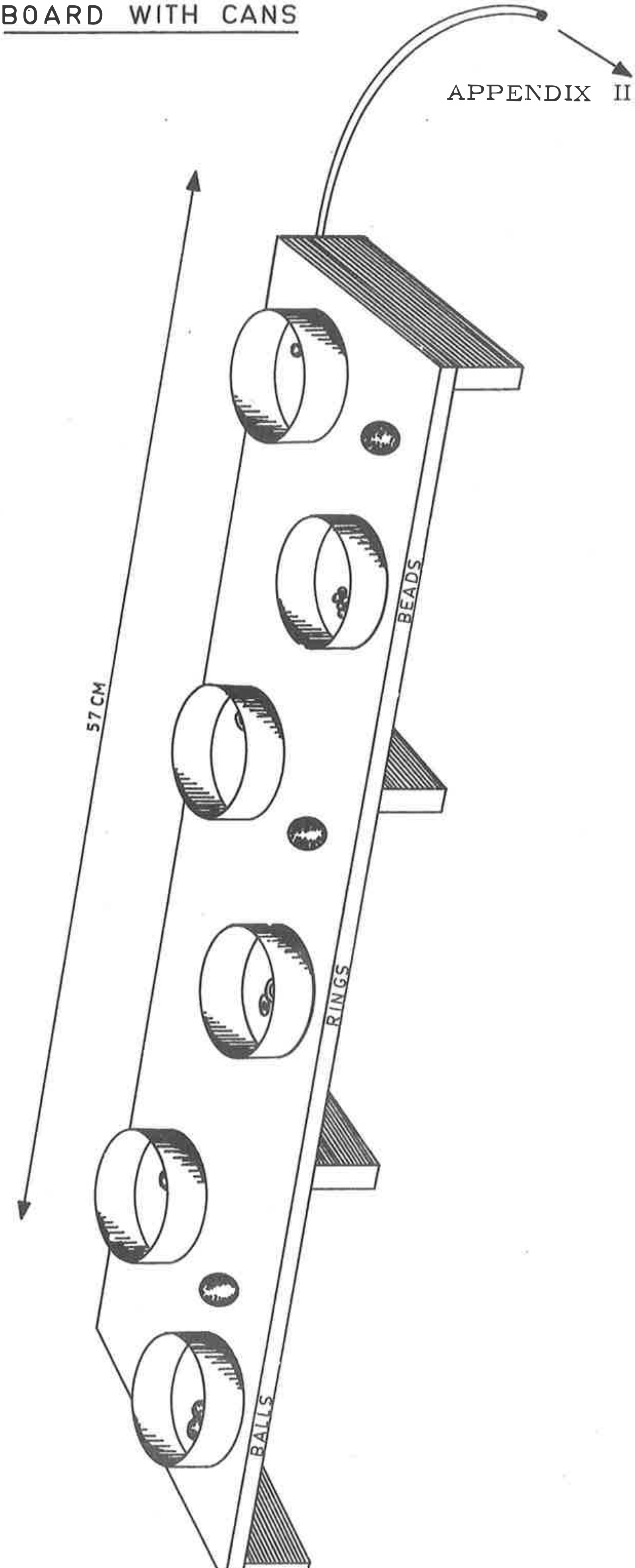
APPENDIX I

PINCETS AND OBJECTS



BOARD WITH CANS

APPENDIX II



APPENDIX III

Evaluation marks for nine combinations
of tool and task
(1 = extremely bad, 10 = perfect)

	subj.	ball	ring	bead	sum
pincet with holes	1	8	3	3	14
	2	9	5	7	21
	3	8	5	4	17
	4	8	3	7	18
	5	7	5	3	15
	6	8	3	6	17
	7	8	6	3	17
	8	6	1	5	12
	9	8	3	5	16
	10	9	6	7	22
total		79	40	50	169

pincet with pins	1	2	8	5	15
	2	2	8	6	16
	3	1	10	6	17
	4	2	8	7	17
	5	2	9	5	16
	6	2	7	5	14
	7	1	9	7	17
	8	3	6	5	14
	9	2	10	4	16
	10	2	10	8	19
total		18	85	58	161

pincet with bush	1	3	5	8	16
	2	8	5	10	23
	3	4	6	10	20
	4	3	5	6	14
	5	6	9	8	23
	6	6	4	7	17
	7	4	7	7	18
	8	4	6	6	16
	9	1	7	9	17
	10	5	4	9	18
total		44	58	80	182

APPENDIX IV

INSTRUCTION

There were two sets of instructions, one for the period in which the subject learned the value of any pincet for executing any task and one for the experiment proper.

The first set was:

" Here you see three pairs of canisters. In the foremost tins there are balls, rings and beads. Now I have here three pincets and with every pincet you are going to transport all three kinds of objects. You may use the pincets in any way you like, but you should not damage them. It is not permitted to touch the objects with your fingers. Every time you have transported ten objects I shall ask you to give a mark for the utility of the pincet for that task. These marks run - just like school marks - from 1 to 10 (1 is completely useless, 10 is perfect). Here you have the first pincet, begin here".

In order to suppress sequence effects, the order of the offered pincets and the order of the objects was randomized. Every subject did all nine combinations of task and pincet.

The instructions for the experimental part of the session were:

" You see there are three pairs of canisters and three corresponding lamps. Your task in the following part will be to transport five objects every time a lamp is glowing. During this time you push the corresponding button here with your other hand. The lamp also indicates the available time. If the lamp extinguishes while you are still at work, you are too late. Then you stop and go back immediately.
The place of the pincets will be on the board over there. After you have finished a task you go back to this board, put the pincet on its original place and wait for the next lamp to glow. You will take only one pincet at a time.
It may happen, however, that once you are on your way to the working table, that the first lamp extinguishes and that a second lamp starts to glow. In that case the first task is cancelled and you have to perform the task corresponding to the second lamp instead.
But on that moment you have got the pincet that is most suited for the cancelled task, a pincet that is probably less adapted to the new task.
Then you may follow two courses of action: you may go on with that pincet or you may go back and exchange it for a better one. Both choices have advantages; if you go back, you lose time,

but you can work with a better tool. On the other hand, if you proceed with the first-chosen pincet it may be worse as a tool, but you have more time for doing the task itself. You are completely free in your choice to go back or not. You have not very much time, so work as quick as possible!