TARTU RIIKLIKU ÜLIKOOLI
TOIMETISED

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ТАРТУСКОГО ГОСУДАРСТВЕННОГО УНИВЕРСИТЕТА
ACTA ET COMMENTATIONES UNIVERSITATIS TARTUENSIS

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ПРОБЛЕМЫ КОГНИТИВНОЙ ПСИХОЛОГИИ

PROBLEMS OF COGNITIVE PSYCHOLOGY

Труды по психологии VIII

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J.Allik, M.Kotik, A.Lunge, K.Toim
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Ю.Аллик, М.Котик, А.Лунге, К.Тойм
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ON THE INFLUENCE OF DANGEROUSNESS ON THE CONCEPTION OF TASK UNCERTAINTY

Mihhail A. Kotik

Abstract. In the present article it is experimentally demonstrated that the factor of dangerousness enhances the subjective entropy of task. On the basis of experimental data the quantitative functional dependence of task entropy on the two arguments - the subjective evaluation of the degree of task dangerousness level and the possibility of realization of this danger - is established. It is shown that the obtained dependence is applicable not only for the factor of physical danger, but also for the factors of social and material danger.

I. Introduction

It is generally accepted that human activity in the control system can be interpreted from the cybernetic point of view as information processing. In the process the subject's estimation of the initial uncertainty of the task appears to be of particular importance. As it was shown in our investigation (Kotik, 1974),it is the initial uncertainty - the entropy of the task - that determines the intensity of the informational processes necessary to solve the task . The more uncertain the task appears to the subject, the more additional environmental information is perceived or actualized from the memory in order to find a solution and the more active is information transformation. It was also shown there, that mistakes made by the subject when solving intellectual tasks are often caused not because of the lack of data for finding the correct resolution, but rather because of the underestimation of the degree of uncertainty of these tasks. It may be said that the subject does not make use of the whole information available. Consequently, the correct estimation of the degree of uncertainty of the task by the subject appears essential in the analysis of an individual's activity.

L.M.Vekker and I.M.Paley (1969), when analyzing the informational processes of ongoing activity, pointed to their close interrelationship with the energetic indices of the organism. The tight link between informational and energetic (including the emotional) manifestations in the process of activity was stressed by K.Pribram (1975), P.V. Simonov (1970), O.K. Tikhomirov (1969) and many others. All that suggests that the subject's images of uncertainty (of the complexity of the task arised) have to be constituted not only from the informational data but also with regard to the emotions evoked by the task.

2. The dangerousness and uncertainty of the task

In oruer to actualize the problem under discussion more exactly we would use a concrete example. Let us imagine that we must walk along a lengthy and thick oak plank of 30 cm width set about a meter above the ground . Such a task undoubtedly seems to us rahter easy and its uncertainty with regard to the reaching the goal implicit in it seems low. Let us suppose now that we shall have to pass the same plank but it has been cast across a deep ravine. The new task probably appears not so simple and the success of its resolution not so guaranteed. Asked "Why did the task become more uncertain?" the answer is sure to be - "It became more dangerous!". Indeed, in both cases the task was the same in fact but in the latter case it was more dangerous to commit an error. And immediately a new question arises:"Why did the factor of danger or the significance of the error make the new task more uncertain,i.e. more complex?" If both tasks were to be solved by a robot, they were probably to be estimated equal in the degree of uncertainty as to reaching the set aim. Hence the difference in the degree of uncertainty of these tasks is determined by some mental or human factors. But what are they?

First,it is natural to suppose that some danger inevitable in a concrete task should lead to heightened excitement (distressed state), disorganizing the activity and lowering the physical potential of the individual in solving such a task. However shifts in the physical functioning of the body are not always manifested by dangerous tasks. Many investigators (Kotik,1974;Pribram,1975;etc.) have shown that the factor of danger (if it is not too substantial)usually favors the mobilization of the inner resources of an organism and thus facilitates the successful resolution of the more dangerous tasks. Consequently there is no reason to consider that dangerous tasks become more uncertain solely because of the lowering of the bodily potentials for their resolution.

Secondly it can be assumed that the idea of dangerous tasks as being more complex and uncertain is based on the specificity of the human evaluations. This assumption could be tested analogously. If in the experiment with the plank raised a meter above the ground, there were 99 successful trials from the total 100, then the overall probability of success is estimated as rather high and uncertainty as low. But in the trials with the plank across a ravine (here a single mistake may mean serious results) the probability of success is estimated relatively low and the task is preceived as being more complex and uncertain than in the first case. Consequently,the factor of danger brings along re-evaluation of the perceived complexity and uncertainty of events,i.e.the psychological phenomenon manifests itself here.

The definition of emotions given by P.V. Simonov (1970) makes it possible to approach the psychological manifestations of task evaluation from the informational point of view.According to this approach the higher the task uncertainty the more emotions are evoked ,i.e. emotions are considered not only to be motivated by satisfaction or nonsatisfaction of the need but also as a function of the task uncertainty which is reduced by the realization of that act.

Proceeding from the assumption that uncertainty creates emotions we suggested that there may be a reversed phenomenon, that emotions give rise to additional uncertainty . In other words - with the increase of the emotiogeneity of a task (emotions evoked by danger included) its uncertainty should heighten too. If this is true then in the above example the second task had to be more uncertain simply due to its being more dangeroius and consequently more emotion-evoking.

Thus a hypothesis can be put forward: The uncertainty of a certain task towards its desired goal is estimated by an individual on the basis of the probability of its successful resolution and the degree of its emotiogeneity (from the point of view of its implicit dangerousness). This hypothesis was tested experimentally. The experiment will be described and the results analysed.

3. The physical aspect of dangerousness

For the experimental control of the above-mentioned hypothesis it was necessary to choose such a category of events the probability of a certain result and the degree of dangerousness of which can be easily normalized. Accident in the industrial settings were our choice. All accidents in production are carefully recorded and the possibilities of their occurrance assessed. The severity of injuries inflicted is also documented (cf. emotiogeneity). As in the present investigation we were concerned with subjective evaluations of the indicators of probability and emotiogeneity of events then engineers of labour safety and senior students-psychologists specializing in engineering psychology were chosen as subjects. They may be considered sufficiently gratified to assess industrial accidents. The investigation was carried out by the method of expert scaling of a group of 50.

It was necessary to establish the interrelations between three(indexes or groups of characteristics of groups)dangerous events: expectation of their occurence, their emotionegeity, and the degree of uncertainty. Being interested in subjective estimates we considered it desirable to use forms of expression which are natural and common. The well-known american mathematician L.A. Zadeh writes: "The elements of human thought are nor the numbers but the elements of some fuzzy multitudes and classes of objects for which the transition form the "membership" in the class to the "nonmembership" is not spasmodic, but indiscrete"(Zadeh , 1974). Hence the expectation and emotiogeneity of events was prefered to be evaluated by relating them,on the one hand,to certain vague concepts of frequency - "rarely","often",etc.- and on the other hand to certain vague concepts of severity - "slight","bad", etc. Only uncertainty or entropy (after Shannon),which,as we know ,is the function of probability, was assessed numerically. However, it was suggested to rate the chances in per cent. Further it was easy to derive the values of entropy - the degree of uncertainty of the analysed events.

The first stage of the experiment consisted of establishing the emotiogeneity scale of events. Six categories of injury severity were introduced to the subjects: (1) micro-injuries (allowing to continue the work), (2) slight injuries (resulting in impaired performance for a day or a few), (3) injuries of medium severity (prolonged impaired performance due to some organic damage), (4) severe injuries (serious malfunctioning or damage of the requiring a course of medical treatment), (5) crippling injuries (i.e. incapacitating the person either totally or partially for work), (6) injuries ending in death - the lethal outcome.

Each subject was given a sheet of plotting paper with the axes of coordinates of 10 cm. The horizontal axis represented the emotiogeneity level of an event graded into 6 degrees of accident severity. The subjects of the experiment were to plot their esimates of the degree of severity of the cases under discussion in this axis.

After completing this task the subjects were asked to assess the occurrence probability of the same cases and plot them on the vertical axis of the graph representing incidence probability in per cent. The experts were to specify the probability of occurrence in per cent of each entry evaluated as frequent. Thus a graph was plotted to represent the correlation between the degree of severity and occurrence estimates of industrial accidents.

The statistical treatment of the material resulted in a graph (Figure 1) representing the mean values of the severity assessments of the industrial accidents analysed (emotiogeneity assessment) plotted against the mean assessments of their occurrence probability provided they have been considered "frequent". The confidence limits are given for the severity scale as well as for the points on the curve $P_f(S)$. The significance level is equal to $\beta = 0.999$. As it can be seen from Figure 1, the actual points at the emotiogeneity scale are distributed nonlinearly and are highly statistically different.

Analysing the obtained curve $P_f(S)$, one may conclude that the subjects regard events as "frequent" not only on the basis of their occurrence probability, but also with due regard to their emotiogeneity. It may be also concluded that

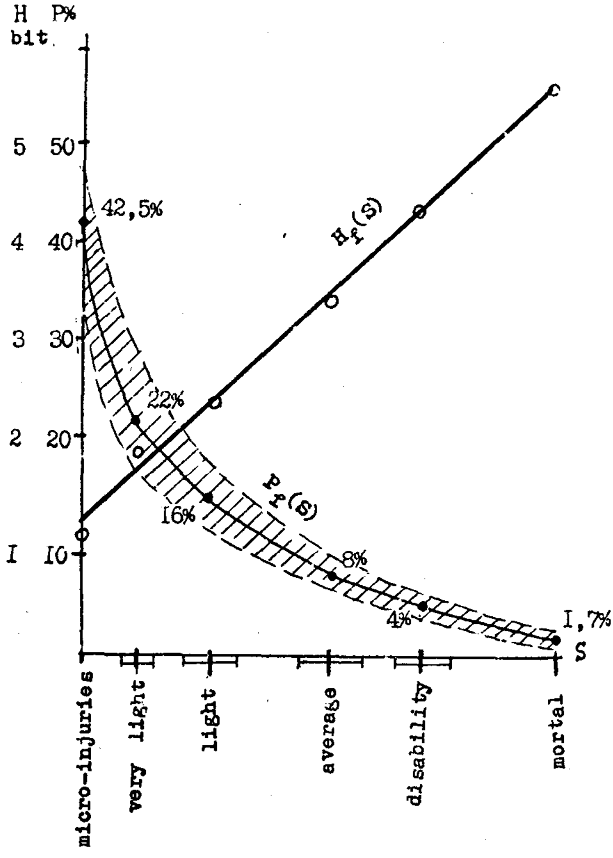

Figure 1. The effect of the degree of hardship of accident on the conception of uncertainity of this event (given the expectancy that this event occurs "frequently").

emotiogeneity has a rather substantial influence on the evaluation of occurrence probability. E.g. the probability of a micro-injury is regarded "frequent" when its occurrence probability is 42.5%, whereas in case of severe injuries 8 per cent of occurrence probability will suffice to consider it frequent. Accidents with lethal outcome are evaluated as "frequent" in case their occurrence probability exceed 1.7 per cent. Consequently the more emotiogenic the event is the smaller are the values of occurrence probability that specify the case as frequent. The analysis of the obtained curve $P_f(S)$ has shown that it approximates fairly well to the logarithmic function.

As it has been noted before, the assessment of occurrence probability constitutes a preliminary stage in the present investigation. Here we are mainly concerned with the characteristics of uncertainty - the entropy of events. Event occurences estimates were recomputed into probabilities (p), and the latter - into entropy indices according to the formula $H = -\log_2 p$. The new averaged characteristic $H_f(S)$ obtained by $P_f(S)$ data transformation constitutes a correlation of the entropy of events with their emotiogeneity of "frequent" occurrence. As it can be seen in Figure 1 this dependence is linear; apparently the entropy is growing proportionally with the emotiogeneity of events. The results gained support the preliminary hypothesis that not only stating the degree of failure probability but also dangerousness connected with it determine task uncertainty assessment by an individual.

4. Dangerousness, its probability assessment and uncertainty of task

The experiment described above shows the dependence between emotiogeneity of events and their uncertainty assessments given that the events are evaluated as "frequent". In other words a functional dependence $H_f(S)$ between certain factors was established. In the next experiment the task to establish the relationship between the same parameters (H and S) for cases assessed as "rare", "very frequent" or "exceptionally frequent" has been set. The experiment is a continuation of the previous one. The procedure was analoguous to the previous one except that the frequency of occurrence was assessed "rare". Analoguously a new curve $P_r(S)$ was obtained.

Two more curves were given characterizing very frequent ($P_{vf}(S)$)and exceptionally frequent ($P_{ef}(S)$) events respectivelly. All in all four curves to characterize the different levels of occurrence probability P(S) are mapped out by each subject.

After the statistical treatment of the data a family of averaged curves P(S) was developed (see Figure 2). The same figure also presents the recalculated characteristics H(S) reflecting the functional relationship between the emotiogeneity of the events under consideration and their entropy for the respective conditions. All these characteristics turned out to be roughly linear with the statistical difference of the significance level of $\beta = 0.95$ (according to the Dixon-Massey "sign test" 1957).

From the obtained characteristics it is possible to conclude that independently from the expectancy level a dangerous event is considered to be the more uncertain, the more emotiogeneity it displays. At a certain level of accident severity the event seems to be the more uncertain the less its expectancy,i.e. occurrence probability is. The conclusions that events evaluated to be rare are thought to be more uncertain as well should be termed trivial. But within the present discussion it should be important to show the mutual influence of the factor of emotiogeneity and the idea of uncertainty in assessing dangerous events. As the factor of emotiogeneity increases the degree of uncertainty (entropy of an event) then the factor of frequency of occurrence,inversely , diminishes this entropy.

As it was shown by P.V.Simonov (1970), the emotions, evoked by a dangerous event depend not only on initial emotiogeneity but also on the subjective assessment of the uncertainty level. The greater the uncertainty of an event the less ready is the subject to face it. Thus dangerous events of high uncertainty should be more emotion-evoking as compared to events of higher certainty for which the subject should be prepared to some extent. Hence it is possible to speak about certain increase in the emotiogeneity of dange-

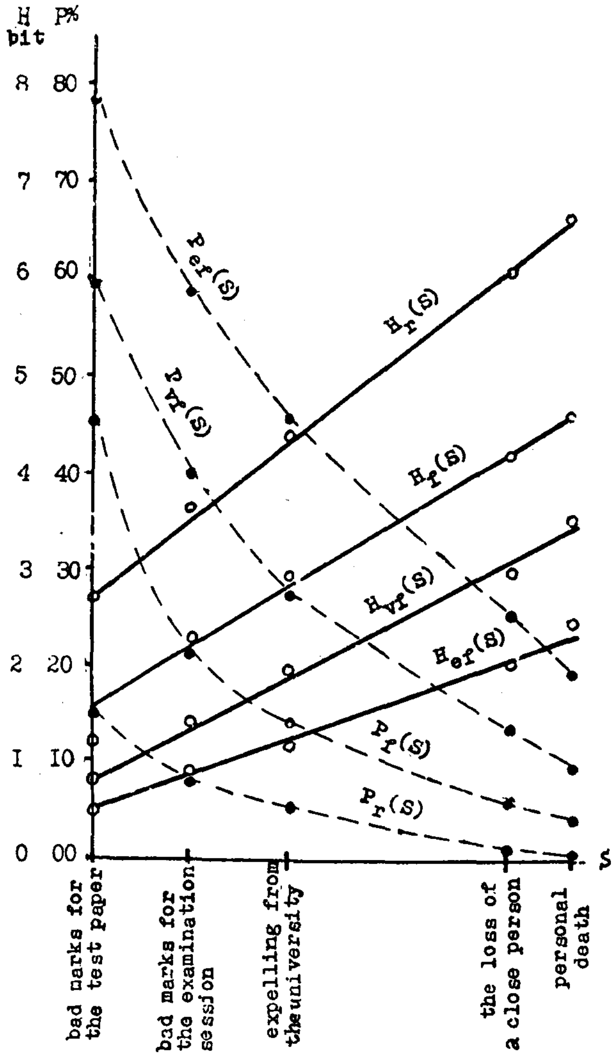

Figure 2. The effect of the degree of event's physical dangerousness on the conception of its uncertainity for different levels of expectancy of this event ("rarely", "frequently", "very frequently", "exceptionally froquently").

rous events just due to the uncertainty of their occurrence.

As it was shown in the experiments described above the uncertainty of an event (its entropy) may be dealt with as a kind of measure of its emotiogeneity. The possibility of facing a dangerous event is reflected both in the subject's assessment of its uncertainty and, as it was shown by Simonov, in the degree of emotiogeneity of the event. A conclusion suggests itself that entropy of a dangerous event includes as its components the initial emotiogeneity of the event and the increase of the emotiogeneity caused by the factor of unexpectedness. All this is in good harmony with the hypothesis that the subject assesses the degree of uncertainty of a dangerous event (which can also be described as the subjective entropy of the event) not only through the assessment of occurrence probability but it should be remembered that the idea of emotiogeneity of the event is also involved in the process.

5. The algorithm

As it has been stated before the entropy of an event reflecting the subject's individual assessment of the uncertainty of the event realization possibility may at the same time be considered as a measure of the emotiogeneity of the event made up of its initial value and the supplement provided by the factor of unexpectedness. The functional relationship between the initial emotiogeneity of events (S) and the subjective expectancies (R) of their occurrence ("rare", "frequently", etc.) on the one hand, and their entropy (H) on the other hand has been expressed graphically on Figure 2. It is of interest to represent the analytical relationships of the entropy measure (H) as a function of two arguments - the initial emotiogeneity (S) of the events and their subjective occurrence expectancy (P). With this goal in mind we processed the data of an investigation by the regression analysis. The results show that H is related to S and R through the dependence

$$H = 3.753 + 0.704S - 0.316R,$$

The hypoyheses were statistically confirmed at the level $\beta > 0.999$.

The dependence holds on condition that the range of event emotiogeneity (S) lies between 3 (i.e. the micro-injury) and 9 (i.e. death). As seen in Figure 1, the cases of slight injury have been taken for an average emotiogeneity value equal to 3.8, the cases of injury of medium severity for the emotiogeneity values of 4.9, and the remaining two subgroups representing cases of severe injury and cases ending in invalidism have been taken for the corresponding values of 6.3 and 7.5, respectively.

The scale of subjective expectancy of a dangerous event (R) also comprehended 9 levels: 1 - "never", 2 - "exceptionally rarely", 3 - "very rarely", 4 - "rarely", 5 - "neither rarely - nor frequently", 6 - "frequently", 7 - "very frequently", 8 - "exceptionally frequently", 9 - "always". In the present work we used only the values of the levels 4,6,7,8. It was on the basis of the evaluations of the events at these levels of expectancy that the algorithm was developed. It may be assumed that the same dependance can be applied to any level of occurrence probability assessment.Now let us return to the examples which started our discussion and with the help of the graphs (Figure 2) and the algorithm let us evaluate the levels of uncertainty of the examples given at the very beginning of the paper. For example in crossing the plank only a meter above the ground the subjects, should they fall it would result in a micro-injury and the probability of failure is assessed as "rare". In case of real failure the uncertainty that has been realized is equal to 2.7 bits. This value of entropy seems also to characterize the level of the emotional reaction evoked by the fall with a resultant micro-injury.

When the plank has been placed across a ravine the subject's assessment of failure probability must,apparently, be different. If we compare these situations further we may conclude that in case of failure with "rare" conditions the lethal outcomes are possible. With this condition (according to the figure 2 or the above algorithm) one can estimate the entropy of such an event as H equal to 7.3 bits. Actually, this is just the characteristic of resulting emotiogeneity of such a situation; the calculations show that the second task is more emotion-evoking this being sufficient to specify it as more uncertain a task.

However, another question can arise - is it possible to use the algorithm in some more general way? For example, to compare the same two tasks but as applied to different sets of hardness or expectancy of failure. In this occasion the second task should be evaluated on the basis of "frequent" diapasone (here the hard accidents are frequently expected) and the first one continues to be evaluated on the "rarely" diapasone (here the micto-injury is expected as a "rare" event). Using the figure 2 we can also pursue the next comparison: The entropy for the first task will be - H=2.7 bits, and for the other - H = 3.7 bits. And though the entropy for the second task appeared a bit higher as compared to the first one, nevertheless the difference (which is the base for evaluation of emotions concomitant with failures of first and second task) was already less significant. Analysing this, one can conclude that in the first task the increase in emotiogeneity was supported by the factor of unexpectedness (such events are rare here) while in the second task, on the contrary, the readiness for a failure of hard outcomes (such events occur frequently) causes the decrease of emotiogeneity of this event. Despite of this kind of explanation it is difficult to imagine that the factors of unexpectedness-readiness scale can so substantially influence the uncertainty of such different events as "micro-injury" and "heavy injury"; it is hardly possible that these factors have the capacity to cause the equalization of their uncertainty levels so strongly.

Our position is that with contrasting the levels of resultant emotiogeneity of events by the means of entropy measure we have to confine ourselves to the examination within the same single level of expectancy until the more convincing data about the generality of the curves found will be obtained. There is not foundation enough at present to argue that between the separate parts of experiment the above relationship must exist. However, the reverse might be assumed also, viz. the possibility of the fuzzy sets of expectangy of a dangerous event being functionally related within themselves, and this should integrate the different parts of the experiments into the solid system.

6. Social and material dangerousness.

In the present investigation we are discussing the problem of subject's relation (attitude) to the dangerousness of physical injury. But in the everyday conditions of human activity there are other kinds of dangers which can trouble a man no less than the physical threat. In particular, the social troubles and sanctions a meant here. Naturally, the question arises - do the obtained principles are analogous when we consider the social danger? In order to get an answer to this question the special experiment was done the students being subjects. The experiment was analogous to the previous one except that the social, not the physical dangerousness factors were evaluated. The next normalized categories played the role of dangerous events : (1) getting bad marks for a test paper, or at a seminar, (2) getting bad mark in an examination session, (3) expelling from university, (4) the loss of close person, (5) personal death.

In doing experiments of this kind (which include the subjects expression of opinions towards some events in a verbal form) it is important (cf. Osgood,1957) to arrange the events on a scale of values which rise monotonically. It was supposed that events under evaluation were arranged according to the increasing emotiogeneity.

The same kind of plotting paper sheets with the drawn axes of coordinates were given to the 40 subjects. They had to locate the events of intermediate levels of dangerousness on the scale between its endpoints analogously to the previous procedure. Further on each subject initially drew the curve $P_f(S)$ for the "frequent" condition, and after that the analogous curves for the conditions of "rarely" ($P_r(S)$),"very frequently ($P_{vf}(S)$) and "exceptionally frequently" ($P_{ef}(S)$) were drawn. After the statistical analysis of all of the characteristics developed by all subjects the four averaged curves P(S) for the different levels of event dangerousness actualization were built up. These curves are depicted on the Figure 3. As it is apparent, the form of the obtained curves is close to the logarithmic function and the curves themselves appear similar to those

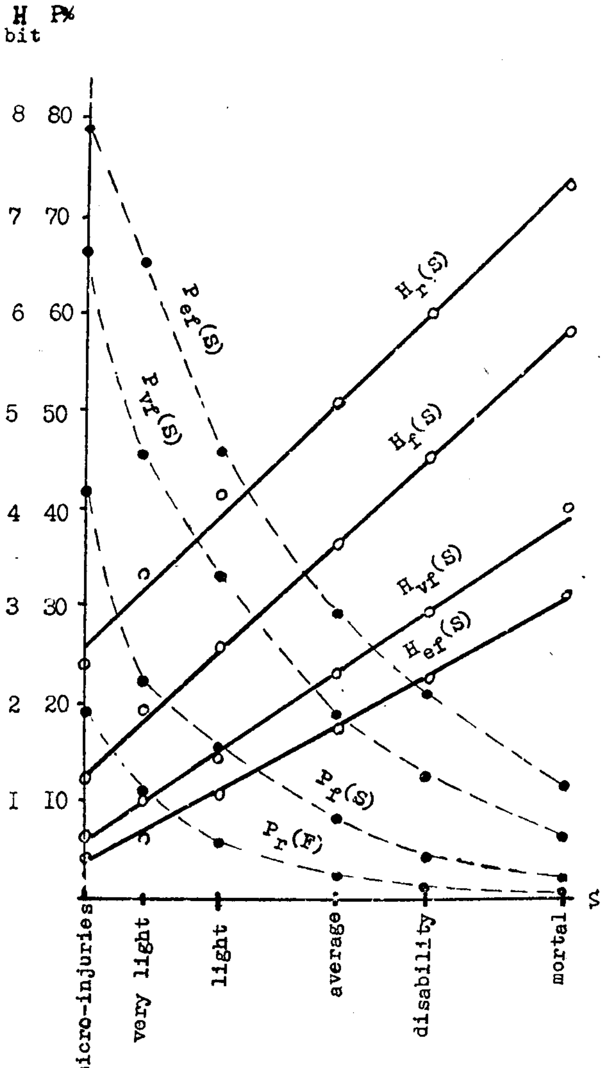

Figure 3. The effect of the degree of an event's social dangerousness on the conception of its uncertainity for different levels of expectancy of this event ("rarely", "frequently", "very frequently","exceptionally frequently").

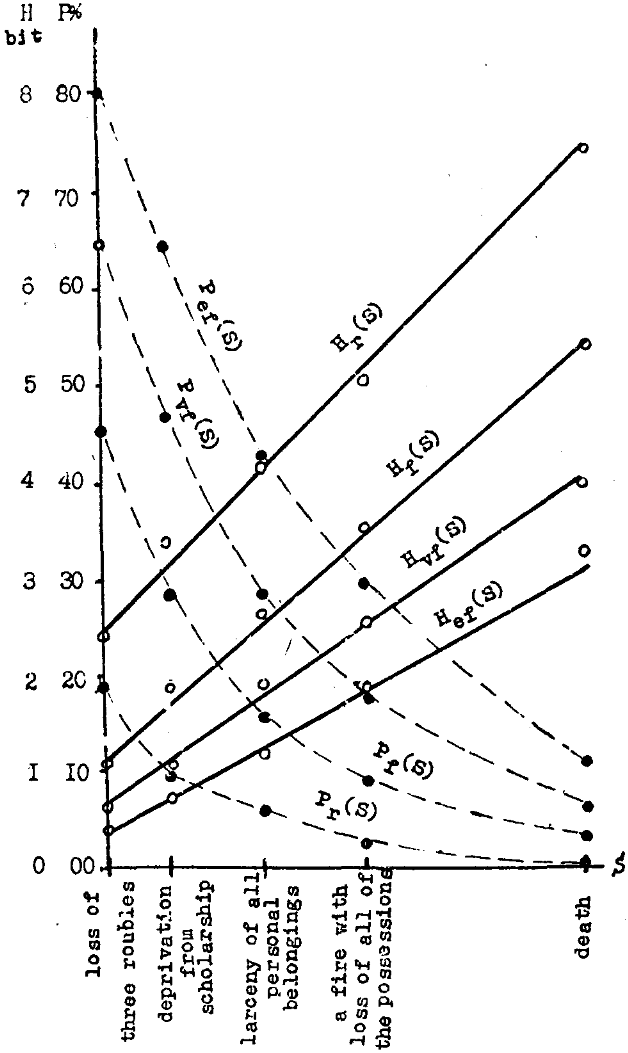

Figure 4. The effect of the degree of event's material dangerousness on the conception of its uncertainity for different levels of expectancy of this event ("rarely", "frequently","very frequently", "exceptionally frequently").

of the previous experiment (see Figure 2). At the Figure 3 the recalculated dependencies of H(S) for different levels of social danger are represented which, analogously with the earlier curves for physical danger, appeared to be almost linear.

Thus the conclusion should be that the above principles which had been revealed with the categories of physical danger, are applicable to the evaluation of human conceptions (ideas) of social dangerousness as well. To enhance the persuasiveness, we decided to repeat the experiment with the categories of the material danger.

The third group of subjects was used. Because it was required to evaluate the various material losses in this experiment, the group of extramural students of the psychology department having a profession (engineers, physicians, teachers, etc.) and having experience of employment acted as subjects. It could be expected that these relatively well-insured subjects can evaluate the different material threats with sufficient precision.

The next categories were normalized and evaluated: (1) loss of three roubles, (2) deprivation from scholarship money for a semester, (3) larceny of all personal belongings, (4) a fire with loss of all of the possessions, (5) death.

7. Comparing the different kinds of danger

The subjects (40 persons) performed the procedure analogous to the previous ones. As a result (see Figure 4) the family of curves P(S) and characteristics H(S) for different levels of expectancy of considered events was developed. The graph represents a picture rather analogous to the depictions at figures 2 and 3.

Special attention should be drawn to the comparison of the characteristics of three different modes of danger - the physical, social and material danger. First of all, we should mention that in each of the three experiments done we wanted to present the subjects with a diapasone of dangers being approximately equal (from the psychological point of view). Departing from the hypothesis that the index of uncertainty of an event indeed reflects its emotiogeneity (given the degree of expectancy), then, as it follows from the figures, our assumptions are not mistaken. Actually, the different groups of subjects specified the minimum dangers with uncertainty value which was roughly the same : H=1.1-1.2 bits at the "frequent" level, H = 2.5-2.7 bits at the "rare" level, and H = 0.5-0.8 bits at the "very frequent" level.

Let us now compare the evaluations of the mortal dangers as taken from the different experiments. Here again the considerable analogy can be observed : at the "frequent" level the lethal danger is specified by uncertainty values of H = 5.3-5.8 bits in all experiments, at the "rare" level H = 6.7-7.3 bits, and at the "very frequent" level H = 3.5-3.9 bits.

On the basis of the obtained graphs it can be concluded that the emotiogeneity scale event of expelling from university roughly equals the injury of the level between the "medium" and "heavy" points, or material loss at the level between "larceny of all belongings" and "fire with loss of possessions". And all these dangers correspond to the uncertainty of about H = 3 bits at the "frequent" level, at the "rare" level H equals about 4.5 bits, at the "very frequent" level H = about 2 bits, and at the "exceptionally frequent" level H = about 1.3 bits.

8. Conclusions

In sum, the investigations conducted enable us to reach the conclusion that the revealed relationship between the degree of emotiogeneity of a dangerous event, the level of expectation of its realization, and the uncertainty of a task presuming such an event, appears to be rather general. We have shown that there is the possibility of quantitative comparison of dangerous events of different origin and level of emotiogeneity on the basis of uncertainty (given the present level of expectancy).

How can we evaluate the importance of our results? It seems that in this way the possibilities and methods to estimate the uncertainty factor in the domain of human performance featuring different tasks can be founded. And these estimations outspring not only from the expected probability of their realization, but from the actualization of the dangers, stemming from the mistakes admitted as well. Present conclusions might have important theoretical and applied meaning for various fields of psychology such as engineering psychology, work psychology, psychology of management , etc. On the other hand, these conclusions could be applicable in some cybernetical domains and, in particular, when constructing and designing robots. Above we have mentioned that uncertainty of a task for a robot is specified solely by the probability of non solving while the topic of emotiogeneity (and related problems) is clearly odd just here. Yet this is substantial shortage of machines which have assimilated some human functions. Whereas the machine - when solving different problems and tasks - does not consider their meaningfulness and may resist solving the vital as well as second sort of the tasks with the same probability, then, as a rule, the tasks of great responsibility are not for it/him. In this respect the main advantage of a man, as compared with machine, is his capacity to consider not only the possibility of a mistake but also the following dangers. Departing from this a man has capacity to perform the most important and dangerous tasks with special attention and diligence. As it was demonstrated above, the factor of task dangerousness is the inevitable ingredient of human conception of task uncertainty and complexity .Such a resulting uncertainty can be expressed quantitatively . Having this kind of estimate at hand, one can rise the problem of surpassing the dangerous and responsible tasks to machine but with the caution that it/he, in accordance with the resulting uncertainty of a task could automatically re-set on the higher degree of precision and certainty as it were to be done by its/his employer when he himself had solved this task . In other words, the possibility of obtaining the resulting index of the task uncertainty which takes into the consideration the cost of possible mistakes, enables us to forward the idea of development of robots functioning with the changing degree od precision and certainty. And these output measures being automatically controlled in accordance with the given uncertainty.

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О ВЛИЯНИИ ФАКТОРА ОПАСНОСТИ НА ПРЕДСТАВЛЕНИЕ О НЕОПРЕДЕЛЕННОСТИ ЗАДАЧИ

М.Котик

Р е з ю м е

В статье экспериментально доказывается,что фактор опасности повышает субъективную энтропию задачи. На основе экспериментальных данных устанавливается количественная зависимость энтропии задачи как функции двух аргументов - субъективной оценки уровня опасности задачи и возможности реализации этой опасности.Доказывается, что полученная зависимость справедлива не только для физической, но и для социальной и материальной опасности.

TACHISTOSCOPIC SEARCH AND QUASISELECTIVE SACCADIC ADAPTATION : SOME STEPS TOWARD A PSYCHOPHYSICAL TEST OF SENSORIMOTOR INTERACTION

T. Bachmann

Abstract. A method for studying the relationships between afferent and efferent subsystems of perceptual information processing is described. It consists of permanent quasiselective (unidirectional in polar coordinates) saccadic eye movements executed by subject in total darkness - this all preceding to the short exposure of four test numbers among which the subject had to search out the target item which he knew beforehand. This saccadic adaptation was thought to "exhaust" the hypothetical neural units responsible(at some stage) for controlling the direction of the functional focus of spatial information processing. In general it was found that while the targets at the test-positions spatially orthogonal to or concomitant with the direction of first "outwards" saccade (with regard to the central fixation) were detected with roughly same effectiveness, the detection of the targets at the positions spatially opposed to the direction of the first saccade was less effective. This result points to the possible interaction of the sensory and efferent mechanisms in the course of selective information processing even without explicit scanning of visual target field. Some possibilities of explanation and several methodological problems are discussed.

1. Introduction

One of the major problems in the field of information processing research is the problem of selectivity: how and at what conditions the important signals (stimuli) are selected; what the characteristics and prerequisites of this selective process are. Frequently researchers have searched for answers investigating the relationships between sensory and motor subsystems active at data processing. Indeed, for example eye movements are shown to be good indicators of overt or covert behavioral and/or mental acts of selection (cf. Yarbus, 1965; Zinchenko & Vergiles,1969,1972; Goldberg, Wurtz, 1972;Crovitz, Daves,1962; Hall,1974; et al.) . Yet the problem of whether the spatially selective eye movements are directly or indirectly connected with the selective perceptual process in case of the retinal sensitivity variable being controlled (image stabilization and tachistoscopic displays) is of interest to day. There are several incompatible hypotheses concerning the above problem. Nissen, Posner and Snyder (1978) outlined the four possibilities of interrelationships between the internal processes of attention and the saccadic eye movements: (a) complete interdependence due to the common mechanism, (b) the efferent theory of attention, (c) the functional relationship, and (d) complete independence. The first possibility seems to be accepted by Zinchenko and Vergiles (1969, 1972). Their basic experimental method employed retinal stabilization of the test images which were the material to be scanned by observers who were performing several special visual tasks (e.g. finding a path through the maze or searching for familiar stimuli). The main finding was that in this case of anatomical fovea being "helpless" the subject (S) experienced that a sensitive focus moved over the visual pattern helping to solve the task as if it were done by the actual successive focusing of gaze on the ever new portions of the visual field. The crucial point here was that the movement of this "functional fovea" was possible only if the directionally "adequate" eye movements of lower amplitude were performed. Zinchenko argued that by these "vicarious perceptive actions" Ss were able to selectively change the sensitivity of certain critical retinal areas*.

The standpoints which equate the attentional mechanism with the efferent program for certain movements are expressed by Mohler, Wurtz (1976), Klein (1978; after Nissen et al., 1978), Crovitz, Daves (1962). Here, in order to move the attentional focus, no actual spatially analoguous eye movements are needed but the program or intention to move eyes onto the certain spatial zone must be activated. The third idea of functional relationship between mechanisms of visuo-

* In a recent personal communication prof. Zinchenko accepted the view that selective sensitivity modification might have some more central (iconic?) site.

spatial attention and eye movements relates them by some third factor, e.g. by important signal which influences independently the eye-movement and attention systems. These two systems resemble functional roles in organism's natural orienting behavior but they may as well function indepedently (cf. Nissen, et al., 1978), or, as Gippenreiter (1978) puts it, eye movements appear as possible indicators,not as mechanisms of perceptual or attentive processes. The possible independence of eye fixations from the actual movement of attentional focus is demonstrated in the experiments by Chuprikova (1974) and Engel (1971) when in case of central fixation Ss were effective at selectively directing their attention to various peripheral zones which resulted in the spatially selective enhancement of sensitivity to brightness contrast or sensory features.

Whatever the nature of relationships between attention and eye movements, there is little doubt,however, that - at least introspectively - some kind of selective attentional tuning to the needed spatial regions really exists even in an inner plane without explicit scanning by anatomical fovea. But how can this phenomenon be justified ecologically? We would outline the next assumptions concerning functional fovea: (1) The system of functional fovea may facilitate the actual eye movements towards an important object. Whereas often there are lots of stimuli then the selective "retouch"of one of them become an additional cue leading to the actual fixation of that object. Thus the "functional fovea" might be considered as the orienting phase of focal attention similar to the orienting reflex. The following events occur: certain signal is made different from others; then the (sub-) mechanism of orienting reflex is set on and as a consequence the different ("new") thing will be fixated. (2) In case of the selective processing of an important stimulus being started before its actual fixation the processing time is saved and the capacity of work at subsequent analysis of actually fixated object is reduced. (3) By the mechanism of functional fovea the wrong reactions could be forestalled . During the "retouch" of peripheral ambiguous stimulus its nonrelevance might be detected and the odd saccade can be prevented. If it were done, the contralateral side of visual field for example might have been left without any substantial sensitivity to potentially important signals. (4) It is possible that the perceptual system must perform several tasks in parallel. In this case the actual eye fixation may help to solve one task (e.g. granting the sufficiently sharp sensory image for the control of highly automatized task requiring no focal attention) while the peripheral processing can be guaranteed by the functional fovea. (5) Whereas the actual saccades are ballistic and the real scanpaths are "nonstable" and "angular", the functional fovea might have the role of compensating this as an "absorbing" or "amortizating" mechanism which grants the stability and higher smoothness of the dynamic image of environment. (6)The purpose of functional fovea could be the running functional correction of fixation errors (as it were the principle of "apparent motionlessness of fixation center"). Of course, the functional fovea may also be a result of phylogenetic development of NS where the intracerebral associations are organized so that the temporally trailing event - the enhancement of the processing exactness (leading to phenomenal clearness) of certain signal due to the fixation on it - became continuously extrapolated ahead the impulse which is responsible for fixation (so-called "vicarious anticipative conditioning").

It is clear that the previous assumptions presume the possibility of perceptual (input) selectivity - one of the massively disputed competing theoretical alternatives. Resting on the data about functional fovea (Zinchenko, Vergiles, 1969, 1972), about the principle of phasic (microgenetic) growth of percept (Lomov, 1966,Vekker, 1974), and on our own data about the differential enhancement of processing effectiveness of masked target and background items during tachistoscopic search with display energy as converging factor we proposed an explanation of how the perceptual selectivity or local "retouch" might be obtained (Bachmann,1977a). The main prerequisite was that in the processing hierarchy the stimulus signals are passed onto the higher levels (including category levels connected for example with name-given pretuning) before their processing at lower levels is completed and icon

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formation finished *. This simultaneous processing at extraction and interpretation stages enables the selectively pretuned standard (target-related information) to give facilitative feedback so that the features (including localization) which are connected with the target become processed more effectively during the yet-lasting process of icon formation. And one of the mechanism-candidates for such a feedback control which leads to the local iconic "retouch" of target and moving of functional fovea onto that zone is thought to be the generator of internal eye movement commands (cf. "address commands" as termed by Gordeyeva et al., 1972). Naturally,one of the prerequisites should be that the set of distinctive features of a stimulus might be associated through an integrating factor which makes a stimulus space-locked as a whole. But, actually, massive psychophysical data on perceptual channels point to the decisive nature of spatial localization factor in testing the work of different detectors. The further work (Bachmann, 1978) also did not exclude the possibility of interaction of feature-specific channels and spatially selectively directed processing focus in the process of selection. The experimental results were based on the selective adaptation (see Blakemore, Campbell, 1969)of Ss to the differently-oriented square-wave gratings before the critical test of searching the target - which represented an "outcut" ring of a grating of certain orientation - among the analoguous background items of different orientation. As a fact, orientation-specific adaptation interacted with the type of stimulus to be processed (target-nontarget) in a way pointing to the possibility of enhancement of sensitivity to the critical features by pretuning. But there was no direct converging on the efferent subsystems of processing. Our purpose is to describe a further method directed at the problem of selectivity and relying on the selective adaptation method. We

* Recently there were published several articles which express analogous ideas on this possibility of above given temporal relationships between processing at different levels (cf.Bachmann,1977b); McClelland,1979; Eriksen, Schultz, 1979).

raised the question, whether it could be possible to develop an "exhausting" of several selective units, which are connected with the control of saccades of certain direction, on the basis of selective adaptation to the unidirectional eye movements with the sensory factors being controlled. If indeed the "functional fovea" and/or spatially selective "retouch" during the search of critical stimulus are directed by certain efferent commands then we may expect the spatially-analoguous impairment of target detection after selective saccadic adaptation. This was the purpose of our experiment. Of course, methodologically there are some difficulties to obtain massively repeated unidirectional eye movements and so we had to be satisfied by the quasiselective adaptation in polar coordinates. Our Ss made back-and-forth saccades in total darkness on an imaginary polar vector connecting the central fixation and a peripheral guiding-mark of one of four possible directions. As it was, the saccades became soon almost automatic and so we hoped more or less to control the pure saccadic system.

2. Experiment

2.1. Method

Thirteen Ss (seven females and six males between 18-25) having normal vision participated in the experiment. They sat opposed to the display at the head distance of 35 cm. Their head was fixed by the head-rest. The stimuli were presented by the microprocessor-controlled display system "Psylab" with the aid of two types of light emitter diodes: the green seven-segment diodes (type AL-304) enabling the exposition of numbers from 0 to 9, and the red point-source diodes (type AL-101-V). The 13 point-source diodes (marked as F, a,b,c,d,e,f,g,h,i,j,k,l) were placed so as to form the eye-movement orienting structure and the four seven-segment diodes (marked as I,II,III,IV) were used for the presentation of test stimuli - the four different numbers from the alphabet from 2 to 9 - at four possible positions around the fixation F (see Figure 1). In the present experiment the luminous points of orienting diodes had the diameter subtending 0.1° of visual angle and the distance between neighbowing orienting points subtended 5° of visual

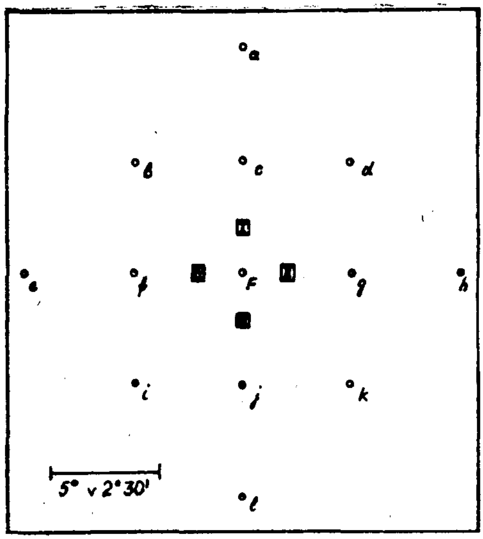

Figure 1. The principal structure of the stimulus display. With the letters a,b,c,d,e,f,F,g,h,i,j,k and l the frame of potential orienting points is marked, the F serving also the function of fixation point. With I,II,III and IV the locations of exposition of four test stimuli are marked

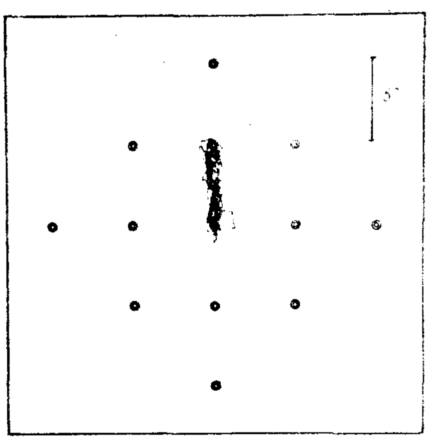

Figure 2. An example eye movement recording made during the typical (here vertical) saccadic adaptation session.

angle. The numbers subtended 0,3° vertically. The exposition-regime of stimuli (sequence, randomization, intervals etc.) was determined by the computer program* . The microprocessor 15-VSM-5 was employed.

The principal methodical idea of the present experiment required the selective saccadic adaptation with the sensory variables (especially the directional and localization ones) being controlled. This means that the saccades had to be made during total darkness and the each successive eye-movement-orienting pattern had to be retinotopically identical to the previous one. This was obtained by the following procedure: After the S having fixated the central fixation F (see Fig. 1) it was possible to switch on the orienting structure of 4 points - c,f,g,j. It could be the signal of the saccadic jump onto the one of the points according to the given directional instruction used within each of the experimental series.

Thus S had to move his eyes either up (c), or down (j), to the right (g) or to the left (f). However, this first pattern of orienting points was exposed transiently and so the saccade, initiation of which requires some latency (ordinally not less than 100 ms) was performed in darkness. After fixating on the supposed location of one of the orienting-points, say g, the new orienting structure (in the present example - d,F,h, k) might be exposed for a while and S makes a saccade back to the F, direction of this saccade with regard to the fixation being 180° opposed to the first saccade. With permanent repetition of analoguous cycles we should hope to obtain the quasi-selective adaptation of saccadic regime. So we could obtain the invariant retinal projection of luminous orienting points with the reservation in mind that the fixation errors are distributed (are clustering) equiprobably to all directions around the given orienting point thus balancing each other and that these errors are not too substantial. Indeed, in the relevant literature one can find that the Ss are capable of rather precise saccades (e.g. 20' value of fixa-

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* The author would express his sincerest thanks to dr. Jaan Huik for elaborating the program and for the very helpful discussions of problems concerned.

tion-error) in darkness relying on their stored memories for localization (Gourevich, 1971; Leushina, 1978; Becker,Klein, 1973; Matin,1976; Skavenski, 1976; Lennie, Sidwell, 1978). In a pilot study we also recorded the precision of eye movements in our experimental conditions and obtained sufficiently satisfying results (see Figure 2)*.

As it can be seen from the figure, the vertical saccades (as were the horizontal ones) are not absolutely straight but are somewhat curved. This is a common phenomenon described in special literature (Bahill, Stark, 1975a). The existing data showed also, that there is the possibility of sufficiently precise sustained maintenance of the taken fixation in the total darkness (op.cit.) Our pilot data showed also that after some 5-15 minutes of training Ss reached the skill of correct performing our procedure without too much effort. The fixation errors did not exceed 1° of visual angle but as a rule they were less than that.

After the last adaptation-saccade,when S fixates at the near F, the F is switched on followed by the simultaneous exposition of four different test numbers at positions I,II, III and IV. The exposition time was controlled by the electronic timer preset at certain temporal value before each of the series and switched on by computer command. The exposure times were chosen individually for each S relying on the preliminary training series. The times falled in between 20 and 60 msec. The S had to detect the localization of the target stimulus which he had memorized before the saccadic adaptation begun. The target alternative was initially shown as a number doubled in each of the four cells for test stimuli.

Ss' localization-responses were stored by the computer. There were 50% test-expositions which contained no target in order to maintain more strict criterion.

The luminances of the orienting points were 20nt and the luminances of the test-numbers were 10nt.

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* The eye movement recordings were done by the apparatus developed by V.Laurutis and K. Krisciunas, which represents an extended and improved variant of Robinson's (1963) method (see Laurutis,et al., 1977). Author wishes to thank dr. Juri Allik for the help with the use of the apparatus.

Four series were used in the experiment, each specified according to the saccadic adaptation direction employed within it. The sequence of events in each trial was as follows. A target number appeared for 3 seconds doubled within each of the four display cells for numbers and the S was required to **repeat** it aloud and to remember it as the critical target stimulus. Then the fixation (F) followed for 3 seconds and S was required to fixate on it. At the termination of F a primary orienting structure (c, f,g,j) was exposed for 20 msec and the S had to make a saccade in order to fixate (relying on his position-memory) one of the peripheral points according to the direction specified for each of the series. After 600 msec a secondary orienting structure (retinotopically equivalent to the primary structure) was flashed for 20 msec and S made a saccade to the F (see Figure 1). Then after 500 msec a primary structure was exposed again. By continuing this procedure repeatedly 30 back-and-forth saccade pairs were evoked. 400 msec after the last exposition of the secondary orienting structure (which included F) the F was switched on again. For 6 of the Ss the exposition time for F was 800 ms (group A) and for the 7 of the Ss this time was 300 ms (group B). All Ss within each group reported after training series that there was enough time to fixate on F before the test numbers appeared. Exactly on the termination of F four different test stimuli were exposed for time interval with value from 20 to 60 msec with unchanging individual value for each of the Ss. The task of the S was to locate the critical target stimulus. The responses were recorded by computer and the hit and false alarm rates for each position were calculated. It was stressed that Ss payed equal attention to all display positions witout any positional preference in order to obtain "the maximum score".

In each of the four series each S was given 240 trials including 120 trials without target exposition. Among the target-present trials the target was distributed equiprobably at wery location giving thus 30 occurrences of target at each location in random sequence. The order of series was balanced between Ss.

2.3. Results

The results were analysed as measures of d' for each type of localization with regard to the direction of adaptation-saccades. Thus three types of location were outlined: "Specific to adaptation, type I" (SI), "specific to adaptation, type II" (SII), and "nonspecific to adaptation" (NS). The SI represented the location in the direction of the first outward saccade from F. The SII represented the location in the opposite to SI or, in other words, in the direction of backwards saccade. The NS represented location orthogonal to the saccadic direction. The results are given in Table 1.

Table 1 . Values of d' for each type of target locus averaged for subjects from group A and group B

Type of target locus with respect to the adaptation saccades	Values of d'		
	group A (longer interval	group B (short interval)	Total group
SI	1.09	1.31	1.2
SII	1.06	1.09	1.06
NS	1.13	1.27	1.2

Unfortunately, the variant of the sign test of testing the difference in d' for NS and SII did not give unambiguous results and there were two Ss who showed higher d' for SII than NS. But the sign test showed that the SI gave significantly ($p < 0.05$) better results as compared to SII. In fact, we are able to speak only of tendencies of d'. As it can be seen from the table, generally the targets were detected worst at the SII location while the SI and NS yielded roughly equal performance. It is also apparent that with the inrease in the time interval between the last adapting saccade and the exposition of test numbers the SI and NS positions "change their roles" - the d' for NS drops less than the d' for SI .

The reason for SI being "better" position than NS at short interval might be the systematic residual fixation error in the SI direction at that interval. Indeed, as our eye movement recordings showed, the correct fixation at F was reached gradually by the very small corrective saccades or drift after the main high-amplitude saccade (see Figure 3).

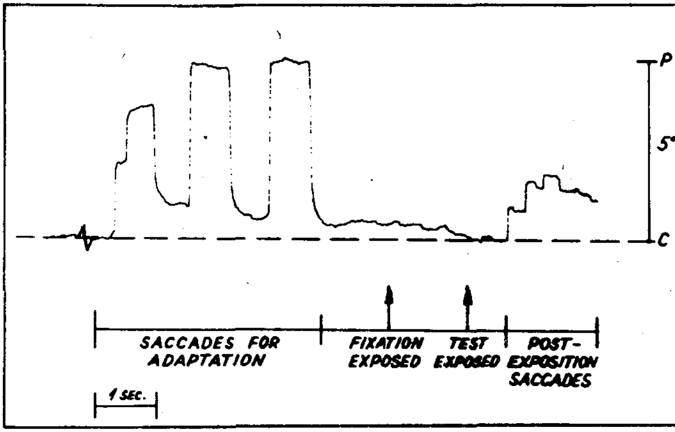

Figure 3. The principal succession of eye-movement performance with regard to the spatiotemporal variables of the method employed. C - central fixation; P - peripheral fixation.

The differences between SI and NS at both intervals are not so substantial however; moreover, whereas we speak of different groups of Ss then the discussion of the present problem should not be guaranteed totally by facts. Running all Ss through both temporal intervals between last saccade and test exposition was difficult because of some kind of unstability of the subjective experiences and tactics ("automatic" and "volitional") associated with the procedure of adaptation itself. Whereas there could not be too many trials a day (long adaptation before each trial and proneness to fatigue under this procedure), we decided to use the independent groups method which seemed applicable for taking the preliminary steps towards revealing the most-convinient conditions of the new technique. So, what follows, is mainly the discussion of the methodological problems and of the possible conclusions from the average d' measures for all Ss.

3. Discussion

It is generally accepted now that in information processing there are two main phylogenetically developed subsystems - the spatial orienting system and the fine pattern discriminating system (cf.Ingle,1967; Schneider,1967; Held, 1968; Trevarthen, 1968; van Galen,1974).This idea of "two visual systems" or ambient and focal processing has strong functional parallels in the recent dichotomy of transient and sustained channels (cf. Breitmeyer, Ganz, 1976). It is clear, that to find an answer to the questions about selectivity we must investigate just the interplay of these two systems - the one, which gives the field of choice, and the other, which focuses on a chosen stimulus. There have been considerable progress in doing this by neurophysiological and neuropsychological methods (e.g. the works of Goldberg,Wurtz, 1972; Mohler,Wurtz, 1976; Singer, 1977; Mountcastle, 1978). In the mentioned works by R.Wurtz and his colleagues, the microelectrode techniques were used to investigate the primate superior colliculus neurones at selective functions, and rather clearcut and precise descriptions of processing mechanisms were obtained. Due to the considerable analogy of the monkey and human brain we certainly are able to reach at rather broad conclusions about the similar functions in humans. Nevertheless, there should additionally be some means of direct control with humans on the one hand, and on the other hand - we can never be totally sure that monkeys are doing just that what men are when we speak of attention. But whereas the possibilities of direct electrophysiological studies of normal humans are hardly possible, we should use some indirect psychophysical methods to reach hypotheses about inner processes by running Ss through behavioral tasks including selection.

While the inner plane of sensory functions has been well studied psychophysically (e.g. the vast amount of various selective adaptations to sensory conditions), the inner plane of motor functions have received somewhat less attention in the psychological works.

It is clear,that one of the general functions of two above-mentioned systems is to set up a goal-directed control system featuring an outer feedback loop . The main source of mismatch signals is the sensory pole of any subsystem; the corrections being done by efferent pole (e.g. eye movements). And just this variant of feedback is mainly investigated - a signal from sensory source directed at efferent links. But another variant leading to another problem exists - is there any inverse possibility?Are there any selective controls from efferent side to the sensory functions in an inner plane? Is the selective spatial attention serviced only by the effective outer adjustments of sense organs or are there any vicarious movements of sensitivity? We supposed this possibility exists (cf. also Posner, 1978; Kahnemann, 1973) and tried to investigate it by the selective saccadic adaptation in special conditions directed at not confounding sensory and motor factors.

In the literature some facts about consequences of efferent adaptation are described. Bahill and Stark (1975)showed considerable changes in neuronal firing patterns paralleling saccadic eye movements as the S fatigues. (The overt form of eye movements changed as well). Whereas our own design used not too large saccades (5°) and whereas the clear signs of fatigue for 10° saccades appeared after more than 30 cycles in Bahill and Stark study,the numerosity value of 30 adapting saccades in our experiment satisfies the requirement to reach at some border condition giving some fatigue but not considerably changing the overt saccadic regime. This was needed for reserving a S with enough time to reach the correct fixation and not to change the type of adapting movements.In the investigation by Rosenbaum and Radford (1979) a method of selective adaptation of "command neurons" in the human motor system is described. A critical point was that adaptation effects were revealed by active rather than passive movements.In our design the movements were deliberate and represented a response to certain special cue.

What were the principally possible outcomes of our adaptation procedure? Or to put it more frankly - what are we adapting by repeated quasiselective saccades without varying the sensory conditions? There are several functional possibilities of outcomes. 1. The fatigue of the vicarious system for selective spatial attention with regard to the initial (and final) point of fixation in the general context of the direction of sensorimotor activity. This was the aspect for which the requirement of truly selective adaptation was satisfied. Actually this variant was ruled out by the fact that just the SI positions which were connected with the saccadic targets, gave high target detection rates. 2. The tuning of this vicarious system and enhancement of its sensitivity. This possibility was ruled out by the fact that SI and NS gave practically equal target detection effectiveness. 3. The fatigue of subsystems which direct spatial attention with the aid of single saccadic commands. The case of this fatigue being accumulated independently for both saccadic directions is not real, because in this case we should have the results at SI as well as at SII being both worse than at NS. But if we suppose the system of spatially opponently connected (180° opposed in the retinotopical sense of mirror symmetry) efferent units then we should expect the process of alternate exhausting and releasing of the given unit with final state generally at the initial "zero" level. In case of this being possible we might also suppose that the units for position directionally relevant to the last saccade (in our case the SII) remain exhausted cf. not yet released at the moment of test numbers exposition, this being in contrast with the state for SI which has been released due to the last saccade to SII. So we could obtain our actual results. Another implication of this principle is that it is not possible to obtain ever increasing spatially selective sensory impairment because of this "seesaw" principle. Our pilot observations with different adaptation cycles gave some support to this idea. Thus it is not impossible that we are just speaking of spatially selective saccadic suppression if only the direction of the last saccade turns out to be a critical factor and not the fact of sustained adaptation. Some support for the above ideas comes also from the investigation by Singer et al. (1977)who showed that saccade to some target is capable of resetting the adaptation of the mirror symmetric area to that target zone.

Of course, there are several possibilities of combination of the above functional mechanisms. The most plausible variant is the conjoint effect of tuning and selective fatigue. For example, the possible SI position's still-accumulating fatiguing adaptation might be compensated for by the tuning effect. Hence the rough equality of NS and SI.

It is clear, however, that it is necessary to develop some additional more precise experimental controls and converging operations in order to converge on a strictly specified structural units of the whole sensory-motor processing system. One important task should be to differentiate (and to experimentally control) between the following stages of saccadic programming (cf. Huik, 1978): 1. The pattern processing during which the number and/or localization of possible targets is determined without too detailed processing (cf. also Levy-Schoen, Blanc-Garin, 1974). 2. The intentional or spontaneous choice of fixation. 3. The programming of saccade parameters. 4. The esimation of the inhibition parameter for the saccade. It is clear, that each of these stages has some structural system of its own, and they are working highly automatically, as it is argued by J.F. Huik (1978). Bearing this in mind we should suppose that in our conditions there could be little effect on the intentional mechanism of the second stage because soon there become not that what to choose - with unchanging fixations saccades became quasi-automatic. Also we are not too selective as to the first stage. The most probable sites of possible adaptation could be the unintentional mechanisms of stage 2, and the stage 3. Indeed, our Ss gave here some objective and introspective evidence of variability and hence the need for permanent control of saccade parameters in the total darkness conditions. (Maybe in order to obtain adaptation at stage 2, which we consider as the important unit for our present selectivity-problem, it would be desirable to introduce a variability into the factor of locations of the orienting points which then might form the zones of adapting guiding-marks within some general direction; both, the directional and amplitude gradients could be used).

The rather plausible neurophysiological site for stage 2 might be the superior colliculus (cf. Goldberg, Wurtz, 1972;

Wurtz, Mohler, 1976; Singer et al., 1977). In particular, the data demonstrated that the collicular responses to the stimulus which was the target for a deliberate saccade were considerably enhanced already before the actual saccade was executed. In other words, the probability and extent of transmission of information from the neurones with receptive fields containing saccade-targets (which were not always actually fixated - cf. Goldberg, Wurtz, 1972) is enhanced . Singer et al. (1977) gave rather convincing discussion that humans might have an analogous tectal system which could be the basis for spatial selective attention. However, as Wurtz and Goldberg (1972) demonstrated on the basis of lesion experiments, this system seems not to be too precise in target location. It can rather be considered as the system for general attention shifts.So it is not clear whether this system could be used for exact choice of the point of fixation and so our stage 2 has probably some additional neurophysiological structural equivalents.The functional role of superior colliculus as mediator of orienting just at far periphery, which is demonstrated by Butter et al. (1978) , neither allow us to take it as the sole substrate of fine attentional tuning.

In addition we accept the idea that the mechanism of spatially directed attention has its important physiological counterpart in the parietal cortex (cf. Mountcastle, 1978 ; Yin, 1978; Yin,Mountcastle, 1978; Lynch,Mountcastle,Talbot, Yin, 1977; Batuyev, Tairov, 1978).Already in the 1876 D.Ferrier described the cases of parietal electrostimulation leading to the eye movements.It is widely known that the parietal lesions destroy the visual orienting,the goal-directed motor acts.Especially relevant for our discussion in the light of two main visual systems is the fact that parietal lobe receives afferents from tectal as well as from the geniculo-striate pathways having detailed retinotopic organization. The precise analysis of parietal units revealed many special types of cells located in this functional zone.These cells may be specific to: visual attention to food, appearence of new objects, the slow eye pursuit (tracking neurons), visual fixation at motivated objects, visually evoked saccades which discharged approximately 70 ms before an actual eye movement (Batuyev, Tairov, 1978; Lynch et al. , 1977).

The important point here again is that in general the units are not related to the motor reaction per se but only to those activities connected with motivation or attention; they show visually evoked discharges. It is also interesting that both attention shifting and maintaining functions are represented by the parietal units. According to Yin and Mountcastle (1979) the cortical area 7 should be taken as a major point of sensorimotor integration controlled by motivational factors. Moreover, it is thought to be an integrator of monomodal sensory inputs from body and environment into the heteromodal unitary multidimensional image (Batuyev, Tairov, 1978). Of importance to our discussion is the fact that parietal areas have close functional relationships with inferotemporal zones (Batuyev, Tairov, 1978) and so the connectedness with the memory functions for patterns analysed in addition to the connectedness with the limbic motivational structure enables us to speak of the relatively autonomous system for data analysis featuring recognition-, evaluation-, and selective functions .

In the light of our previously discussed model (Bachmann, 1977 a,b), the preliminary tentative recognition of stimuli which is performed before the processing at lower levels is finished, saves enough time for using the efferent subsystems in order to amplify selectively the still lasting lower-levels processing at the target locus. The discharges which were observed substantially before the moment when the actual saccades were realized might reflect the work of mechanism which could be the source of vicarious selective "retouch". In general, the " coarce spatial frame" of actual stimulation might be given by the tectal-perietal visual system (1), the parallel continuously lasting build-up of fine representation is probably performed by the geniculo-striate-inferotemporal system (2), the evaluation and comparisons might be done by parietal-limbic (3) and/or parietal-inferotemporal (4) mechanisms, and the selective emphasis at target processing is executed by top-down control from parietal and tectal quasiefferent signals when the most-convinient real candidate-location for target is revealed by systems (1-4). The adaptive advantages of this vicarious principle of functional fovea are listed in the introduction above previously.

In any case our data as taken together, demonstrates either the perceptual (d'-measures!) selectivity in general at certain critical spatial zone relative to the central fixation and/or the existence of localization-tuning mechanisms with retinotopically mirror-symmetric opponent units capable of fatigue and resetting after single saccadic acts. It is important to mention that there was not any preliminary explicit spatial tuning of Ss. The instruction emphasised that attention had to be distributed equally over all stimulus positions. The spatially anisotropic effects were due to some implicit influences of set on local sensory processing (this set being transferred from the dominant efferent activity), or due to the selective exhausting of efferent control units as discussed above. It follows that the present method as used does not allow to conclusively settle the basic problem - the problem of relative independence of spatial attention and efference - because it leaves open the nature of exact mechanisms of the obtained functional relationships between sensory and efferent subsystems. Indeed, our data seem to support the idea of functional linking (cf. - Nissen, et al., 1978) of these systems but without unequivocal reference to some single stage or mechanism. The existing data on the possibilities of independent control executed over eye movements and spatial attention or perceptual functions (Nissen et al., 1978; Hallett, 1978) do not allow to converge conclusively either. Most plausible explanations should probably stem from the postulation of some mechanism integrating sensory and efferent signals by the means of some abstract retinotopically organized "screen" or "chart of foci" with motivation-connected sensory data being decisive in the whole sensorimotor activity; this all both in its outer-contour aspect and inner plane. The data by Andreyeva, Vergiles and Lomov (1975) include elegant demonstration where the Ss, when searching the visual field for perceptual objects through a narrow spatial window mounted on the moving eye by the Yarbus technique, had substantial difficulties in the deliberate carrying over the gaze after its "sticking" on an object which had been occasionally fallen into the region projecting through widow. I.e. if there are no other potential targets in the visual field ("empty field") the activities of saccadic commands at some level are inhibited. (In Andreyeva et al. study the minimum fixations in the above conditions lasted approximately 800-1000 msec and some of the Ss even refused to continue the search). This means that the mechanism of deliberate eye movements should be closely connected with the sensory analysis in that the activities of both subsystems must converge on common spatially defined stimuli in order to be optimized. Otherwise there are strong inhibition (cf. Andreyeva et al.,1975) or anomalies (cf. Hallett,1978) of the (saccadic) eye movement patterns.

Interesting research relevant to our problem have been conducted also by Barabanshchikov and Belopolsky from Soviet Academy of Sciences Institute of Psychology. They have developed a method of changing the nature of visual feedback during eye movements - again by the use of the modified Yarbus technique. There was an optical system (lenses or prism)within the suction cup enabling the permanent inversion of the sign of feedback or permanent variation of the magnitude of visual feedback. On a more general scale Vergiles, Barabanshchikov and Belopolsky (1976) have shown that the size of the functional visual field (deduced from the presence and size of the corrective saccades) is substantially determined by the task of an observer. Of particular interest are the cases of inverse visual feedback (see Barabanshchikov, 1979). One of the basic features of this technique is that Ss are practically unable to totally ignore the visual "unexpected" events paralleling eye movements - the moving of visual field 180° opposite to the normal direction. Most of the time the eye shows nystagmic reactions or sinusoidal oscillations. This again points to the crucial role of sensory stimuli in controlling the efferent activity which hardly executes totally autonomous work. In a more recent article (Barabanshchikov, Zubko, 1980) the ambivalent visual feedback was given to Ss who could either attend to the outer visual field through a prism-cup system giving negative feedback, or to the objects mounted on the cup (with zero feedback). Depending on the attention focusing (not perception in conventional sense) the eye-movement patterns changed drastically - nystagm manifestation observed with the "outer" attention and oscillations with attention to stimulus with zero feedback. This again means that depending on the task the visual system can use different sensory data to change the oculomotor patterns or, in other words,"...the relationships between attention and efferent tuning of eye movement system are of complex and ambiguous nature" (Barabanshchikov,Zubko, 1980, p. 223).But, nevertheless, the gain in the relative degree of freedom obtained in this procedure relyed on the additional variant of sensorimotor feedback granted by this condition.

The facts exist that the pure sensory signals eliciting spontaneous saccades neither are the sufficient elements to describe the basic mechanism of attentional control; the motivated or volitional state should accompany the saccades in order to obtain the neurophysiological indices of relatedness with (pre-) attentional system (Mountcastle et al.,op. cit.). And on the other hand,the efferent processes alone do not account for the data. In particular, Singer et al. (1977) have shown that the saccades which have desadapting effects on the mirror symmetric visual spatial zone and which are considered to be related to attention have their effects only if being directed to some sensory stimuli. In the parietal cortex the units connected with saccadic control manifest their activity mainly when the saccades are visually elicited (Batuyev, Tairov, 1978).

Thus we are faced with the system which is testable in functional terms rather than with reference to a fixed single structural unit. And hence the methodological problems which seem to reduce the value of our method. The main shortcomings we can outline are the following. The procedure of saccadic adaptation in our present variant certainly leaves open too many alternative possibilities of functional interpretations.And several of them may have influences of opposite directions, as for example the possible selective fatigue of efferent units, development of conscious or unconscious spatial set, the possible saccadic suppression effects etc. Moreover,there are too many uncontrolled possibilities of actualization of experimental situation and performance structure on the S side, e.g. unrevealed hypotheses about the influence of actualized saccade direction on the perceptual performance.In addition to other problems, this may lead to the uncontrolled differences between Ss. So the method should be modified so as to obtain the more strict control on the actualization of saccadic regime.

Another problem is that,in the light of the fact that just the volitional eye movements are important (cf.Lynch et al., 1977; Singer et al., 1977; Goldberg,Wurtz,1972), we have no guaranty for stable Ss' motivation level through the experiment. It could be that soon the saccades become automatic and we do not know to what level our supposed adaptation can be applied. There can be some buffer channel for "direct access" bypassing any attentional mechanism.The degree of automatization is not precisaly controlled.

A weakness of the method is that the exposition of test stimuli is independent of the actual eye fixation. (This is not too uncomplicated a problem since the adaptation procedure should keep stable the intervals between the completion of adaptation and test exposition,but the reaching et precise central fixation should not be temporally stable).So the objection concerning our results might be that they are the consequences of "residual" biased fixation error towards the direction of first outwards saccade.But this argument could be weakened by the fact that several Ss who demonstrated substantial advantage of SI position over SII (what itself is in accord with the fixation error explanation) had NS-position effectiveness equal to or greater than SI-effectiveness.

One of the most serious problems is that we had polar adaptation on both opposite directions,i.e. the adaptation was selective in only one aspect.There were not unidirectional adaptation saccades. And if our idea of spatially opponent relationships ("the seesaw principle") between the units directing "functional fovea" is correct then we had not obtained any substantial adaptation in that functional locus.

In order to more precisely control the most of the listed ambiguous factors we would propose the possibility to use the phenomenon of fixational optokinetic nystagmus,i.e.the saccadic adaptation phase should be based on the involuntary <u>unidirectional</u> saccades traditionally observed when S is refixating a fixation point on the background of unidirectionally moving display(e.g.texture).In addition to the unidirectionality we can control the actualization diversity and volitional status.The saccadic regime becomes truly automatic, and actualization points to the conscious need for <u>central</u> fixation. An interesting possibility connected with the additional type of eye movement - the drift - will be added too. Now the spatial opposites will be just the different types of eye movement. Besides, the drift itself has appeal enough as a possible equivalent for overt attentional indice.(cf. Jung, 1978; Gippenreiter,1978). So we shall have just a means of converging operations in order to reveal the respective roles of two important eye-movement candidates for overt correlates of spatial selective attention given that the adaptation process can be effective.And,hopefully , we shall also recieve additional information in order to specify the meaning of the results of our present study.

The first stages of information processing undoubtedly include the processes by which the frame of localizations of stimuli is specified without detailed analysis of single items (Snyder,1972; Hepler,1977).On the other hand,no doubt that the important signals are selected afterwards with unimportant ones left without responses. Some introspective (cf.Zinchenko,Vergiles,1969,1972;Bachmann,1978) data convinsingly points to the spatially selective amplification of perceptual image on the target locus.And as we saw, most of the researchers admit the possibility that some spatially isomorphic efferent systems are connected with this process of selective retouch. But what are the precise mechanisms and deterministic relationships of this connection remains still an open question motivating the new research to be done. Our hope is that the methods following the line as dectibed in our present work could help to advance our knowledge of the discussed problem.

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ТАХИСТОСКОПИЧЕСКИЙ ПОИСК И КВАЗИСЕЛЕКТИВНАЯ САККАДИЧЕСКАЯ АДАПТАЦИЯ:К ПОСТРОЕНИЮ ПСИХОФИЗИЧЕСКОГО ТЕСТА СЕНСОМОТОРНОГО ВЗАИМОДЕЙСТВИЯ

Т. Бахман

Резюме

В предлагаемой статье описывается метод исследования взаимодействия афферентных и эфферентных подсистем переработки перцептивной информации. Данный метод состоит из постоянно повторяемых квазиселективных (однонаправленных в полярных координатах) саккадических движений глаз, выполняемых испытуемым в абсолютной темноте - все это предшествует кратковременной экспозиции четырех тестовых цифр, среди которых испытуемому необходимо найти целевую цифру, известную ему заранее. Предполагалось,что такая саккадическая адаптация "утомляет" гипотетические нейральные единицы, ответственные за контроль направления функционального фокуса пространственной переработки информации. В основном было найдено , что в то время, когда целевые стимулы с тест-позиций, пространственно ортогональных к направлению первой саккады или же совпадающих с этим направлением,были обнаружены приблизительно с одинаковой эффективностью, обнаружение целевых стимулов на позициях, противоположных к направлению первой саккады, было менее успешным. Указанный результат допускает возможное взаимодействие сенсорных и эфферентных механизмов в процессе селективной переработки информации даже без участия эксплицитного сканирования зрительного стимульного поля. В статье приведено несколько возможных объяснений полученных фактов и обсуждены некоторые методологические проблемы.

THEORETIC SYLLOGISTIC REASONING - REGRESSING WHEN NOT USED?

Tiia Tamm   Peeter Tulviste *

Abstract. Results of a study of verbal syllogistic reasoning in school-educated subjects with traditional cultural background who returned to their traditional economic activities after schooling are presented. The hypothesis about the regression of theoretic syllogistic reasoning, acquired at school, but not used after school, is confirmed by the results. The conclusions are in favor of the idea, expressed in an earlier paper, that theoretic syllogistic reasoning represents a specific mode of thinking functionally related to solving scientific (school) tasks, rather than a general higher stage in the development of thinking.

1. Introduction and problem

In cross-cultural studies of verbal syllogistic reasoning, schooling has been found to be the decisive factor determinating the way subjects try to solve syllogistic tasks, the answers they give, as well as the type of their explanations for the answers (Luria, 1976, pp. 100-116; Cole et al., 1971, pp. 184-195; Cole, Scribner, 1974, pp. 160-168; Scribner, 1975; Scribner, 1976). In a previous paper, one of us has argued that the switchover occurring at school consists in emergence of a qualitatively new mode of syllogis-

* The data reported in the present paper were obtained during an expedition organized by Tartu University Psychology Department to Kirghizia (Central Asia) in July, 1977. The support and encouragement, as well as organizational help to carry out the expedition given to us by various colleagues in Kirghizia was essential to make the endeavour a success. Prof. M.M. Mirrahimov, the Head of the Institute of Cardiology, Frunze, Kirghizian SSR, Dr. V.V. Solozenkin from the Kirghizian Medical Institute Psychiatry Department, Mrs. S. Umuralieva of Kirghizian State University, Dr. E. Shukurov from the Insitute of Philosophy of Academy of Sciences (Kirghizian SSR) were especially helpful, and the authors wish to express their sincerest gratitude to them. The participation of our colleagues Tiia Laak, Lembit Allik and some others, as well as our interpreters Mrs. Dzyldyz Mambetalieva and Mr. Amantur Torogeldiyev, in the process of data collection is also gratefully acknowledged.

tic reasoning termed theoretic syllogistic reasoning (Tulviste, 1978). In this mode of syllogistic reasoning, the subject turns his attention to the logical validity of the conclusion rather to its factual correctness or to its agreement with his knowledge and beliefs, and respectively proves the conclusion against the premises given in the task, not against his knowledge and beliefs concerning the reality present in the task. This mode of thinking permits one to solve correctly syllogistic tasks of any content, unfamiliar as well as familiar, and to present explanations that include only the data presented in the premises. This kind of reasoning has been argued to be a rather specific one, functionally related to solving scientific (school) problems, where it is unreasonable and often impossible to prove the answers on the basis of common knowledge about surrounding reality or beliefs, and to prove the conclusion via the rules of reasoning is often the only possible way to prove it. In subjects without schooling, only empiric syllogistic reasoning is found that permits the subject to prove his conclusions against his knowledge about outer reality and his general beliefs. This kind of syllogistic reasoning seems to be not only sufficient but also purposeful in everyday life where it seems to be more important to count for possible exceptions than to operate with explicit general premises as in deductive scientific thinking. It has been also argued (Tulviste, 1978) that theoretic syllogistic reasoning emerging at school does not substitute for empiric syllogistic reasoning, although it dominates in subjects with schooling and is used by them in the experimental situation to solve syllogistic tasks of everyday as well as scientific content.

It sometimes happens that after schooling, subjects with a traditional cultural background return to their traditional economic and cultural activities that do not seem to need "thinking in scientific concepts" (Vygotsky), including theoretic syllogistic reasoning. (Indeed, many widespread kinds of economic and cultural activities were and still are possible without any schooling, without acquiring and using scientific knowledge). The question of the fate of theoretic syllogistic reasoning in those subjects is tackled in the present paper.

TRU Raamatukogu

If theoretic syllogistic reasoning presents a general higher stage in the development of thinking that permits to solve all kinds of problems in a better way we should expect it to be maintained and perhaps even developed further in the subjects who once acquired it at school. On the contrary, if it is a specific mode of thinking,functionally related to solving just scientific or school problems (more generally, for acquiring, using and producing scientific knowledge), it should regress in the subjects who do not solve this kind of problems and do not use this kind of knowledge, but rather use common sense and empiric reasoning in their everyday life.

There seem to be no ready data available about verbal syllogistic reasoning in subjects with a traditional cultural background who returned to their traditional way of life and their traditional activities after school. In the pioneer study by Luria (1976,pp.100-116), conducted in Soviet Central Asia in the early 1930s, the subjects of the "advanced" group who solved simple syllogistic tasks on a practically 100%-level, not only had received short-term (one to two years) schooling, but were also collective-farm activists. So the subjects' everyday activities also had changed from traditional to modern, in some sense. In the recent studies reviewed by Scribner (1976), the economic activities in which the subjects from the schooled groups were engaged were not indicated. (Scribner notes that schooling is the only characteristic of populations that was systematically investigated across cultures.) Most of the schooled subjects in those studies were young people, many of them still attending to school. Summing up the experimental results of the schooled groups, Scribner (1976) notes that with schooling, little between-culture variation in performance for the cultures studied is present. Grade, rather than society, is most determinative of performance. Does this also hold for subjects who have attended to school once, but have returned to their traditional activities later?

2. Subjects

68 adults (age 25 to 87 years, most of them between 30 and 50) engaged in traditional economic activities (farming and

sheep breeding) were investigated in the remote regions in Eastern Kirghizia (Kazarman and Dyurbeldzin regions) in July, 1977. 13 Ss had received no schooling, 55 had attended to school for 2 to 10 years (see Table 1).

3. Method

The subjects were told the following three syllogistic task "stories" (of the first figure) by the experimenter.*

1. Asan and Kenesh always drink tea together. Asan is drinking tea now. Is Kenesh drinking tea now or not?

2. Anara invites Damira to her place every Thursday. Tomorrow is Thursday. Will Anara invite Damira to her place tomorrow or not?

3. In a certain village, everybody has got a dog in his house. My friend lives in that village. Has my friend got a dog in his house or not?

After each answer, the subject was asked: "Why do you think so?" When no reason was given by the subject, the task was repeated once more , and after answering, the subject was asked for an explanation again.

4. Results

The results are presented in Table 1.

1. "No answer" marks the cases in which the subject stateed that no answer could be given for some reason (e.g.," I don't know those people", or "I never saw them with my eyes"), and the cases in which the subject said that both answers , "yes" as well as "no", would be correct. In both kind of cases, a purely empiric approach to the task was observed, e.g.: "I don't know. May-be she fell ill, or removed to some place. If I stood nearby, I would know" (task 1), or: "If I ever had been to her place, I could say it, but it is so difficult to say about things I never saw" (task 3).

"Correct hypothetical" we termed the correct answers to which the subject added some condition on what it would hold.

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* The experiments were carried out in Kirghizian with the help of two interpreters with higher linguistic education and good knowledge of both Russian and Kirghizian languages.

TABLE 1. Types of answers and of explanations (reasons) for answers

Schooling	Number of Ss	Number of tasks	Answers								Explanations							
			No answer		Correct		Wrong		Correct hypothetical		No explanation		Empiric		Theoretic		Theoretic and empiric	
			N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
2 to 3 years	13	39	10	26	15	38	8	21	6	15	11	28	21	54	7	18	-	0
4 to 5 years	9	27	2	7	10	37	9	33	6	22	-	0	22	81	5	19	-	0
6 to 7 years	20	60	10	17	31	52	13	22	6	10	2	3	36	60	19	32	3	5
8 tO 10 years	13	39	3	8	22	56	9	23	5	13	4	10	20	51	12	31	3	8
Schooled total	55	165	25	15	78	47	39	24	23	14	17	10	99	60	43	26	6	4
Unschooled	13	39	20	51	12	31	6	15	1	3	7	18	26	67	5	13	1	2
Total	68																	

E.g., "If she can invite guests, she will invite her", or: "If Anara has anything to serve her friend, she will invite her" (task 2). This type of answer was never given to task 1, possibly because no doubt was cast on its first premise-most Kirghizians drink tea every day with somebody.

In some cases, both a theoretic and an empiric reason were given to the same answer. As long as we know, this result has not been obtained in earlier studies and seems to be specific to our subjects.

2. Among schooled subjects, the percent of correct answers was 47, among unschooled, 31. This significant difference ($t = 4{,}07; p < 0.001$) is in line with the differences obtained by other investigators, but the percent of correct answers in schooled subjects is strikingly different from the nearly 100%-level of the schooled groups in other studies when solving first figure syllogisms. Even among the subjects who had attended to school for 8 to 10 years, the percent of correct answers was only 56 in our study - a near chance solution rate. The major increase seems to occur at the level of 6 to 7 years of school (37.9% correct answers with 2 to 5 years of school and 53.5% with 6 to 10 years). In her review, Scribner (1976) locates the breakthrough at the level of 2 to 3 years of school for the subjects investigated when still at school or not much later.

3. The percent of theoretic explanations was significantly higher among schooled subjects than among unschooled - 26 and 13, $t = 2.04$, $p < 0.05$. This result, too, is in line with the results of previous studies (Scribner, 1976), but both percents are strikingly low in the present study. According to Scribner, in all the educated groups investigated earlier, theoretic explanations dominated (from 72.2% among the Vai to the practically 100%-level in American adults). Again, the major change in the nature of explanation occurs at the 6 to 7 years of school level (18.2% theoretic explanations with 2 to 5 years of school and 31.3% with 6 to 10 years; $t = 1.97$, $p < 0.05$). Only two subjects with 6 to 7 years of school and one with 8 to 10 years gave theoretic explanations to all answers.

4. The most significant difference in the results of schooled and unschooled subjects lies in the number of the

cases where no answer was given at all. Schooled subjects left unanswered 15% of all tasks, unschooled subjects - 51%; $t = 4.39$, $p < 0.01$. There are no significant differences in the number of unanswered tasks between subjects with different amount of schooling.

5. Whereas subjects with 2 to 3 years of schooling left 28% of their answers unexplained, - more than subjects without schooling (18%), - among subjects with 4 to 5 years of school there were no answers without explanation at all. With 8 to 10 years of school, for 10% of all answers no explanation was given.

6. There were no significant differences between the groups in the percent of empiric explanations. Explanations of this kind dominated in subjects of all groups. According to the data reviewed by Scribner (1976), this is usual in unschooled subjects, whereas in the schooled groups, as was mentioned above, theoretic explanations have absolute dominance.

7. Theoretic explanations in all cases co-existed with correct answers. This is in line with earlier findings (Scribner, 1976; Tulviste, 1978).

5. Discussion

The results obtained from a group of adult schooled subjects with a traditional cultural background who returned to their traditional kinds of economic activities after school, confirm the general hypothesis advanced in this paper. Their answers to simple verbal syllogistic tasks and the reasons (explications) they give to their answers permit to locate them nearer to the uneducated subjects investigated in this and other studies, than to the subjects still attending school or engaged in modern economic and cultural activities who formed the educated groups in earlier investigations. To only 31 percent of all tasks correct answers were given, and theoretic explanations were presented in 26% of all cases, whereas educated subjects in other groups solve correctly practically all tasks of this type and give theoretic explanations to most or all answers. We interpret these results as indicating importance of the main kinds of activities in which the subjects are engaged.

Although we could not investigate thinking of our educated subjects when they were still at school, there can be no doubt that they had acquired theoretic syllogistic reasoning there (one to three years of schooling are sufficient, as a rule; see Luria, 1976; Scribner, 1976). We think that when the subjects returned to their traditional activities in which thinking in scientific concepts was not necessary, including theoretic syllogistic reasoning, this mode of thinking regressed, and empiric syllogistic reasoning, functionally related to traditional activities, regained its dominant position again. It is reasonable to think that this regression and return to empiric syllogistic reasoning would not have occured if theoretic syllogistic reasoning represented a general higher stage in reasoning that permits to solve all kinds of problems better.

Still, some significant differences between the results of schooled and unschooled subjects were obtained.

Unschooled subjects left unanswered 51% (more than a half) of all tasks, whereas schooled subjects left unanswered only 15% of the tasks. This difference is connected with schooling <u>per se</u>, irrelevant to how many years the subjects had been at school. Schooled subjects look upon the tasks as problems that can be solved - in spite of their content being unfamiliar to them in their own experience.

Usually, schooled subjects give no empiric explanations (Scribner, 1976), and unschooled subjects give few (Scribner, 1976) or no (Tulviste, 1978) theoretic explanations. In the present study, the subjects of the schooled group in 6 cases gave both a theoretic and an empiric explanation to the same (always correct) answer: First, a theoretic explanation was given, and an empiric one followed. This is in line with the idea that this group of subjects lays between the schooled and unschooled ones in their thinking mode.

The absence of significant differences between schooled and unschooled groups in the amount of empiric explanations demonstrates the importance of everyday activities for thinking. It is quite obvious that the schooled subjects investigated in earlier studies also can give empiric explanations when asked or instructed to do so, but without such instruction, they give theoretic, not empiric explanations in the experimental situation. So we propose that in our schooled subjects, theoretic syllogistic reasoning had regressed to leave the dominance to empiric syllogistic reasoning.

Two findings confirm the idea presented in the paper already mentioned that theoretic explanation indicates a new mode of syllogistic reasoning, theoretic syllogistic reasoning. Firstly, both of the two major "jumps", from 37.9% correct answers to 53.5% and from 18.2% theoretic explanations to 31.3%, occur at the same level of 5 to 6 years of school. Secondly, earlier findings were reaffirmed by the fact that theoretic explanations always co-exist with correct answers.

Although the main hypothesis of this study was confirmed, the question of the fate of theoretic syllogistic reasoning in schooled subjects who return to their traditional economic activities, needs further investigation. The kinds of different activities in which the subjects are engaged must be varied systematically. A longitudinal study would permit to reveal the dynamics of the changes occuring in the syllogistic reasoning of the subjects. Last but not least, it would be more informative to use syllogisms with everyday as well as scientific content in this kind of study. We propose that theoretic syllogistic reasoning, first arising in the sphere of scientific or school knowledge (Tulviste, 1978), should first disappear in experimental situations in the sphere of everyday knowledge, where it is not only unnecessary but often also misleading.

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ПРИВОДИТ ЛИ НЕПРИМЕНЕНИЕ ТЕОРЕТИЧЕСКОГО СИЛЛОГИСТИЧЕСКОГО МЫШЛЕНИЯ К ЕГО РЕГРЕССИИ?

Т.Тамм П.Тульвисте

Р е з ю м е

В статье представлены результаты эксперментального исследования вербального силлогистического мышления у людей из традиционной культуры, которые получили школьное образование, но после школы вернулись к традиционным видам экономической деятельности. Подтвердилась гипотеза о возможной регрессии теоретического силлогистического мышления у этой группы испытуемых. Результаты исследования говорят в пользу высказанной в одной из предыдущих работ идеи о том, что теоретическое силлогистическое мышление представляет специфический тип мышления, функционально соответствующий решению научных (школьных) задач, а не универсальную высшую стадию в развитии мышления.

ESTONIAN WORD ASSOCIATION NORMS FOR THE KENT-ROSANOFF TEST

Kalju Toim

Abstract. The paper presents the norms for Estonians for the Kent-Rosanoff Word Association Test, with English and Russian translations. A short overview of the attempts by other authors to compile norms for Kent-Rosanoff WAT in different language groups is also presented.

1. Introduction

The more frequently used procedure of Word Association Test (WAT) is that in which the subject is given a single stimulus word and asked to respond as rapidly as possible with the first single word which comes to mind. This procedure belongs to the discrete free association tests. The first most detailed experimental studies of free association by the discrete method have been made by Kent and Rosanoff (1910). In the selection of the stimulus words the referred authors "have taken care to avoid such words as are especially liable to call up personal experiences, and have so arranged the words as to separate any two which bear an obviously close relation to one another" (Kent , Rosanoff, 1910, p. 38). This list of 100 stimulus-words seems to be the most popular among investigators and has been most often used. The present author has applied the test to over one thousand normal Estonian subjects. The data of this experimental study makes it possible to compose a normative dictionary of responses which has been given by subjects to stimulus words. In the normative dictionary, the frequency which demonstrates associative response strength is presented after each response . That response which occurs with the greatest frequency to any one stimulus is called popular, or primary response. The quantity of primary responses of a complex of the associative responses of a concrete subject is an important variable of response commonality and demonstrates the response set of the subjects.

The norms of Kent-Rosanoff WAT have been composed by several authors. In 1916 Woodrow and Lowell used it with one thousand Minneapolis school children. In 1928 O'Connor used it with one thousand industrial workers. In 1952 Russell and Jenkins gathered so-called "Minnesota norms" from one thousand University of Minnesota students. The Australian norms have been obtained from two hundred university-students in Sydney and Tasmania (1957-1958). The English sample consisted of four hundred students who were drawn from 7 universities located throughout England (1961-1962) (Postman,Keppel, 1970, pp. 40-52).

Inter-language comparisons have become possible only since translations of the Kent-Rosanoff test were used in France, Germany,Italy. M. Rosenzweig gathered French norms from 288 Sorbonne students (1955-1956) (Postman, Keppel , 1970, pp.108-116).

Russell has gathered German language norms for responses to Kent-Rosanoff stimulus (1957-1958). The German sample consisted of 331 subjects (31 females and 300 males) from the psychology courses at the University of Würzburg and from advanced classes in Hochschulen and Gymnasiums in Würzburg, Aschaffenburg, Scheinfurt (Postman,Keppel, 1970 , pp. 53-94). An Italian translation of the list of Kent-Rosanoff's WAT was administered in Italy by Levi. The subjects were chosen to be fairly representative of the Italian population in age and social class, although the majority were students. About two-thirds of the 229 subjects were man (Rosenzweig, 1961,p.348). Polish word association norms have been gathered from about one thousand Polish university students (491 of the University of Warsaw and 525 Warsaw Engineering School: 442 of them were girls and 574 boys , with age ranged from 16-34 (Kurcz, 1966,p.152).

The normative data of Russian and Kirghiz association-responses have been gathered by Titova (1975). Her Russian sample consisted of 500 Russian students of institutes of Frunze. Among the stimuli there were 89 words equivalent to the Kent-Rosanoff list. The Kirghiz sample consisted of 1000 Kirghiz students. The responses to 91 stimuli, equivalent to the Kent-Rosanoff list, could be compared with the responses in other languages.The tests were carried out in Frunze in 1972. In 1977, the first part of the "Dictionary of Russian Associations norms" has been published (edited by A.A.Leontyev).

In this paper, Estonian norms of Kent-Rosanoff WAT are published. The tests were carried out in 1973-1974 with one thousand normal subjects. Among these subjects there were 500 pupils from 13 Estonian secondary schools (170 males and 330 females). The age of the pupils was 15-19 years. The other half of the subjects consisted of 500 adult persons (200 males and 300 females). Among adult subjects there were persons of different occupations, possessing various degrees of mental capacity and education (50% of subjects had higher education), and living in widely separated geographical points. The age range of the adult subjects was 18-60 years, especially 20-35.

The norms were collected in a classroom setting. The subjects wrote responses on answer sheets provided beside each stimulus word. The text consisted of two pages, 50 stimuli on a page. The instruction was a standard word-association instruction - to respond as rapidly as possible with the first single word which comes to mind.

In this paper, associative norms are presented in the following table. In the first column, the original stimulus-words (in English) in the order of the Kent-Rosanoff WAT are presented. The Estonian equivalent forms of this word and the Russian translation of Estonian equivalent are printed under the English word. Few stimuli have been presented twice. In that case, different Estonian translation-variants were used. The norms of primary stimuli have been gathered from 1000 subjects, but of secondary stimuli from 500 subjects. In the dictionary the secondary stimuli have been marked (in all 11 stimuli). In the second column 5 Estonian responses to each stimulus are presented. In the third column, frequencies of each responses (how many percent of subjects have given this response) are presented . In the fourth column, the English translations of Estonian responses (and in the fifth column Russian translations) can be found. In some cases , the English translation may be followed by the abbreviation "sub". in the brackets, denoting a substantive. For example: valge = light, white; valgus = light (sub.).

Estonian responses to Kent-Rosanoff stimuli

1. Stimuli	2. Responses in Estonian	3. Freq. %	4. Translation in English	5. Translation in Russian
1.	tool	70.8	chair	стул
Table	lina	3.9	cloth	скатерть
Laud	pink	2.5	bench	скамейка
Стол	puu	1.8	wood	дерево
	sook	1.1	food,meal	пища
2.				
Dark	valge	51.7	light,white	светлый,белый
Pime	oo	7.8	night	ночь
Тёмный	nagija	7.1	p.who sees	видящий
	hele	4.2	bright, clear	яркий,светлый
	valgus	2.7	light (sub.)	свет
2.*				
Dark	hele	69.0	bright,clear	светлый,яркий
Tume	must	5.1	black	чёрный
Тёмный	pime	4.0	dark	тёмный
	oo	3.4	night	ночь,
	valge	2.8	light,white	белый,светлый
3.				
Music	heli	11.9	sound	звук
Muusika	laul	11.3	song	песня
Музыка	vaikus	6.5	silence	тишина
	klaver	6.0	piano	рояль
	pill	3.3	instrument	инструмент
4.				
Sickness	tervis	34.0	health	здоровье
Haigus	terve	9.7	healthy	здоровый
Болезнь	gripp	5.5	influenza	грипп
	valu	4.4	pain	боль
	arst	4.3	physician	врач
5.				
Man	naine	77.9	woman	женщина
Mees	tugev	1.5	strong	сильный
Мужчина	isa	1.0	father	отец
	pikk	0.8	tall	высокий
	habe	0.7	beard	борода
6.				
Deep	madal	44.9	low,shallow	мелкий,низкий
Sügav	vesi	5.2	water	вода
Глубокий	auk	4.2	hollow	яма
	kaev	4.2	well	колодец
	jôgi	3.6	river,stream	река
7.				
Soft	kôva	52.7	hard	твердый
Pehme	padi	6.9	pillow	подушка
Мягкий	voodi	3.6	bed	кровать
	soe	3.3	warm	тёплый
	diivan	2.8	divan,sofa	диван

1.	2.	3.	4.	5.
8.				
Eating	joomine	45.0	drinking	питье
Söömine	magamine	6.7	sleeping	спаньё
Еда	toit	4.5	food	пища
	nälgimine	4.4	starving	голодание
	nälg	3.0	hunger	голод
9.				
Mountain	org	34.5	valley	овраг
Mägi	kõrge	10.6	high	высокая
Гора	jõgi	8.1	river,stream	река
	kungas	5.9	hill	холм
	madalik	2.3	lowland	низменность
10.				
House	katus	10.9	roof	крыша
Maja	tuba	9.7	room	комната
Дом	aed	8.7	garden	сад
	uks	6.6	door	дверь
	kodu	6.2	home	родной
11.				
Black	valge	66.0	white	белый
Must	punane	2.2	red	красный
Чёрный	värv	1.8	colour	краска,цвет
	puhas	1.8	clean	чистый
	kass	1.4	cat	кошка
12.				
Mutton	šašlõkk	19.2	shashlyk	шашлык
Lambaliha	sealiha	17.6	pork	свинина
Баранина	lammas	5.3	sheep	овца
	loomaliha	4.9	beef	говядина
	praad	4.8	fry,roast	жаркое
13.				
Comfort	ebamugavus	9.2	uncomfort	неудобство
Mugavus	laiskus	8.4	laziness	лень
Удобство	diivan	5.8	divan,sofa	диван
	tugitool	5.5	armchair	кресло
	tuba	2.8	room	комната
14.				
Hand	jalg	65.5	foot	нога
Käsi	sõrm(ed)	6.7	finger(s)	палец
Рука	sõrmus	1.5	ring	кольцо
	kindas	1.4	glove,mitten	перчатка,рукавицы
	töö	1.1	work	работа
15.				
Short	pikk	71.2	long,tall	длинный,высокий
Lühike	paks	4.6	fat,thick	толстый
Короткий	väike	1.5	small,little	маленький
	kleit	1.4	dress	платье
	jalg	1.2	foot	нога
16.				
Fruit	õun(ad)	36.9	apple(s)	яблоко
Puuvili	juurvili	23.1	edible root(s)	корнеплод
Фрукты	aedvili	5.0	vegetable	овощи
	pirn	3.7	pear	груша
	apelsin	3.2	orange	апельсин

1.	2.	3.	4.	5.
17.				
Butterfly	kirju	11.7	many-coloured	пёстрая
Liblikas	lind	9.5	bird	птица
	lill(ed)	6.9	flower(s)	цветок
Бабочка	putukas	6.9	insect	насекомое
	kollane	6.2	yellow	жёлтая
18.				
Smooth	kare	22.7	rough	шершавый
Sile	krobe(line)	13.9	uneven,rough	шероховатый
Гладкий	konarlik	7.6	angular,bumpy	неровный
	libe	4.4	slippery	скользкий
	laud	4.4	board,plank	доска
19.				
Command	täitma	5.7	carry out	исполнять
Kasutama	alluma	5.5	to be subject	подчиняться
Распоря-жаться	kamandama	5.1	to be bossy	командовать
	keelama	4.2	forbid	запрещать
	ülemus	4.0	chief	начальник
19.*				
Command	keelama	23.4	forbid	запрещать
Käskima	paluma	8.4	ask	просить
Приказывать	täitma	6.5	carry out	исполнять
	karjuma	3.5	vociferate	кричать
	ülemus	2.7	chief	начальник
20.				
Chair	laud	63.2	table	стол
Tool	istuma	4.8	sit	сидеть
Стул	pink	4.0	bench	скамейка
	iste	3.1	seat	сиденье
	jalg	2.6	leg	нога
21.				
Sweet	hapu	20.8	sour,acid	кислый
Magus	kibe	14.1	bitter	горький
Сладкий	mõru	13.1	bitter	горький
	mesi	8.2	honey	мёд
	suhkur	7.0	sugar	сахар
22.				
Whistle	laulma	21.3	sing	петь
Vilistama	vile	10.3	whistle(sub.)	свисток
Свистеть	poiss	5.1	boy	мальчик
	huudma	3.6	call,shout	звать,кликать
	vaikima	2.7	to be silent	молчать
23.				
Woman	mees	64.7	man	мужчина
Naine	laps(ed)	5.4	child(children)	ребёнок
Женщина	ema	4.2	mother	мать
	ilus	3.5	beautiful	красивая
	kleit	1.4	dress	платье
24.				
Cold	soe	58.3	warm	тёплый
Külm	talv	6.9	winter	зима
Холодный	kuum	4.6	hot	горячий
	ilm	3.9	weather	погода
	lumi	2.8	snow	снег

1.	2.	3.	4.	5.
25. Slow Aeglane Медленный	kiire tigu inimene laisk pikaldane	54.6 5.0 2.0 1.6 0.9	fast slug man,person lazy leisurely	быстрый улитка человек ленивый медленный
26. Whish Soovima Желать	tahtma paluma õnne hea täituma	18.7 7.1 7.0 5.9 2.9	want ask congratulate well to be realized	хотеть просить поздравлять хорошего исполняться
27. River Jõgi Река	järv vesi mägi oja meri	23.9 12.2 9.9 9.3 7.0	lake water mountain brook sea	озеро вода гора ручей море
28. White Valge Белый	must pime lumi hele puhas	49.9 9.2 7.9 2.1 1.7	black dark snow bright,light clean	чёрный тёмный снег светлый чистый
29. Beautiful Ilus Красивый	inetu kole kena naine tüdruk	26.2 19.6 6.8 5.2 4.1	ugly horrible nice,pretty woman girl	некрасивый ужасный хорошенький женщина девочка
30. Window Aken Окно	uks klaas(id) valgus maja suur	48.7 5.2 4.6 3.1 2.9	door pane(s) light house great	дверь стекло свет дом большое
31. Rough Kare Шершавый	sile pehme käsi(käed) riie krobe(line)	35.9 14.5 4.7 4.5 2.2	smooth soft hand (s) cloth,material rough,uneven	гладкий мягкий рука материя шероховатый
32. Citizen Kodanik Гражданин	inimene seltsimees mees elanik nõukogude	17.1 10.5 6.4 3.1 3.0	man,person comrade male,man dweller soviet	человек товарищ мужчина житель советский
33. Foot Jalg Нога	käsi king(ad) saabas varvas(varbad) (jalg)pall	54.6 5.8 5.5 2.8 2.3	hand shoe(s) boot,high shoe toe(s) (foot)ball	рука туфля сапог палец(пальцы) мяч(футбол)

1.	2.	3.	4.	5.
34.				
Spider	võrk	30.8	web	паутина
Ämblik	putukas	15.0	insect	насекомое
Паук	kärbes	7.1	fly	муха
	rist(ristiga)	3.9	cross-spider	крестовик
	vastik	2.5	repugnant	отвратительный
35.				
Needle	niit	60.0	thread	нитка
Nõel	terav	10.0	sharp	острая
	(nõela)silm	1.8	the eye of	игольное
Игла	õmblema,		a needle	ушко
	(õmblemine)	1.4	sewing	шить
	peenike	1.3	thin	тонкий
36.				
Red	must	29.4	black	чёрный
Punane	sinine	20.8	blue	синий,голубой
Красный	lipp	10.8	flag	флаг,знамя
	valge	4.6	white	белый
	veri	3.4	blood	кровь
37.				
Sleep	voodi	14.1	bed	кровать
Magama	ärkama	12.3	awake	просыпаться
Спать	tõusma	9.5	rise up	подниматься
	uni	9.0	dream	сон
	puhkama	8.5	rest	отдыхать
38.				
Anger	raev	11.7	rage,fury	ярость
Viha	vaen	8.8	hostility	вражда
Гнев	rõõm	6.1	joy,delight	радость
	vaenlane	3.4	enemy	враг
	sõprus	2.5	friendship	дружба
39.				
Carpet	põrand(a)	18.6	floor	пол
Vaip	pehme	10.5	soft	мягкий
Ковёр	tekk	9.0	blanket	одеяло
	sein	4.2	wall	стена
	kate	3.3	cover(ing)	покрывало
40.				
Girl	poiss	60.9	boy	мальчик
Tüdruk	ilus	3.5	beautiful	красивая
Девочка	kena	2.8	fine,pretty	милая
	väike	2.0	little,small	маленькая
	patsid	1.9	plaits	косы
41.				
High	madal	51.9	low	низкий
Kõrge	mägi	9.4	mountain	гора
Высокий	torn	4.4	tower	башня
	maja	3.9	house	дом
	puu	2.4	tree	дерево
42.				
Working	laisklemine	12.7	to be lazy	безделничание
Töötamine	puhkamine	12.3	rest	отдых
	magamine	5.4	sleeping	спаньё
	töö	4.1	work	труд
Работа	logelemine	3.0	loaf,idle	ничегонеделание

1.	2.	3.	4.	5.
43.				
Sour	magus	50.0	sweet	сладкий
Hapu	kurk	9.1	cucumber	огурец
Кислый	õun	4.7	apple	яблоко
	kapsas	3.7	cabbage	капуста
	kibe	3.2	bitter	горький
44.				
Earth	taevas	21.3	sky	небо
Maa	muld	10.5	mould, soil	почва, земля
Земля	kuu	6.1	moon	луна
	meri	5.5	sea	море
	vesi	4.7	water	вода
44.*				
Earth	taevas	18.0	sky	небо
Maapind	muld	13.2	mould, soil	земля, почва
Поверх-	rohi	4.3	grass	трава
ность	sile	3.0	smooth	гладкий
земли	õhk	2.4	air	воздух
45.				
Trouble	rõõm	34.8	joy, delight	радость
Mure	suur	5.0	great	большая
Забота	kurbus	4.7	sadness	печаль, грусть
	vaev	2.5	pain	мука
	ema	2.2	mother	мать
46.				
Soldier	sõda	12.6	war	война
Sõdur	poiss	11.6	boy, young man	молодой чел.
Воин	sõldat	7.8	soldier	солдат
	püss	7.5	gun	ружье
	sinel	5.1	soldier's coat	шинель
47.				
Cabbage	kaalikas	18.7	rape, rutabaga	брюква
Kapsas	supp	7.5	soup	суп
Капуста	kartul	7.0	potato	картофель
	hapu	6.9	sour	кислый
	porgand	6.4	carrot	морковь
48.				
Hard	pehme	57.8	soft	мягкий
Kõva	kivi	8.7	stone	камень
Твёрдый	pää	3.6	head	голова
	pähkel	2.8	nut	орех
	leib	2.0	bread	хлеб
49.				
Eagle	lind	31.3	bird	птица
Kotkas	kull	9.4	hawk	ястреб
Орёл	kalju(kotkas)	5.0	golden eagle	горный(орёл)
	tiib(tiivad)	3.4	wing(s)	крыло(крылья)
	taevas	2.8	sky	небо
50.				
Stomach	tühi	19.8	empty	пустой
Kõht	selg	12.4	back	спина
Живот	magu	6.1	maw	желудок
	täis	4.7	full	сыт
	naba	4.7	navel	пуп

1.	2.	3.	4.	5.
51.				
Stem	lill(ed)	11.9	flower(s)	цветок
Vars	hari(harja)	10.8	brush	щётка
	õis	10.0	blossom	бутон
Стебель	leht(lehed)	8.2	leaf(leaves)	лист(листья)
	luud(luua)	7.8	besom	метла
52.				
Lamp	valgus	19.9	light	свет
Lamp	tuli	15.5	light,fire	огонь
	laud	9.5	table	стол
Лампа	pirn	8.4	bulb	лампочка
	lagi(lae)	4.7	ceiling	потолок
53.				
Dream	uni	16.0	sleep(sub.)	сон
Unenagu	magama	9.0	sleep (verb)	спать
Снови-	ilus	7.9	beautiful	красивое
дение	og	4.0	night	ночь
	varviline	3.0	coloured	цветное
54.				
Yellow	punane	11.8	red	красный
Kollane	sinine	9.7	blue	синий,голубой
Желтый	liblikas	9.1	butterfly	бабочка
	roheline	9.1	green	зеленый
	paike	5.0	sun	солнце
55.				
Bread	sai	49.0	white bread	белый хлеб
Leib	sool	3.5	salt	соль
Хлеб	liha	3.5	meat	мясо
	või	2.9	butter	масло
	soe	1.9	warm	тёплый
56.				
Justice	vale	43.5	lie	ложь,неправда
Õigus	tõde	9.6	truth	истина
Право	kohus	6.9	court	суд
	seadus	2.2	law	закон
	ebaõiglus	1.4	unjustice	несправедливость
56*.				
Justice	vale	22.1	lie	ложь,неправда
Õiglus	ebaõiglus	9.9	unjustice	несправедливость
Справед-	kohus	8.1	court	суд
ливость	tõde	5.3	truth	истина
	ausus	3.2	honesty	честность
57.				
Boy	tüdruk	61.8	girl	девочка,девушка
Poiss	mees	2.4	man	мужчина
Мальчик	laps	2.2	child	ребенок
	vaike	1.8	little	маленький
	ulakas	1.2	naughty	озорной
58.				
Light	tume	54.7	dark	тёмный
Hele	valge	7.0	white,light	белый
	valgus	6.5	light (sub.)	свет
Светлый	paike	5.5	sun	солнце
	paev	3.2	day	день

1.	2.	3.	4.	5.
58.* Light Valgus Свет	pimedus hele lamp pime paike	53.0 6.7 5.1 4.5 4.2	dark(sub.) bright lamp dark sun	темнота светлый,яркий лампа тёмный солнце
59. Health Tervis Здоровье	haigus hea tugev haige arst	42.9 8.3 3.2 2.4 2.2	sickness good strong ill,sick person physician	болезнь хорошее сильное больной врач
60. Bible Piibel Библия	raamat usk jumal kirik paks	24.4 16.8 9.0 7.1 3.3	book religion god church thick	книга религия,вера бог церковь толстый
61. Memory Malu Память	mõistus hea aju pea mõte	10.4 7.5 7.1 6.8 5.9	mind good brain head thought	ум, разум хорошая мозг голова мысль
62. Sheep Lammas Овца	oinas vill lehm loom siga	26.4 18.6 11.5 3.8 3.4	ram wool cow animal pig	баран шерсть корова животное свинья
63. Bath Vann Ванна	vesi kauss (vanni)tuba pesema pesu	40.1 6.8 3.9 3.4 2.9	water wash-basin bathroom wash washing	вода таз ванная мыться мытьё,бельё
63.* Bath Kumblus Плес-кание	vesi suplus vann saun duš	16.8 10.3 5.3 4.3 3.6	water bathing,swim tub sauna shower-bath	вода купание ванна баня душ
64. Cottage Majake Домик	onn onnike vaike suvila aed	16.2 5.9 5.8 3.6 3.5	hovel,hut hovel (dim.) little,small summer cottage garden	лачуга,шалаш лачужка маленький дача сад,огород
65. Swift Kiire Скорый	aeglane ruttu auto lennuk jooks(mine)	51.4 3.8 3.6 2.5 2.4	slow hurry automobile airplane run,running	медленный спешно машина самолет бег

1.	2.	3.	4.	5.
66. Blue	punane	32.0	red	красный
Sinine	taevas	23.0	sky	небо
Голубой	meri	4.8	sea	море
	kollane	4.4	yellow	желтый
	valge	4.3	white	белый
67. Hungry	(täis)söönud	15.5	fill eaten	сыт
Näljane	hunt	13.1	wolf	волк
Голод-	koer	5.9	dog	собака
ный	leib	3.8	bread	хлеб
	toit	3.7	food	пища
68. Priest	kirik	24.1	church	церковь
Prees-	papp	15.1	pope	поп
ter	usk	4.0	religion	вера, религия
Священ-	piibel	3.5	bible	библия
ник	(kiriku)ôpetaja	3.5	clergyman, vicar	пастор
69. Ocean	meri	21.3	sea	море
Ookean	vesi	17.6	water	вода
Океан	laev(ad)	11.1	ship(s)	судно, корабль
	suur	4.7	large	большой
	avarus	2.3	spaciousness	простор
70. Head	juuksed	15.2	hair	волосы
Pea	jalg(jalad)	8.7	foot ,leg(s)	нога
Голова	kael	8.1	neck	шея
	muts	3.9	cap	шапка
	môistus	3.8	mind	ум, разум
71. Stove	soe	21.9	warm	тёплая
Ahi	soojus	10.3	heat(sub.)	теплота
Печка	pliit	10.2	kitchen range	плита
	tuli	8.0	fire	огонь
	puu(d)	6.1	firewood	дрова
72. Long	lühike	53.6	short	короткий
Pikk	poiss	4.3	boy	мальчик
Длин-	tee	3.8	road	дорога
ный	lai	3.7	broad, wide	широкий
	mees	3.4	man	мужчина
73. Reli-	kirik	14.8	church	церковь
gion	jumal	12.0	god	бог
Usk	piibel	7.1	bible	библия
Вера	ebausk	5.6	superstition	суеверие
	lootus	3.9	hope	надежда
74. Whiskey	vein	13.9	wine	вино
Viin	pudel	10.3	bottle	бутылка
Водка	joodik	10.2	drunkard	пьяница
	alkohol	5.0	alcohol, spirits	алкоголь
	vesi	4.6	water	вода

1.	2.	3.	4.	5.
74.*				
Whiskey	jook	20.1	drink (sub.)	напиток
Viski	viin	11.1	vodka	водка
Виски	pudel	9.3	bottle	бутылка
	alkohol	4.3	alcohol,spirits	алкоголь
	klaas	3.0	drinking-glass	стакан
75.				
Child	ema	18.7	mother	мать
Laps	väike	12.3	little,small	маленький
Ребёнок	taiskasvanu	6.1	adult	взрослый
	poiss	3.4	boy	мальчик
	hea	2.6	good	хороший
76.				
Bitter	magus	34.9	sweet	сладкий
Kibe	mõru	13.2	bitter	горький
Горький	viin	10.6	vodka	водка
	pulm(ad)	4.6	wedding	свадьба
	pipar	4.1	pepper	перец
77.				
Hammer	nael(ad)	32.3	nail(s)	гвоздь
Haamer	vasar	19.2	hammer	молоток
Молоток	alasi	4.9	anvil	наковальня
	kirves	4.5	ax	топор
	tangid	4.0	tongs	щипцы
78.				
Thursty	vesi	26.7	water	вода
Janune	naljane	14.5	hungry	голодный
Жаждущий	jook	4.2	drink (sub.)	напиток
	kõrb	3.7	wilderness	пустыня
	inimene	2.3	man, person	человек
79.				
City	maa	18.9	country	село
Linn	küla	10.5	village	деревня
Город	maja(d)	10.1	house(s)	дом(а)
	suur	9.0	grand,large	большой
	Tallinn	4.7	Tallin	Таллин
80.				
Square	plats	21.8	place,ground	площадка
Väljak	suur	7.9	large	большая
Площадь	Võidu-	5.9	Victory	Победы
	tanav	5.9	street	улица
	Punane	5.8	Red	Красная
80.*				
Square	kolmnurk	33.6	triangle	треугольник
Nelinurk	ruut	15.8	square	квадрат
Четырёх-	matemaatika	7.5	mathematics	математика
угольник	viisnurk	4.9	pentagon	пятиугольник
	ring	2.2	circle	круг
81.				
Butter	leib	27.6	bread	хлеб
Või	sai	12.3	white bread	белый хлеб
Масло	piim	5.3	milk	молоко
	kollane	5.0	yellow	желтый
	rasv	4.9	fat	жир

1.	2.	3.	4.	5.
82.				
Doctor	haige	19.6	patient	больной
Arst	haigus	7.5	illness	болезнь
Врач	doktor	6.8	doctor	доктор
	valge	4.2	white	белый
	tohter	4.1	physician	врач
83.				
Loud	kuri	11.3	evil	злой
Vali	tuul	10.4	wind	ветер
Громкий	karm	7.0	severe,harsh	суровый
	kõva	5.7	hard	твёрдый
	tugev	4.4	strong	сильный
83.*				
Loud	vaikne	12.6	silent,still	тихий
Valju	tasane	12.2	low,soft	кроткий
Громкий	kõva	11.8	strong,hard	крепкий
	haal	11.8	voice	голос
	tasa	5.7	low	тихо
84.				
Thief	röövel	6.0	robber	разбойник
Varas	miilits	4.8	militia	милиция
Вор	vangla	4.5	prison	тюрьма
	aus	4.1	honest	честный
	vargus	4.1	stealing	воровство
85.				
Lion	tiiger	19.1	tiger	тигр
Lõvi	loom	7.4	animal	животное
Лев	lakk	6.7	mane	грива
	loomaaed	4.5	Zoo	зоопарк
	puur	4.0	cage	клетка
86.				
Joy	mure	39.5	sorrow	забота
Rõõm	kurbus	15.5	sadness	печаль
Радость	õnn	3.6	happy	счастье
	naer	3.4	laugh	смех
	suur	2.6	great	большая
87.				
Bed	magama(magamine)	11.8	sleep	спать
Voodi	tekk	11.4	blanket	одеяло
Кровать	uni	8.6	sleep(sub.)	сон
	padi(padjad)	8.5	pillow	подушка
	pehme	8.0	soft	мягкая
88.				
Heavy	kerge	56.0	easy,light	легкий
Raske	too	5.9	work	работа
Тяжё-лый	kott	2.9	bag,sack	мешок
	kivi	2.3	stone	камень
	raud	1.8	iron	железо
89.				
Tobacco	suits	32.3	smoke	дым
Tubakas	piip	16.3	pipe	трубка
Табак	sigarett(id)	4.4	cigarette(s)	сигарета
	kibe	3.6	smart,bitter	едкий
	mõru	2.3	bitter	горький

1.	2.	3.	4.	5.
90.				
Baby	laps	23.6	child	ребёнок
Beebi	mähkmed	7.0	nappies	пелёнки
Младенец	väike	6.3	little	маленький
	tita (titt)	5.6	tiny tot	дитя
	imik	5.0	suckling	грудной ребенок
91.				
Moon	päike	21.9	sun	солнце
Kuu	öö	8.9	night	ночь
Луна	täht(tähed)	8.5	star(s)	звезда
	taevas	7.8	sky	небо
	kollane	4.4	yellow	жёлтая
92.				
Scissors	nuga(noad)	18.4	knife(s)	нож
Käärid	riie	15.9	material,cloth	материя
Ножницы	terav(ad)	7.9	sharp	острый
	lõikama(-mine)	7.5	cut	резать
	paber	6.2	paper	бумага
93.				
Quiet	õhtu	7.9	evening	вечер
Vaikne	müra	7.6	noise	шум
Тихий	tasane	7.1	low,soft	кроткий
	kärarikas	5.2	noisy	шумный
	lärmakas	4.8	obstreperous	крикливый
93*.				
Quiet	rahutu	15.0	restless	беспокойный
Rahulik	närviline	10.3	nervous	нервный
Спокойный	inimene	6.9	man,person	человек
	aeglane	5.7	sluggish	медленный
	kiire	3.6	quick,rapid	быстрый
94.				
Green	kollane	11.2	yellow	жёлтый
Roheline	rohi	9.3	grass,nerb	трава
Зелёный	sinine	9.1	blue	синий,голубой
	muru	7.9	grass	газон
	aas	7.6	meadow	луг

1.	2.	3.	4.	5.
95.				
Salt	suhkur	28.8	sugar	сахар
Sool	leib	10.8	bread	хлеб
Соль	kibe	6.9	bitter	горький
	soolane	5.9	salty	соленый
	pipar	4.4	pepper	перец
96.				
Street	maja(d)	9.5	house(s)	дом (дома)
Tanav	auto	8.5	car	машина
Улица	linn	6.5	town	город
	valjak	5.7	square	площадь
	tee	5.6	road	дорога
97.				
King	kroon	17.3	crown	корона
Kunin-gas	kuninganna	12.7	queen	королева
	keiser	8.2	emperor	император
Ко-роль	(riigi)valit-seja	4.6	ruler	властитель
	troon	3.5	throne	трон, престол
98.				
Cheese	vorst	15.7	sausage	колбаса
Juust	või	10.7	butter	масло
Сыр	sai	6.7	white bread	белый хлеб
	auk (augud)	6.2	hole(s)	дырка (дырки)
	piim	6.1	milk	молоко
99.				
Blos-som	lill(ed)	38.7	flower(s)	цветок, цветы
	vars	10.6	stem	стебель
Õis	roos	6.0	rose	роза
	ilus	5.0	beautiful	красивый
Бутон	leht(lehed)	4.4	leaf (leaves)	лист (листья)
100.				
Afraid	ehmunud	7.5	frightened	испуганный
Hirmu-nud	laps	6.3	child	ребенок
	julge	5.9	bold	смелый
Напу-ган-ный	kartlik	5.3	timid	боязливый
	arg	4.8	coward	трусливый
100.*				
Afraid	julge	26.0	bold	смелый
Kart-lik	arg	11.8	coward	трусливый
	habelik	3.2	bashful	стыдливый
Бояз-ливый	laps	2.8	child	ребёнок
	inimene	2.6	man,person	человек

3. Conclusion

In the Table, 555 responses to 111 stimuli were presented. 226 responses or 40,7% can be classified as homogeneous-logical, 189 or 34.1% homogeneous-nonlogical and 140 or 25.2% heterogeneous associations. Estonian association-norms demonstrate great associative-response strength of the primary responses. The frequencies of primary responses to 33 stimuli are greater than 40%, to 42 stimuli are smaller than 20%, but the mean frequency of primary responses is 30%.

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ЭСТОНСКИЕ НОРМЫ СЛОВЕСНЫХ АССОЦИАЦИЙ ТЕСТА КЕНТ-РОЗАНОВА

К. Тойм

Р е з ю м е

В статье представляются эстонские нормы словесных ассоциаций теста Кент-Розанова, снабженные переводом на английском и русском языках. Также дается краткий обзор о попытках других авторов составить нормы теста Кент-Розанова для различных языковых групп.

DEVELOPING A METHOD TO MEASURE ATTITUDES TOWARDS DANGEROUS OR ALARMING EVENTS

Mihhail Kotik Lauri Õõvel

Abstract. A method to study attitudes towards dangerous or alarming events is proposed. The method is based upon the general idea that fuzziness of word meanings used in describing an event can be taken as a basis for judgement about subjects' attitudes and emotions. Experiments were performed with electricians who had had few or many accidents in their work. The comparison of these groups revealed that they differ from each other in a number of personality and motivational variables, as well as in their meanings of different current strength (voltages). The group with more accidents considered 90V "very weak", whereas the group of no accidents considered it only "weak". The tension of 260V was regarded by the first group as " "very strong", whereas the more cautious group considered it already mortal. The possibility to get engaged in an accident with electricity has its concomitants in the ways the subjects conceptualize the dangerous and alarming stimulus values for themselves, and by measuring these conceptualizations their attitudes and the emotional significance of the given event can be studied.

1. Introduction

In previous studies on this problem, one of the authors (Kotik, 1978a) stated that by the vocabulary a person choses for estimating the possibility of occurrence of an unexpected event one can judge his attitude towards the event.

For example, if one person estimates the possibility of occurrence of a dangerous event with the word "often" but the other the same event with the word "seldom", then by these estimations one can judge that for the first person the event is a emotionally stronger than for the other. So by the way the person describes the membership of an unexpected event in a certain fuzzy set (Zadeh, 1976) we can decide the degree of significance - of anxiety (Kotik, 1978b) of the event for him. Besides, it was quite clearly shown that it is characteristic for human beings to strengthen verbal estimation about the possibility of occurrence of events proportionally to their entropy (but not to the possibility of their occurrence).

The last conclusion is well connected with Simonov(1970) information theory of emotions that argues in favour of entropy as the measure of emotional events.

To test this, a hypothesis was put forward that the word chosen for estimating the intensity of the effect of a dangerous (or an alarming) event can also be an indicator of the given person's emotions. This idea was subjected to control in this study.

2. Experiment I

To carry out the study, first of all it was necessary to find such a dangerous influence the intensity of which could be measured quantitatively and estimated by the person who has experienced such an influence already. The effect of electric current proved to be comfortable to estimate and measure of this influence.

As verbal estimations are basic for the diagnostic method under study, the experimental subjects had to be the people who had formerly experienced the effect of electric current and who knew its value - electricians of high voltage transmission were selected for that purpose. Studies show (Manoilov, 1976) that they get electric shocks with frequency of 4-5 times a year.

In the present study, we are also interested in individual differences that appear in estimating the intensity of such an influence. The differences are related to temperament, social and professional qualities, motivation etc. All these qualities that have an effect on a person's attitude towards dangers had to be revealed in electricians' practical activity already (including breaking, the instructions of safety devices, punishments for it and in accidents).

2.1. Subjects

Two groups of experimental subjects were formed (with equal Ns = 19 men) on one hand, the electricians who worked safely and had had no accidents; and on the other hand, the electricians who had had breakings of safety instructions, punishments for it and who had had accidents. The two groups were matched for the length of service, age qualification and education. The length of service had to be at least a year in order to be included in the study. The first group was conventionally called "cautious" and the other "breakers". It was presumed that the members of these two groups differed in their estimation of the effect of different electric voltages and that such a difference may be a practical corroboration to the diagnostic method.

To control the supposition about the existence of individual differences between "the cautious" and "the breakers" they all were subjected to tests of temperament, risk-taking, ego defence, motivation to succeed , as well as the estimation of their social and professional qualities. We saw that "the breakers" differed from "the cautious" in greater mobility of nerve processes, greater inclination to career and alcohol, worse attitude towards work and lower motivation to success (all $p < 0.05$). All these factors, especially the connection of the inclination to rise in career with lower motivation to success (in accordance with Ehlers (1964) studies and their mutual connections, as it is known from studies about the psychology of safety - (Balint, Murani, 1968), promote underestimation of dangers, breaking instructions and higher risk for accidents. The present data also prove it.

2.2. Method and Results

At first, the members of both groups were subjected to the previously described method to estimate their attitude towards danger. As that method is described in detail in Kotik (1978a), we report only the final results in the both groups shown in Figure 1. We can see curves that connect the severeness of accidents (S) and the possibilities of their occurrence (P%) when the event was estimated as "often".

In Figure 1., two characteristics are to be seen separately: that of "the cautious" and that of "the breakers". Comparing them it is easy to conclude that "the breakers" tended more to reduce the rate of danger. For example "the cautious" regarded the event frequent if the possibility of occurrence of an injury of average severeness was 20%, "the breakers" regarded it frequent only at 30%. So it was established that the formerly used method about people's attitude towards a dangerous event proved to be useful.

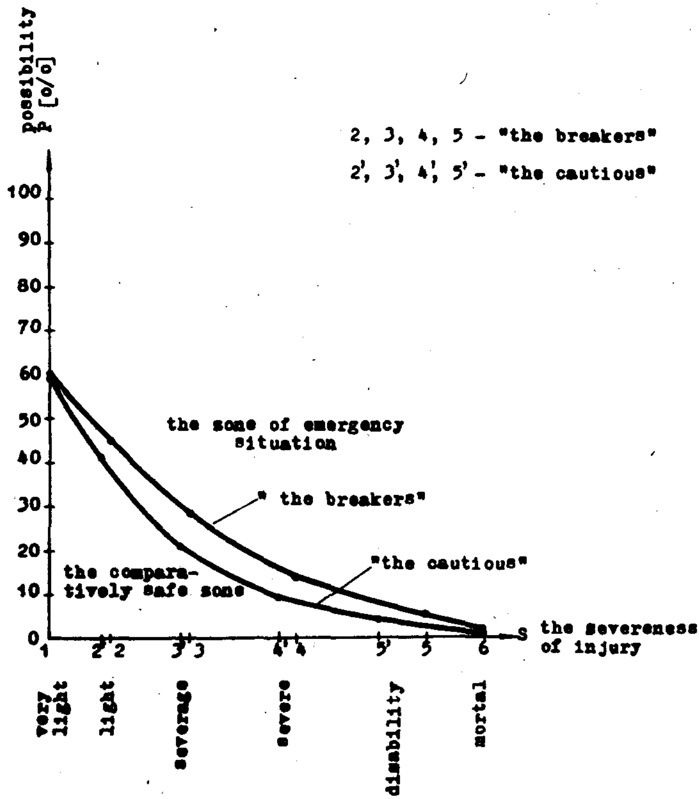

Figure 1. The possibility of occurence the bodily injury of their significance.

3. Experiment II

Now let us describe the experiment that was aimed to prove the above-mentioned hypothesis: to establish the connection between the intensity of electric tension and the words that were used to estimate that tension.

3.1. Method

All the members of the groups of electricians were instructed as follows:

"Imagine that you were told to disconnect the conducting poles in the transformer stall. You were announced that the poles were without tension. The stall is small, confined and uncomfortable. With your one hand you have to hold on the door of the stall, with your other hand you have to disconnect the pole. It turns out that because of a "parasitic chain" the pole has been given a potential. We ask you to determine by which tension the effect of the electric current is <u>always</u>:

- mortal
- extremely strong
- very strong
- strong
- neither strong nor weak
- weak
- very weak
- extremely weak
- reduced to nought.

The same instruction was repeated, the experimental subjects were asked to carry out the same estimation procedure but only about the cases when the above-mentioned tension gives <u>often</u> such consequences (mortal, strong etc.).

3.2. Results

The data collected in such a way were processed and graphs were constructed. These are presented in Figure 2. On the basis of these graphs we can conclude that with both instruction variants between the quantity of dangerous tension and the verbal estimation of its quantity, almost linear relationship emerges. The more determined the dangerous effect is, the

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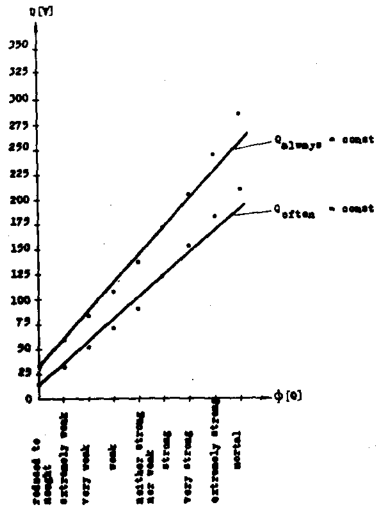

Figure 2. The connection between the intensity of electric tension and the verbal estimation of its quantity.

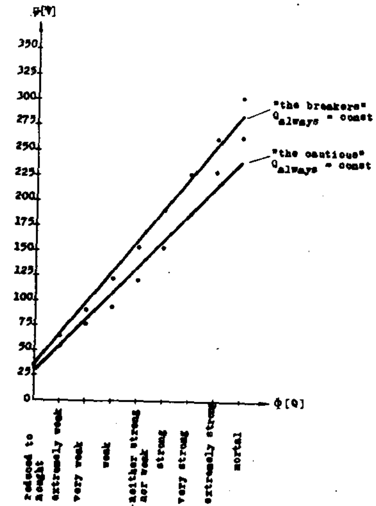

Figure 3. The connection between the intensity of electric tension and the verbal estimation on its quantity by the members of two groups.

higher is the function U (Q_{int}) placed on the graph. Most likely, if the estimation is carried out on condition that if the examined tension seldom causes the given effects (mortal, strong etc.) then such a characteristic - U (Q_{int}) would be placed lower than that on condition often in the graph. Hence the lower the characteristics of Figure 2 are placed in the graph, the more determined an event they reflect. From Simonov's theory (1970) we know that , as the uncertainty of occurrence of a dangerous factor grows, its realization appears to become a stronger emotional event (here-emotional factor strengthens as a man is less ready to meet danger).

Hence we can make a conclusion that the lower the characteristic is placed in the graph the stronger emotional event it describes.

One must mention that if a word that was chosen to estimate the frequency of a dangerous event was connected by a logarithmic relationship with the possibility of its occurrence (Kotik, 1977,1978a), then the word that was chosen to estimate the intensity of the effect of the event proves to be linearly connected with its size (here with its tension).

All these results are well connected with W.Wundt's and P.Simonov's theories of emotions. W.Wundt claimed that the greater is dissatisfaction of the necessity, the degree of being left without, the stronger are negative emotions; that is also confirmed by our study. Simonov (1970) showed that emotions strengthen the factor of uncertainty, the unexpectedness of occurrance of emotional effects and they increase proportionally to entropy (to the logarithm of the possibility of its expectedness).

4. Discussion

As we could see the first part of our study showed that by the word that the subject uses to describe the intensity of the dangerous effect of an event, one can ascertain the degree of emotional role of the event for the subject.

We had to prove also the validity of this method with the help of the estimations measured by a more reliable method . Such suitable control may be achieved by the use of our method to estimate the electricians attitude towards danger .

The answers about the degree of dangerousness of the tension given by the members of the both groups were selected from the whole block of experimental data. The characteristics are shown in Figure 3.

As we can conclude from the Figure, "the cautious" estimate the danger clearly higher than "the breakers". The characteristics of "the cautious" U (Q_{int}) is placed clearly lower than that of "the breakers" (on the level of the difference p = 0.99 ; Dixon,Massey,1957). Only by that one can conclude that for "the cautious", the dangerousness of electric shocks of various degrees is a stronger emotional event than for" the breakers". That conclusion can be illustrated by Figure 3.

The breakers" regarded tension of 90V as very weak but the "cautious" regarded it only weak."The breakers" regarded it only weak. "The breakers" regarded the tension of 190V as only strong but "the cautious" already rated it very strong. "The breakers" regarded the tension of 260V as very strong but "the cautious" as mortal.

We can conclude that the presented diagnostic method to determine attitudes towards a dangerous event is fixed by practical control: the experimental subjects who avoid danger in their practical activities can rather reliably be determined as well as described by this method (Kotik, 1977; 1978a).

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РАЗВИТИЕ МЕТОДА ОЦЕНКИ ОТНОШЕНИЯ СУБЪЕКТА К ОПАСНЫМ ИЛИ ТРЕВОЖНЫМ СОБЫТИЯМ

М.Котик Л.Ээвель

Р е з ю м е

Настоящая статья является новым экспериментальным подтверждением ранее высказанной нами идеи о том, что по тому к какому размытому множеству субъект относит данное опасное событие возможно диагностировать его отношение к этому событию. Для такой диагностики прежде использовались размытые множества частоты (считает ли субъект появление данного опасного события "редким", "частым" и т.п.). Наши результаты показывают,что отношение к опасному событию может определяться и по тому к какому размытому множеству интенсивности будет отнесено это событие (сочтет ли субъект его воздействие "слабым", "сильным" и т.п.). Валидность предложенной методики проверялась на двух экспериментальных группах электриков высоковольтных сетей. Первая группа была сформирована из электриков, которые пренебрежительно относились к опасности и попадали в несчастные случаи. Тестовые исследования испытуемых этой группы подтвердили их высокую склонность к риску и низкую мотивацию к труду. Во второй группе были электрики примерно того же возраста и квалификации, но по своим индивидуальным качествам менее склонные к риску, более мотивированные к успеху в труде и не попадавшие в несчастные случаи. Предложенная методика позволила с высокой достоверностью диагностировать указанное различие в отношении к опасности первой и второй группы испытуемых.

WHAT CAN LATERAL PREFERENCE TELL US ABOUT HEMISPHERIC SPECIALIZATION IN LANGUAGE FUNCTIONS?

Jüri Rosenfeld *

Abstract. A group of non-right-handed (N=37) and right-handed (N=34) children (M=13.7 yr.,range 7 to 18 yr.) were compared on a number of dichotic measures mapping different components of lateralized language abilities.The results failed to support the notion of higher precedence of the "atypical" cerebral laterality pattern among the non-right-handed. However, some of the findings indicated the possibility of the existence of subtle differences in hemispheric speech organization between the Subjects showing left preference in visual domain (in the right-handed group), extreme left manual preference on the objective manual laterality tests (in the non-right-handed group), and those tending to prefer right side in both groups.

1. Introduction

At the present time the asymmetry of human cerebral hemispheres' contribution to the psychological processes involving language is a well established fact (Dimond,Beaumont, 1974; Harnad et al., 1977 etc.). Although it is generally accepted that most of us "are speaking with the left half of the brain", the specifications about hemispheric laterality pattern seems to appear complicated by at least two factors in every single case. First, by the varying degree of the functional asymmetry in different individuals (Zangwill, 1960; Luria,1947; Shankweiler,Studdert-Kennedy, 1975) and second, by the specific contribution of "non-specialized" in verbal capacities hemisphere to the language functions (Balonov, Deglin, 1976; Searleman,1977 etc.).

How to predict which hemisphere is the more crucial one for the language capacities in a given person has been the

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perennial topic of the neuropsychological investigations since Boilland's supposition about right-handedness as a possible reason of left hemisphere dominance in most people and Broca's doctrine of the speech-specialized hemisphere as contralateral to the preferred hand (cit. after Penfield,Roberts,1964).A great deal of evidence has been obtained ever since, indicating that the relationship between preferred hand and superior in language skills hemisphere is not so rigid, especially in case of left-handedness (Hécaen, 1962; Roberts,1969;Gloning,1977; Davis,Wada,1978 etc.).

Although the left manual preference is more frequently associated with "atypical" dominance pattern, there is considerable disagreement between different authors as to the degree of left-handedness which allows reliable prediction for deviation of the cerebral laterality pattern (see a review by McKeever, VanDeventer, 1977). The data about relationships between dominant eye and leading hemisphere seems to be quite inconsistent as well (Porac,Coren,1976).

In the present study, we are searching for the possibility to predict definite pecularities of hemispheric specialization in language functions on the basis of the manual and visual laterality patterns without restricting the concept of the manual preference only to hand dominance in the everyday sense of the word and the concept of hemispheric specialization in language only to the left hemisphere' verbal capacities.

2. Methods

D i c h o t i c t e s t. Broadbent's version of verbal dichotic test procedure (Broadbent,1954) was used for evaluating the patterns of hemispheric laterality. In spite of numerous experimental data showing great sensitivity of the dichotic effects to the demanded report strategies(Bryden, 1962) , type of response (Kotik,1975) and acoustic structures of dichotic stimuli (Berlin, Cullen,1977), most authors agree with Kimura's proposition (Kimura,1961a;1961b) about "leading ear effect" as being determined by specialization of the hemisphere contralateral to the "dominant ear" in verbal abilities (Berlin, McNeil ,1976; Baru,1977). Our dichotic test includes ten series of stimuli, each consisting of four dichotic pairs of monosyllabic words with intervals of 500 ms between the pairs. Within interval of 20 s between the series, the Subject had to recall words he had heard (immediate recall - IR). After passing ten series he was asked to reproduce all the words presented to him during the test, although no special instruction for this task was given before (delayed recall - DR). DR was followed by the task in which subject was instructed to recognize stimuli of the dichotic test in a written list of words which also contained semantically and phonetically similar items (recognition - R). The whole procedure (IR,DR,R) was repeated with the reversed position of the head-phones in order to reduce possible channels' inequality in acoustic and semantic parameters.

Manual superiority tests. A questionnaire containing 12 items shown to be the most valid and reliable by Raszknovski et al. (1974) was used to determine hand preference in everyday activities.

Beside this questionnaire, the following objective measures of manual laterality were used in this study: the Steingrüber's Hand-Dominance test, Van Ripper's test, Černaček's test and the comparative evaluation of hand grip strength. The Steingrüber's Hand-Dominance test makes it possible to assess the performance of each hand separately in three motor tasks including line tracing in irregular labyrinth, dot tapping into aligned squares and into randomly spaced circles (Steingrüber, Lienert, 1971). In contrast, Van Ripper's and Černaček's tests are based on the phenomenon of contralateral motor irradiation that is more pronounced from the dominant hand to the subordinate one. The Subject has to perform two, in some respect different tasks simultaneously, using his left and right hand for different tasks at the same time. The attention is usually focused on the leading hand's activity. As a result, the subordinate hand either adopts the preferred hand' movement pattern (Černaček's test) or starts to produce mirror-inverted movements (Van Ripper's test). While performing Černaček's test (Černaček, Podvinsky, 1972), subjects try to draw simultaneously the circle by one hand and the square by the other with both eyes closed. As a rule, two similar drawings are produced with the subordinate hand's drawing resembling that of the dominant hand. In Van Ripper's test (Černaček, Podvinsky,1972) simultaneous drawing of two heart-like figures similarly oriented in horizontal plane are required, also, in eyes-closed condition. The Subject places each of his hands upon one of the two cardboard sheet, together composing a two-folded angle. He then draws figures, while the experimenter gradually changes the angle between the cardboard sheets. At a certain angle, one hand usually inverts the drawing's orientation. If the adoption and the inversion of the drawing were doubtful or did not appear at all, we scored such data as ambilateral.

In grip strength evaluation we considered the results ambilateral if the difference between the hands was less than 2 kilograms of pull. Besides the above-mentioned laterality tests, we used indirect indicators of hand dominance chosen from Luria's test battery (Luria,1969): interlacing of the fingers, the arms folding on the chest, the position of the hands while applauding.

O t h e r l a t e r a l i t y t e s t s. Our questionnaire also included two most valid and reliable items indicating foot preference in everyday activities (Raszknovski et al., 1974).

For the dominant eye evaluation three highly intercorrelated tests were chosen from Coren and Caplan's study(1973): pointing test, Asher test and hole test. Also, eye dominance test from Luria's battery that is nearly analoguous to Coren and Caplan' "alignment test" was included.

Besides, our battery contained the time-sharing procedure and the "rhythmical probe". The "rhythmical probe" is based on the notion that dominant in language functions hemisphere may be crucial for producing rhythmical sequences through the contralateral motor pathways (Wolf et al., 1977). In our "rhythmical probe", the Subject had to produce the rhythms of varied complexity by one hand, while tapping with the other. We determined a relatively optimal position for rhythm producing without total adaptation of the rhythmical pattern by the hand engaged in tapping. As has been shown in Peter's study, the independent in rhythmical sense tapping was possible only when the left hand in a group of right-handed people was used for rhythm production (Peters , 1977).

Therefore, in condition of optimal labour division between the hands for independent rhythm reproducing, we consider the hand engaged in tapping as dominant.

Our time-sharing procedure was the modification of that proposed by Lomas and Kimura (1976). They have reported selective impairment of sequential finger movements while repeating nursery rhymes that appeared to be more pronounced on the hand contralateral to the dominant hemisphere. It seems, however, that nursery rhymes are of somewhat ambivalent value to be used in unilateral hemispheric overloading tasks, because such kinds of verbal activities are likely to demonstrate high level of automation and consequently may rely upon the right hemisphere's structures (Searleman, 1977). Therefore, a sentence with quick alternation of opposite consonants from word to word (Саша шла по шоссе и сосала сушку) was used as a verbal interference task in our time-sharing procedure. Before the test, the Subject had to pass through two training trials in order to reach the criteria for participation in further procedure. Firstly, he repeated the sentence in interference-free condition without any misarticulation, at least once. Secondly, the Subject had to produce sequential finger movements from the little finger to the thumb until he was able to perform it without mistakes at least three times. The second training trial was administered to each hand separately. In the test trial, the Subject, with closed eyes, was instructed to repeat the sentence four times while trying to produce sequential finger movements (by one hand at a time). More than one misarticulation, the alternation of the finger movements' direction and an appearance of tripple finger synergies were considered as criteria for the occurrence of interference. The interference effect was interpreted in accord with Kinsbourne and Cook's hypothesis attributing its occurrence to the competition of the two concurrent activities in the verbally dominant hemisphere (Kinsbourne, Cook, 1971). The more pronounced impairment of one hand performance was considered to reflect, therefore, the specialization of the contralateral hemisphere in verbal production.

3. Subjects and Procedure

Subjects were children (M=13.7 yr., range 7 to 18 yr.) from a local secondary school chosen on the basis of their self-identifications and information from teachers about their hand preferences. Two opposite handedness groups were derived from the total of 71 children (56 males, 15 females) relying on the criterion decribed below. Non-right and right preference groups consisted of 37 and 34 children respectively.

In order to reduce possible genetic influences on the cognitive performance, the Subjects lacking left-handed persons among close relatives were included into the group of right-handers. Nobody reported any problem in hearing, vision or manual performance.

All Subjects were tested individually. Hand order was counterbalanced within the groups in the tasks where result might have depended on the hand initiating performance.

4. Scoring

For the laterality tests, all scores, whether in patterns of inversion (Van Ripper's test), kilograms of pull or indicated manual preference in response to the handedness questionnaire,etc.,were evaluated in trichotomized manner with possible scores ranging from - 1 (completely left) through 0 (ambidextrous) to + 1 (completely right).

Handedness classification was based on the summation of the answers to the inventory. A Subject was classified as right-hander only if the right hand usage was indicated for at least 10 different activities. Otherwise, he was regarded as non-right-hander.

The scores of 6 objective manual laterality measures were summed up to calculate the composite Manual Laterality Index. The same was done in this respect to the 4 tests of visual dominance, 2 questions concerning foot preference and indirect laterality measures from Luria's battery that separately composed complex indices of Visual Dominance, Foot Dominance and Luria's Complex Laterality Criterion.

Although not all of our tests included in the composite manual laterality index may be regarded as pure m a n u a l preference indices, there seems to be at least two reasons to compose such complex measure. Firstly, none of the single objective laterality measures appeared to be significantly correlated with dichotic test performance and secondly, all of them ascertain laterality patterns through some kind of manual performance.

The Laterality Coefficient ($\frac{Rc - Lc}{Lc + Rc} \times 100\%$) was used for evaluating "Right Ear Advantage" of the IR, DR and R in dichotic task. Rc and Lc are sums of the correct scores on the right and left side, respectively obtained in two sessions that differed in head-phones position.

The mean of the "double correct response"(DCR) for the two sessions was calculated. By "double correct response" we bear in mind two correctly recalled words (in Immediate Recall) that were simultaneously presented in concurrent channels. It is believed that the ability to process signals that overlap temporally and spectrally with one another may indicate improving brain efficiency (Berlin, 1977).

5. Results

Table 1 shows the means and standard deviations(SD) of the Laterality Coefficients and composite laterality indices for each group. The following means were found to be significantly different for the two groups: the handedness inventory scores ($t = 9.3$, $df = 69$, $p < 0.001$), Manual Laterality Index ($t = 5.1$, $df = 69$, $p < 0.001$), Visual Dominance Index ($t = 2.8$, $df = 69$, $p < 0.01$) and Foot Dominance Index ($t=6.3$, $df = 69$, $p < 0.001$).

It is apparent that all complex laterality measures indicated patterns of lateral preference in the groups in the expected direction, with the exception of the Luria's Complex Laterality Criterion that did not differ between the groups.

Among the indices used in dichotic test, the "Double Correct Response" was the only significantly different measure between the two groups ($t = 2.36$, $df = 69$, $p < 0.05$).

Within Subject comparison of the mean Laterality Coefficient revealed significant differences between the Immediate and Delayed Recall ($t = 2.4$, $df = 33$, $p < 0.05$: in Right-Handed Group; $t = 2.9$, $df = 36$, $p < 0.01$: in Non-Right-Handed Group), and between the Immediate Recall and Recognition ($t = 2.6$, $df = 33$, $p < 0.02$: in Right-Handed Group ; $t = 3.0$, $df = 36$, $p < 0.01$: in Non-Right-Handed Group). This decrement in "Right Ear Advantage" due to the changing from response type to another is consistent with previous observations (Curry,Ford,1967; Kotik,1975) attributing this effect to the right hemisphere equal involvement in such kind of performance.

Tables 2 and 3 present the distribution of the positive, negative and ambilaterality scores of Laterality Coefficient in Immediate Recall as a function of the age and sex. We assumed a conventional value for the ambilaterality scores to be equal to ± 3. All scores that exceed that value were regarded as negative or positive depending on the direction of the deviance.

Table 1.Group Means (M) and Standard Deviations (SD) for the measures of Dichotic Performance and Composite Laterality Indices for Right-Handed (R) and Non-Right-Handed Group (NR).

Group:	M		SD		x_{max}		x_{min}	
	R	NR	R	NR	R	NR	R	NR
I. IR	7.4	10.1	21.8	17.7	64.2	63.1	-58.6	-38
2. DR	-0.1	0.4	17.1	24.5	40	50	-37.9	-66.8
3. R	1.3	0.7	13.5	17.5	33.5	84.6	-31.2	-23
4. DCR	4.4	3	2.6	2.4	10	8.5	0	0
5. HS	11.7	2.9	0.6	5	12	9	10	-12
6. MLI	3.6	0.5	1.4	3.3	6	6	1	- 6
7. VD	1.8	-0.4	3.2	3.4	4	4	- 4	- 4
8. FD	1.7	-0.2	0.5	1.7	2	2	-2	-2
9. LCLC	1.3	0.6	1.5	2	3	3	-3	-3

IR - immediate recall, DR - delayed recall,R - recognition, DCR - "double correct response", HS - handedness score, MLI - manual laterality index, FD - foot dominance index, VD - - visual dominance index, LCLC - Luria's complex laterality criterion, x_{max} and x_{min} - maximal and minimal results that occured in the two groups of subjects.

Table 2. Number (and Percentage) of Subjects in each group (Right-Handed - R, Non-Right-Handed - NR) with ambilaterality (±3), negative (< -3) and positive (> +3) scores of the Immediate Recall in Dichotic Performance as Function of Sex.

Group	> + 3				< -3				±3			
	R		NR		R		NR		R		NR	
	f	%	f	%	f	%	f	%	f	%	f	%
1. ♀	4	66.6	6	66.6	2	33.3	2	22.2	0		1	11.1
2. ♂	17	60.7	17	60.7	7	25	6	21.6	4	14.3	5	17.8
Total	21	61.7	23	62.1	9	26.4	8	21.6	4	13.9	6	16.2

Table 3. Number (and Percentage) of Subjects in each group (Right-Handed - R, Non-Right-Handed - NR) with ambilaterality (±3), negative (< -3) and positive (> +3) scores of the Immediate Recall in Dichotic Performance as Function of Age.

Age	≤9 yr.				10-14 yr.				14,5-18 yr.			
Group	R		NR		R		NR		R		NR	
	f	%	f	%	f	%	f	%	f	%	f	%
1. >+3	1	33.3	3	50	7	53.8	11	84.6	13	72.2	9	50
2. <-3	2	66.6	1	16.6	2	15.3	1	7.7	5	27.2	6	33.3
3. ±3	0		2	33.3	4	30.7	1	7.7	0		3	16.6
Total	3		6		13		13		18		18	

Table 4 displays intercorrelations among the different measures of the lateral preference and Laterality Coefficients of dichotic performance. Positive relationships between the Immediate Recall and Delayed Recall ($p < 0.05$), negative correlations between the Recognition and "Double Correct Response" ($p < 0.05$), Visual Dominance Index and Recognition ($p < 0.05$) in Right-Handed Group were found out. In the Non-Right-Handed Group, three measures of the dichotic performance were positively intercorrelated: Immediate Recall and Delayed Recall ($p < 0.05$), Immediate Recall and Recognition ($p < 0.05$), Delayed Recall and Recognition ($p < 0.05$).

Table 4. Intercorrelations (Pearson r) for measures of Dichotic Test and Composite Laterality Indices for Right-Handed (upper right triangle) and Non-Right-Handed (lower left triangle) groups.

	IR	DR	R	DCR	HS	MLI	FD	VD	LCLC
1.IR	-	0.46**	0.26	0.11	-0.04	0.1	-0.1	-0.03	-0.03
2.DR	0.59**	-	0.03	-0.02	-0.22	-0.06	-0.02	-0.07	-0.08
3.R	0.33*	0.36*	-	-0.36*	-0.07	0.12	0.01	-0.33*	0.07
4.DCR	-0.22	0.03	-0.07	-	0.25	0.23	-0.18	-0.09	-0.14
5.HS	-0.01	0.10	0.31*	0.32*	-	-0.14	0.12	0.24	0.14
6.MLI	0.05	0.14	0.00	-0.42**	0.14	-	0.1	-0.24	0.15
7.FD	-0.07	-0.02	0.18	0.23	0.43**	-0.01	-	-0.01	0.3
8.VD	0.00	0.25	0.22	-0.06	-0.22	-0.01	-0.12	-	0.18
9.LCLC	0.40**	0.18	0.21	-0.28	-0.11	-0.14	-0.29	-0.04	-

* - $p < 0.05$

** - $p < 0.01$

IR - immediate recall, DR - delayed recall, R - recognition, DCR - "double correct response", HS - handedness score, MLI - manual laterality index, FD - foot dominance index , VD - visual dominance index, LCLC - Luria's Complex Laterality Criterion

The correlations in that group between the Foot Dominance and Handedness Score ($p < 0.01$), "Double Correct Response" and Handedness Score ($p < 0.05$), Recognition and Handedness Score ($p < 0.05$) were found to be positive, and strong negative correlation between the "Double Correct Response" and Manual Laterality Index ($p < 0.01$) was revealed.

6. Discussion

In general, our results failed to confirm the more frequent occurence of "atypical" cerebral laterality patterns among the non-right-handers as compared with the right-handers in a given sample. These data are consistent with Fennel et al. (1977), who have employed the dichotic stimuli that were very similar to those used in our study, and with Penfield and Roberts' (1964) conclusions based on the direct examination of the cerebral laterality. It seems that the lack of inter-group differences could not be explained by the groups' heterogenity with respect to sex and age. However, the studies regarding the influence of sex and age on the dichotic performance are controversial (Lake, Bryden, 1976; Porter, Berlin, 1975; Hynd, 1977; 1979). The inspection of the Tables 2 and 3 makes it clear that the effect was not revealed in our results. Even, if we hypothetically assume the existence of the influence of sex and age this must appear in excess of the bilateral cerebral patterns just in the non-right-handed group, because of the higher precedence of females and younger subjects in this group relative to the right-handed group. And this would enhance differences between the groups in the expected direction (more frequent "atypical" among the non-right-handers). Within Subject differences in the Cerebral Laterality Effect between the measures of dichotic performance used once more indicated the short-sightedness of regarding the left hemisphere as the exclusive organ for language. Non-right-handed as well as right-handed subjects showed similar bilateral patterns of hemispheric specialization when the processes of involuntary memory (Delayed Recall) and passive recognition were emphasized in the task. This is in agreement with Simernitzkaya's results indicating right hemisphere involvment in the involuntary retention of the verbal material (Simernitzkaya, 1975).

It is of interest, however, that unlike the right-handers, non-right-handers showed laterality scores in recognition that appeared to be correlated with immediate and delayed recall scores (Table 4). This may point to differences between the two groups in the dynamics of Right Ear Advantage change in various response conditions and, consequently, to subtle differences in cerebral organization of the language functions. Specifically, non-right-handers may still rely more heavily on the "dominant" hemisphere structures while performing the dichotic tasks where the involuntary retention and recognition are substitute for the active recall. Indeed, lack of the differences between the two groups in laterality scores need not be necessarily extrapolated to all the levels of such higher order cortical function as language is. They may still exist beyond the sensitivity of certain dichotic laterality measures. For example, Obrzut et al. (1979) have found discrepancies between the cerebral laterality patterns obtained in dichotic and time-sharing procedure with disabled children.

The explanations in respect to the "Double Correct Response" seem to be less challenged when based upon the Pearson coefficient, than on the means, because the former takes the Subjects' age - the critical variable in that measure (Berlin, 1977) - into account. The negative correlation between the Manual Laterality Index and "Double Correct Response" in non-right-handed group may indicate higher brain efficiency in persons that tend to demonstrate the extreme left manual preference. It is possible that this population displays more bilateral representations of certain components of the verbal abilities that, although not discovered by laterality scores, may facilitate the retention of the concurrently presented dichotic signals by ensuring the storage of the non-dominant message that does not interfere with the dominant one.

As it seems, the negative correlation between "Double Correct Response" and Recognition in the right-handed group may hint at the existing of the right-handed Subjects showing the bilateral cerebral pattern similar to that described above. Indeed, the more concurrently presented stimuli are reproduced by the Subject, the more enhanced becomes the asymmetry indicated by his recognition score, and therefore it is more likely that the hemispheric asymmetry would not be reduced by changing the response conditions in dichotic procedure that may be salient, as it was supposed, to the non-right-handers.

Positive correlation between the Luria's Complex Laterality Criterion and immediate recall in non-right-handers and negative correlation between the visual dominance and Recognition in right-handers may be interpreted along the same lines, i.e. as showing that left lateral preference increases the probability of the hemispheric laterality to approach the pattern expected to be more frequent in non-right-handed group.

There are two correlations that apparently contradict our conjectures: between the Double Correct Response and Handedness score, and between the Recognition and Handedness score. One possibility is that Handedness Inventory and Manual Laterality Index measure different aspects of the Manual Laterality phenomenon, as it is comfirmed by lack of correlations between these two tests in both groups. However great the temptation to prefer objective measures of laterality to the subjective ones on the experimental grounds is (Benton, 1962), it can be argued that a more confident answer regarding these discrepancies may be given only when these data are compared with those obtained by more direct examination of hemispheric laterality.

To conclude, the results reported here do not support the notion of more frequent precedence of the "atypical" laterality pattern as revealed by means of the dichotic paradigm in the group of the non-right-handed subjects. Although there appeared to be evidence for subtle discrepancies in hemispheric organization of the language functions between the subjects tending to prefer left and those preferring the right side in both groups, it remains still a hypothesis at this stage of study. Although this is possible, several findings argue against such an explanation. More serious experiments are needed to support or reject the speculations offered above.

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ЧТО МОЖЕТ ЛАТЕРАЛЬНОЕ ПРЕДПОЧТЕНИЕ СКАЗАТЬ НАМ О ГЕМИСФЕРИЧЕСКОЙ СПЕЦИАЛИЗАЦИИ В РЕЧЕВЫХ ФУНКЦИЯХ?

Ю.Розенфельд

Р е з ю м е

Группы правшей и левшей, определенных на основании вопросника мануального предпочтения, сравнивались по ряду объективных тестов латеральности и по 4 показателям дихотической процедуры. Существенных различий между группами в полушарной речевой специализации обнаружить не удалось, хотя в обеих группах вероятность обнаружения в них атипичного паттерна полушарной специализации возрастала с увеличением степени левостороннего предпочтения.

GENESIS OF A SUBJECTIVE IMAGE*

Talis Bachmann

If I chose the action, don't you therefore think yet that sensual apprehension is unknown terrain for me.

A. Camus

Abstract. The present article gives an overview of microgenetic research in the form more close to an essay than a technical research paper. The various theoretical and methodological aspects of the problem, including interrelationships of microgenetic phenomena with information - processing, psychophysical, and neuropsychological paradigms, are dealt with. The problem is discussed in an evolutionary context. The author reaches conclusion that the present subject matter seems important enough in order to care for its revival among the psychologists, working within currently popular paradigmatic trends of perception research.

1. Introduction

Behavioral sciences have been dealt with three types of genetic processes: the phylogenesis, the ontogenesis and the microgenesis. At the time of the first two concepts being well-known, the concept of microgenesis (or German "Aktualgenese") is relatively less familiar. It refers to the process which is less durable and could be embraced by a definite situation. Microgenesis might be termed as the origination and formation process of some behavioral act, given psychological state or reaction which is fixed by an observer (experimenter) and which goes through a series of

*The original Estonian variant of this article was prepared for the presentation during the celebration of the 100th birth anniversary of Prof. Konstantin Ramul (1879-1975), the founder of the Laboratory of Experimental Psychology at Tartu University. The special kind of the participants of this celebration, including nonprofessionals, determined the popular style of this article.

specific observable phases. One example of this kind is the process of subjective image (percept) genesis.

At first moment, one may feel that perceiving of surrounding world could be understood as a phenomenon of instantaneous, direct, immediate reflection. More exact experimental measurements demonstrate, however, that such an "immediacy", common to everyday introspective perceptual experience, turns out to be misleading. The percept in its differentiated, adequate and clear form is the percept in its final phase of formation. Most expressively it comes to the fore with visual perception. We may use the next analogy: Beginning with the first moment of influence of a complex of external stimuli (appearence of an object or stopping the gaze on a new stimulus) up to the adequate subjective reflection the perceptual image "matures" analogically with the development of a photo on a sheet of photographic paper after putting it into the developer. But as such a process at the mental level is completed incomparably faster (approximately 0.1-0.4 seconds), then, as a rule, it remains elusive for introspection. In order to investigate the microgenesis of the perceptual image we must use the special apparatus (e.g. tachistoscope) or special conditions of observation.

What is the reason of paying attention to such an "exotic" topic? It seems to us that while the host of current researchers of perceptual problems are in one or another way engaged in the information-processing research including determination of temporal stages of successive data processing operations, nevertheless, most of them approach the problem according to the "neoclassical" Broadbentian scheme almost totally excluding the very specific form of psychological subject-matter - the psychic, subjective reality. Indeed, it has some merit to consider many of the approaches of cognitive psychology as quasi-behavioristic. The present article tries to outline some characteristic features of microgenetic research which may point to the possibilities of integration of some relatively independently developed cognitive-psychological paradigms.

2. On the history of the problem

Alongside the concept of "microgenesis", the development of subjective image is described in terms such as "microdevelopment", "formation of percept", "the growth of an image", "the phasic nature of perception", "the principle of graduality", "the maturation of percept", "the build-up of an image", "the clearing-up process" etc. It should be stressed that the phenomenon of microgenesis must not be confused with the well-known principle of latency (delay) of mental processes. Here we have not to do merely with the temporal interval between the appearance of a stimulus and a response following it but we have a sequence of reactions beginning with most primitive and ending with the accomplished ones. Not so much a delay between the stimulus and the evoked response in the form of subjective image is examined as the change of the subjective image itself in time is analysed.

In the present context, the investigations by Donders from the 1860ies in the area of reaction time research should be emphasized. Donders differentiated between three classes of reaction times according to the subject's task - A, B, and C, resp. detection, detection-identification-response choice, and detection-identification. His investigations are close to the microgenetic domain due to the subtraction method introduced by him. In order to measure the durations of different mental processes, Donders subtracted the reaction time of one kind from the reaction time of another type. For example, to find the time needed for the completion of the process of identification, it was necessary to subtract the type A reaction time from the type C reaction time. The time of response choice might be obtained by the subtraction of C from B (an example from Donders: 284 - 237 = 47 msec). These investigations enabled to specify the temporal structure of the classical array of psychological operations. This array, as we know, consists of detection, recognition-identification, response choice, and execution of response if to mention the basic ones. But what the sequence of subjective perceptual states in time is like is not answered by Donders' methods. (The subtraction method is criticized by the school of O. Külpe and among the contemporary psychologists the American researcher S. Sternberg also objected to this method. The last investigator in turn offered a method of additive factors which however remains out of the scope of the present text).

Besides Donders, one of the most important researchers of the previous century who considerably influenced the studies of the problem of microgenesis was the Russian psychologist Nikolai Lange. In his monograph from 1893 (Lange,1893)* one may find several important ideas which were reformulated not until the middle of the present century. As a result of his experimental and theoretical work Lange reached the next standpoints. After generalization upon the research data of Wundt, Exner, Donders and himself he concluded that the classical array of psychological processes should be based on one general legitimacy - on the so-called "law of perception". "Every process of perception consists of extremely rapid alternation of several moments and stages, and each preceding stage represents less concrete, more general psychic state while each next one - more concrete and differentiated state" (Lange,1893).Lange differentiates between four different stages: First, the "incitement in consciousness" without any definite quality is perceived ("something happened"). Further on the perception of modality without definite quality follows. The third stage consists of the perception of quality without form characteristics (e.g. what color or size or sound is characteristic of an object or stimulus). The fourth stage finally grants that the exact form and fine localization are perceived. "In these stages of consciousness ...the paralleiness with the stages which developed in the process of general animal evolution should be seen: along with the differentiation of the sense organs and nerve centers, ever more specific qualities of things became evident to the consciousness of animals exactly in parallel with that, about which the above-mentioned principle speaks when dealing with an individual consciousness. Analoguously to the

*In order to be more precise it should be noted that the contents of this monograph had been preliminarily published already in 1892 in the four issues of the Russian journal Problems of Philosophy and Psychology, vol.III and IV.

mode by which the human embryological development repeates during some several months the stages traversed once along the general development of the kin , the individual perception repeates by several tenth of second the stages which developed within millions of years in the general evolution of animals" (Lange, 1893,p.2). So Nikolai Lange should be considered as one of the first formulators of the microgenetic-phylogenetic principle of isomorphism in the aspect of perceptual psychology. Running ahead it should be said that this principle applies well to the treatment of semantico-linguistic material either. In parallel with the formation of the linguistic correlates of perception at the latest stages of phylogenesis the semantic (including verbally categorial) aspect of perception of an outer stimulus reaches consciousness at the last stages of microgenesis.

With respect to the problem of percept genesis such 19th century authors as J.M.Cattell and N.Baxt were also influential through their experiments on temporal perceptual processes.

Beginning with the first years of the present century the schools paying attention to microgenetic problems have developed in Russia (later on in the Soviet Union), in the central Európe (mainly in Germany and Italy, less in Sweden and France), and in America. If Donders and Lange were mainly engaged in the analysis of the array of general mental reactions, then later on the problem of microgenesis of form and scene perception was focused upon. In other words - one (or two) stage(s) from the classical array were taken and the investigation of their own temporal dynamics became the research subject in turn. In Russia such works were done under the supervision of Bechterev (Nikitin,1905) and afterwards this trend transformed into the Leningrad school (Lomov, Vekker, Aleksandrova, Zabrodin, Loskutov,Panferov, Varskij, et al.). Gestalt psychology was mainly the theoretical basis for an analoguous work in Germany and Italy. The most outstanding of this was the Leipzig branch of gestaltists with their leaders Felix Krüger and Friedrich Sander. They and their many followers and colleagues (Carl, Dun,Galli, Hausman, Mantell, Undeutsch, Werner, Wohlfahrt, et al.) were first to explicity speak of microgenesis (German equivalent - <u>Aktualge-</u>

nese). The peak of activity of this school belongs to the period 1930-1945. In addition to the two above-mentioned schools a number of psychologists - microgenetic researches can be listed who did not form independent schools and who did not always spoke explicitly about microgenesis: in Anglo-American literature - Bridgen, Cheatham, Davies, Dickinson, Dodge, Douglas, Drury, Fehrer, Flavell, Draguns, Freeman, Helson, Ogden, Rogers, Wever, Wilcox, Zigler, McFarland, Kaswan, Young, Vernon, Dixon, et al.; in Japan - Hayami, Tanaka, Tomoda, Kaneko; in Sweden - Smith, Kragh, Borg; in Belgium - Michotte; in Australia - Day, Kirkham, et al. The works of the enumerated psychologists belong mostly to the interval from 1907 (Dodge) to 1960. In Tartu State University the investigations of microgenesis have received attention too. In 1930-ies a Doctoral dissertation was written by R. Hippius on the problem of "Cognizing Touch" in which several stages of perceptual experience were outlined. Before the analoguous work in Leningrad University was begun, M. Aleksandrova worked on the microgenesis at Tartu University. Under her supervision several course- and graduate theses were prepared. The well-known report at the all-Union Psychological Meeting in 1955 introduced the microgenetic work from Tartu State University (Aleksandrova, 1957). However, already in the nineteenth century, the investigations close to the microgenetic domain were performed in Tartu by the famous E.Kraepelin who worked in our University until 1891. Though Kraepelin worked as psychiatrist and although there was not any special psychological laboratory, he and his colleague and follower professor V.F. Čzisz, who both had been students of Wundt in Leipzig, supervised several purely experimental psychological works (including doctoral dissertations). To mention one of them for instance: K.K.Dehio, 1887, "Investigation of the relative influence of cofein and tea on the duration of mental processes".

What is, then, the principal scheme of a microgenetic investigation? The works of the previously-listed authors are very close to one another in this respect. In all of them the data about Aktualgenese is obtained by the systematic (step-by-step) improvement (or impairment) of subject's viewing conditions and by the fixation of the perceptual quality characteristic to each stage or phase. As stimuli the geometric forms, words, pictures of certain scenes or objects, outline drawings, random patterns etc. have been used. The task of the subject consists of recognition of exposed stimulus, of the drawing of it, or of the estimation or scaling of some qualities of the stimulus. In any case the task should be of this kind, on the basis of which it would be possible to fix or specify the mode of perception proper to the given perceptual conditions. The main methods are: alteration of the exposure time, changing of the luminance, decreasing of the speed of movement of a stimulus, systematic optical focusing of the blurred image (or vice versa), alteration of the size of a stimulus as measured in degrees of visual angle, moving of a stimulus from the visual periphery to the center, increasing of the speed of successive presentation (temporal integration) of the elements of an image, masking, successive scanning of the visual pattern by the spatial window of different dimentions, repetition of the temporal frames of a stimulus, stabilization of the retinal image (with special emphasis on fading-reappearence), perceptual testing at the different phases of recovery from neuropsychological damages, auditory loudness modification, etc. The overview of these works could be found in the writings by Lomov (1966), Flavell and Draguns (1957), Smith (1957), Kragh and Smith (1970), Vernon (1937), Zusne (1970), Murch (1973), Forgus and Melamed (1976), Draguns (1978). The previously listed different methods have lead to the surprisingly similar sequence of microgenetic stages obtained by different authors. To illustrate the phases of microgenesis we would introduce a table from which the examples of phase orderings outlined by different investigators can be found. From the great deal of such examples only some of the typical ones are used.

As we can see, different researchers with different methods have revealed the principally coinciding sequence - perception develops from general, nonspecific quality to the concrete, differentiated one. The continuous approach to the adequate reflection is taking place.

Many psychologists have payed attention to these stages of microgenesis, at which the image might be interpreted in se-

Author and the year of publication	Phases of microgenesis (improvement of perceptual conditions) →						
Nikitin (1905)	Perception of diffuse background	Detection of lines	Specification of single lines	Indistinct form	Exact fragments	Idea, not clear form	Complete similarity
Day (1956)	Light threshold	Threshold of indefinite form	Threshold of definite form				
Zigler et al. (1930)	Lack of figure	Formless figure	Formlike figure	Distinct (clear) figure			
Douglas (1947)	Sensory phase	Exploratory phase	Interpretation phase				
Freeman (1929)	Level of the preperceptive determination (general extent perceived)	Stage of the perceptive particularity (thingness perceived)	Stage of perceptive familiarity (recognition of the object)				
Dickinson (1926)	Visual pattern	Generic object	Specific object				
Undeutsch (1942)	Diffuse undifferentiated unit	Vague differentiation of figure from the background (Gestaltgerüst)	Preliminary hypothesis, preconfiguration phase (Vorgestalt)	Clear percept			
Hebb (1949)	Primitive, sensorically determined unity (figure-ground)	Nonsensory differentiation of figure from background	Identification, associations				
Lomov (1966)	Differentiation of general proportions	"Flickering" phase	Differentiation of details in general	Globally adequate perception	Optimal perception		
Murch (1973)	Detection of light	Nonspecific figure	Differentiated object	Specific object	Manipulation		
Forgus, Melamed (1976)	Detection of energy	Discrimination of unified brightness, figural unity and orientation	Resolution of finer details, differentiated figure	Identification and recognition	Manipulation		
Bachmann (1977)	Sensory analysis →	Sensory-objective synthesis →	Concrete image representation →	Abstract image representation →			

veral different ways without alterations in physical conditions of exposition. As a rule, this multistability manifests itself at the intermediate phases. Lomov (1966) termed one such phase as the "flickering" phase: in the case of an invariant stimulus, e.g. outline square, the subject perceives a triangle in one occasion but ring in another occasion etc. Such a variation of interpretations or ambiguity resonates well with the standpoints of Jerome Bruner or Richard Gregory on the hypothesis-testing nature of perceptual act: We can perceive the surrounding stimuli according to the perceptual hypotheses which come into action due to the cooperative effect of the actual stimulation and the long-term perceptual experience.

In order to illustrate the categorical, and at the beginning stages hypothetical, nature of perception, Bruner and Potter (1964) carried out the next experiment: The slides of the familiar objects initially defocused (blurred) were shown to the subjects with the stepwise focusing of the pattern and with the sufficiently thorough analysis of the subjects' responses. A paradoxical result became evident showing that the more the subjects saw out-of-focus pictures, the higher had to be the level of clearness of the picture in order to recognize it. The authors concluded that the higher the duration of exposition of that stages of clearness which lead to the wrong interpretations, the stronger the perceptive set to see just those perceptual variants corresponding to the preliminary hypotheses. And, of course, these preliminary ideas need not correspond to the reality.

The already classical work of Nikitin (1905) threw light on the problem of perceptual hypotheses. In his experiment several, different contoured drawings were tachistoscopically shown to a subject with ever increasing exposure times. In the course of investigation the phases of perception described in the table turned out. The method included subjects drawing of their impression. Special attention was drawn to these end phases, where the clear perception of fragments and whole parts of figure preceded to the vague form perception given that in the latter case the idea of form category not corresponding to the actuality had been cropped up. This might be considered as a peculiar example of masking where the analysis of the perceptual category might restrain the analysis of the physical form of the same object. With the formation of the hypothesis about an object in whole this hypothesis becomes a leading factor of perceptual process and the physical form reaches its adequate representation in awareness only if the conditions of exposure are already sufficiently favourable and if the hypothesis is adequate. One of the general laws of perception could be formulated as follows: With favourable, easy, unequivocally determined conditions of perception (sufficient observation time, sufficient energy of stimulus, central projection of stimulus with regard to the visual field, sufficient contrast, normal acuity, steady stimulation, lack of masking factors, relatively small number of stimuli, etc.) decisive for the perceptual process and its subjective counterpart - image - is just the physical stimulation; the less favourable (more ambiguous) the observing conditions, the greater the increase of the relative share of perceptual hypotheses and sets in the process of percept development. From this it becomes evident that as the middle phases of microgenesis correspond still to the ambiguous conditions then just at these phases the lack of correspondenence between the hypothetically presupposed and actually exposed categories could be possible.

As we can see, it is difficult to differentiate between the sensory and higher cognitive operations even at the level of elementary cognitive processes. Such a "smoothness" of transition is evident also in the microgenetic paradigm as a whole. So, in addition to the perceptual microgenesis such problems as microgenesis of thought, microgenesis of emotional states, microgenetic aspects of personality and creativity have been dealt with (see Flavell, Draguns, 1957; Smith, 1957; Kragh, Smith, 1970; Smith, Danielsson, 1976, 1979).

3. The problem of microgenesis in the light of current investigations

One might ask whether the problem is at all important enough in order to treat it among the classical problems of perceptual psychology. All the more - a great deal of the microgenetic research is in one or other respect based on the introspective method. It should be stated however, that many theoretical problems exist, in the resolution of which the important role has an understanding of the principles of microgenesis. The objections to the introspective methods could be weakened by the fact that the introspective act, on the basis of which the subject reports about his subjective impression, is only an intermediate stage whereas the control of these reports with regard to their accuracy presumes juxtaposition of the objective and subjective. The subjective reality is not independent from the physical experimental material and on the other hand - the consistency between the independent observers points at the objectivity too.

Subsequently, I will deal with some domains, facts and theory of what have been riched due to the investigation of microgenesis. In the sphere of neuropsychology and psychopathology researchs have been encouraged by the theorists of microgenesis probably most frequently as compared to other disciplines. In connection with this, Heinz Werner (1956) discussed the problem of aphasia. According to his data the responses of the patients suffering from aphasia, to the prolonged exposition of words in principle do not differ from the responses to the same words given by normal subjects with very short expositions. These responses, which are based on the intermediate phases of Aktualgenese, are characterized by the dynamic nature of semantics, by the frequency of somatic experiences, and by the generality of descriptive responses (difficulty to answer using a concrete concept). The subject (patient) would succed in grasping the general semantic sphere and the responses are of highly associative nature. The process of recovery from aphasia also goes through certain stages which are analoguous to the microgenetic phases of normal subjects in the special experimental conditions. Relying on the data of Goldstein, Wepman, and Conrad, Werner argues that the functioning of the higher mental levels is impossible without corresponding functioning of the lower levels and the development becomes arrested at some low stage if the activity of higher stage is not fostered. It would be said that the subjects with aphasic diagnosis are perceiving the surrounding world on the basis of incomplete microgenesis.

Soviet researchers Zhirmunskaya and Beim (1974) compared the visual gnostic functions of healthy and pathology-prone subjects using also microgenetic methods (yet without explicit use of this term). Patients who had various injuries of brain bloodvessels, local brain damages and several resulting gnostic impairments were studied. To these subjects different contoured drawings of common objects were shown tachistoscopically. The subject had to redraw the picture according to his impression. The temporal recognition thresholds were also found. Whereas the perceptual phases of the normal control subjects corresponded to the well-known principles, then at the same time the microgenesis of the agnosic patients was impaired. The characteristic features where: hypertrophic perceptual phase of amorphous form without apprehended "thingness", the scattered nature of figure elements and the resulting difficulty in extraction of the essential features, the high inertness of the hypotheses or conversely - superlability, lack of the capacity of synthesis etc. The more expressed disturbances of microgenesis became evident with bilateral injuries of the occipital zones of the brain and with right hemisphere dysfunctions. The damages of the left hemisphere and frontal zones did not lead to comparable severity of perceptual deficiency.

Jason Brown in his monograph (1977) payed even more attention to the psychoanatomical bases of microgenesis: To each evolutionary or ontogenetic stage of development of the perceptual capacities and modes, a given basic activity of certain brain structure corresponds. The more primitive the perceptual function is the more archaic brain structure is mainly responsible for the realization of that function. The phases of perceptual process transverse in direction from the primitive to the accomplished, from the preconscious to the conscious, and analoguously the activity of the more primitive structures is followed by the activity of neocerebral spheres. In Brown's theory, it is interesting to emphasize the recapitulative or repetitive nature of the perceptual process: the perception is not a unique single act but rather it is a sequence of perceptual acts where each new cycle should be considered as a repetition of the previous one but on a more advanced and perfect level. It is important to draw here the parallels with the classical ideas of Lange about the microgenetic and phylogenetic isomorphism.

The psychophysical trend as compared to the microgenetic trend is of course much more widespread among the perceptual psychologists. The present-day psychophysics have made a paramount advancement as with regard to the experimental basis (equipment) as well as in the development of the research problems. The connections with the contemporary neurophysiology are tightened. In our present case, special interest is aroused by the part of psychophysics, which is devoted to the problem of spatial frequency perception and texture analysis. As we know, the term "spatial frequency" could be understood as a measure of the amount of contrast changes in a spatial unit (e.g. for one degree of visual angle). Hence the "finer", more detailed, the stimulus is, the higher its main (fundamental) frequency and vice versa. Psychophysical and neurophysiological investigations have shown that different spatial frequencies are analysed by the visual system with different speeds and also the sensitivity to the stimuli with different spatial frequencies is different (an optimal stimulus appr. 6-10 cycles per degree of visual angle). The more global an object or pattern is, the faster is the reaction time to it and the faster is the process of image formation. According to one hypothesis the more "coarse" stimuli are analysed by the transient (phasic) perceptual system and the "finer" ones by the sustained (tonic) system of perceptual channels. In addition to the smaller latency to the stimuli the other peculiarities of the transient system are the tuning to the periphery, the maintenance of the operating with blurred (defocused) image, sensitivity to motion or transients, capacity to encode the location of the stimulus without a fine analysis etc. The sustained system, on the contrary, being slower, requires also sufficiently focused image, in general the central stimulation is needed; it reacts to the sharp edges and is not so effective in analysing the moving patterns. If we now recollect the qualities of image, characteristic to the phases of microgenesis, and the corresponding experimental conditions, then we detect that the operating of the transient system corresponds to the earlier (lower) stages of microgenesis which are followed by the working of the endstages which in turn might be connected with the sustained activity. Certain controversy could arise from the fact that between the percept-genetic phases the relatively smooth quality changes are taking place, not the polar states could be observed. Consequently, the data from microgenetic research supports more the hypothesis, according to which in perception we have to do with a system of multiple interchangeably connected information processing channels which flexibly changes its behavior parameters depending on the spatiotemporal structure of stimulation. In the course of a genesis of the perceptual image, the faster but "coarser" analyzing mechanisms are giving their leading role to the slower but "finer" channels step-by-step. So, in general, the current psychophysical and psychophysiological data are in accordance with the research results of microgenetic problem in this aspect (see Breitmeyer, Ganz, 1976).

As another contemporary popular trend in perceptual research - the information-processing approach - uses predominantly tachistoscopic method and is directed to the discovering the temporal microstructure of cognitive processes in their inner, vicarious plane, then these investigations are in one or another way related to the problem of microgenesis. One of the main formulators of the fundamentals of information-processing approach - Ralph Norman Haber (1969) - denominates the microgenetic works as among the precursory developments to the contemporary paradigm. However, it seems to us that he underestimates the importance and potentials of the microgenetic ideas.

Among the Soviet researchers being active in the information-processing area, the microgenetic problem is accepted by Vladimir Zinchenko (1972, 1976), the founder of the microstructural trend in the Soviet cognitive psychology, by Lev M.Vekker, and by Mark S. Shekhter - to name a few.

Among the basic paradigmatic methods of information processing research which are closely related to the problem of percept genesis we could list: masking, search, analysis of reading operations, investigation of the "repetition-clarity effect" (see Haber, 1969), investigation of the mode and speed of coding operations of the stimuli belonging to different physical and/or semantic classes, a question of subliminal perception, etc. Due to the lack of space we would refer only to some general conclusions which might be reached at on the basis of information-processing studies.

As we know, the masking phenomenon should be termed as the impairment of perception of one stimulus by the presentation of another stimulus in close spatial and temporal proximity. The masking may result in total suppression of the test stimulus by the masker or in the reduction of some perceptual feature such as clearness, contrast, spatial frequency etc. If the masking stimulus temporally follows the test-stimulus (e.g. for 50 milliseconds), then we speak of backward masking; on the contrary the phenomenon is forward masking. Such experiments have shown that the microgenesis of an image could be stopped or restrained in different ways by the use of a backward masking stimulus. The common temporal range for masking are the intervals between test and masker from 0 to 250-300 milliseconds. If the interval between the presentation of two short different stimulus impulses exposed in the same spatial area goes in the above range then the nature of masking in turn depends on the form of both stimuli and on the precise value of the interval. It seems that at short intervals (0-50 msec), the masking is based on simultaneous microgenesis of two different stimuli at once at each stage resulting in the formation of a "montage", a common image of both objects. From such composition it must be difficult to read out the information. With longer intervals (e.g. 50-150 msec), albeit the percept of the first stimulus in its physical analogue form can "mature" independently to clear form, nevertheless before the completion of the genesis of an "idea" or category state for that stimulus the physical percept of the succeeding stimulus is formed already and attention switches to the new microgenetic cycle. Now on the account of the interruption (or "sublimination") of the previous microgenetic cycle the processing continues with the completion of conscious later cycle (see Bachmann, Allik, 1976). The subjective impression in such masking situation is analoguous to the experience of clearly contoured objects flashing between the wagons of meeting train when you nevertheless can not tell the nature and meaning of these objects.

Why is that the psychological time appears us paradoxically in such situations (information entering before lefts priority to aftercoming data)? One reason could be the ecological advantage of switching the processing to the ever new signals because the earlier the time of entrance for sense data the more must it be deciphered as compared to the latercoming bits and so the attentional priority should be given to new information in order to quickly determine its potential dangerousness or significance. This principle of processing would have been guaranteed phylogenetically by natural selection in the case that some ecologically important reactions could be switched in already at the level of incomplete microgenesis. Otherwise this principle becomes useless. The other explanation of the priority of backward masking over the forward masking forces us to draw attention to the oculomotor aspect of perception. During a day the eye makes thousands of saccadic jumps in order to fixate the ever next objects important for behavior. But as, in general, the every new fixation is connected with the planning of performance, with the goal-directed behavior, then the information from every next fixation should be of higher importance as compared to data from the previous one - otherwise the jump would be odd. So the every new image automatically receives priority and the "old" information should be suppressed in order to diminish its possible interfering effects. Thus the masking situation could be regarded as a modeling situation of saccadic and scanning regime without actual eye jumps and hence the backward masking naturally should receive priority. This idea predicts that the interruptive backward masking be maximal had the interval between the test and the second interfering stimulus correspond to the normal intervals between two visual fixations. After consulting the special literature one could find that the prediction works (standard intervals include the short periods of 40-50 msec ; Avetissov, Rosenblum, 1973). Another important function of backward masking must be the suppression of microgenetic process evoked by the producing of the retinal blur during an eye movement. One more point we should turn to is methodological: It appears that with few exceptions (Schiller; Harcum; Bachmann, Allik; Hellige), most of the experimental situations using masking work with artificial conditions when the maskers represent meaningless noise or random patterns - contrary to the everyday interaction of stimuli having the object nature.

In general, on the ground of masking technique researchers have succeed in specification of the times of microgenesis of different perceptual material and in the discovering of the structure of inner mental operations on which the microdevelopment is based. The last point here we would touch is the question about the physiological mechanisms guaranteeing the interruptive type of masking. It appears that in addition to the feedback-controlled attentional mechanism of interaction of inferotemporal cortex and subcortical nuclei (Pribram, et al.) and in addition to the interaction of the transient and sustained neuronal channels (Breitmeyer, Ganz, Matin, Weisstein, et al.), one more mechanism, an older and perhaps forgotten one, could also well explain the facts. The classical studies of reticular formation have told us that for the conscious perception both the specific reticular impulses and nonspecific reticular influence should converge on a single cortical area (see Hassler, 1978). At the same time there are enough facts - neurophysiological and psychological - that the specific signals coding the meaning or structure of the stimulus can, first, be transversed to the highest cortical centers by several dozen milliseconds (hence before the completion of microgenesis) and , second, the time of arrival of specific and nonspecific impulses could be temporally dissociated. The situations when the nonspecific influence linger in comparison with the specific one are common (Hassler, 1978; Libet, 1978). Hence we have the data at hand allowing to speak about some "consciating" operations which give subjectivity, give awareness to the already processed data. So the microgenesis should be considered as the continuous process of catching consciously the contents of processed data. With regard to the masking situation it might mean that the "consciation" process "finds a wrong item", i.e. the recurrent impulse from the cortical structure which is representing the structural information of the first stimulus activates special reticular mechanisms projecting nonspecific impulses to that critical zone (by some address system). But as the specific mechanisms represent already a new information having the same "spatial address" then the nonspecific ascending impulse, activated itself by the first stimulus, makes subject aware of the second stimulus. One more conclusion now is that we could not speak of interruption but rather of the erroneously directed (shifted) focal attention switching. These ideas have several implications for the reaction time studies, refractoriness studies, studies of subliminal perception (including masking technique) and others.

What else have the experiments belonging to the information-processing paradigm clarified? First, the importance of the localization feature for the whole perceptual process. Almost all operations of microstructure are based on the preliminary orienting of perception in space and as a rule this orienting stage precedes to the configurative determination. The data point also to the multidimensionality and cyclic nature of microgenesis (see Bachmann, 1977; Bachmann, Velichkovsky, 1979). The "maturation" of the higher perceptual qualities may begin before the completion of the genesis of representations at previous stages. For example, category genesis could start before the development of analogue physical representation (an icon) is finished. This adds plasticity to the system, enables feedback-control in the course of a microgenetic cycle and thus guarantees the running correction of processing mistakes and variety of interpretation. By this way the influence of motivational and social sphere to the perceptual process is possible in ambiguous and diverse complex situations (see Dixon, 1971; Bruner, 1977). The information-processing investigations have proved the multiplicity of different codes in perceptual system, and different speeds of encoding characterize different stimuli and stimulation aspects. Due to this, we can separate the microgenesis into subcomponents, e.g. iconic, abstract-visual, nominal, emotional, general-semantic microgenesis etc.

The interrelationships of visual, auditory and verbal perceptual subsystems are specified, established is the general temporal structure of microoperations with special emphasis on the problem of simultaneity and seriality (successiveness) of processes and on the question of limited capacity of operations. The information-processing approach consists considerably of the studies investigating the manifold mechanisms of selectivity, their optimal working regimes and critical features - in other words, the investigation of the attention microstructure have been started. The originally simple and clear model "object - representation" is transformed into the rather complex theoretical domain which requires the special terminology and experimental base.

4. In conclusion

In connection with the widespread and justified popularity of objective and quasi-objective trends of perception research it seems that surpassing the old sometimes we have thrown the baby away with bathwater. Investigating perception we can never completely get rid of the subjectivity of the image, of that specific form in which the objective reality represents itself to us. The problem of microgenesis we have dealt with could be one of such problem areas unjustifyably forgotten to some degree. As we have seen (but not proved here), the data of microgenetic research considerably coincide with the data of contemporary psychophysical and information-processing research fields. In addition to this, as it were by surplus product, the usage of the old method in a new context enables us to widen the theoretical interpretations, to notice the new possible hypotheses and to develop the interdisciplinary investigations. Relying on this it appears justified to try to integrate the research methods independently developed within different schools and trends and through this avoid the terminological parallelism so common to day. The exciting perspectives of this context include integration of biological, evolutionary,and psychoanatomical knowledge and principles with cognitive-psychological research in order to reach at the unitary scientific landscape of perception theory. And probably the most-appealing feature of our subject matter is just the possibility to relate the subjective and objective phenomena scientifically through the Darwinian methodological traditions. All the more, the microgenetic ideas can well absorbe the psychodynamic factors as well as the theoretical aspects of the important consciousness problem.

But who makes it sure that the problem of microgenesis is not an artificial problem? Have the experimental situations of artificial conditions something to do with the perception in everyday life? The experiments with masking, analysis of the pathological material etc. have shown, however, that the normal layman's perceptual process represents a microgenetic phenomenon. Especially vividly this comes to the fore at the first moment of every new eye fixation. But the eye of a man moves permanently. Secondly, the control and direction of the oculomotor functions is a task of the earlier, "raw" stages of image also (e.g. the blinking reflex, some components of the orienting reflex, the directing of gaze at the new suddenly appearing object, etc.). Further on - dayly situations and professional settings often present us with the difficult perceptual conditions (the fog, twilight, far distance,quick motion,noisy displays, and so on), the reacting and performance in which can be better understood if we know the principles of microgenetic dynamics in the diapasone of "unmature image".

Above, we have seen that microgenesis might be a paying mean in the analysis and diagnosis of the pathological cases. In principle it would be possible to develop a new diagnostic apparatus and methods on the ground of microgenetic ideas. The work on the development of children's cognitive processes could be advanced too. It would not be forbidden to conceive a situation where in the microgenetic demonstration we could introduce the adult observers with the infant perception modes*. And last but not least - the aquaintance with microgenesis could advance our understanding of the unconscious.After all, we here deal with the qualitatively and quantitatively specified stages and mental states each of which is differently related to consciousness, beginning with the total unconscious (unawareness) over the quasiconscious up to the categorical, volitional conscious reflection. The possible set of problems here includes the questions of anatomical substrates of consciousness, the ontogenesis of conscious, the problem of constituents of subjective awareness departing from the psychological nomenclature, etc.

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*Yet there are standpoints according to which the perceptual ontogenesis and microgenesis should not be isomorphic processes (Draguns,1978).

As we can see, we permanently live "a bit in the past", though not more than some 200 milliseconds, but yet. By what is this warranted? And another question - if this latency is inevitable, why the image could not appear, after the latency, in its final, "matured" form according to the "all-or--none" law? First, it should be said that we have to do with phylogenetic inevitability. The previous must survive given it may be in principle still useful. Here we speak of the neurostructures which mediate perception, of their psychoanatomy. In order to preserve the older functions adequate, the new functions can only add to the older ones during the development of the species by modifying them and by using their products in turn. This way we reach at the stages-nature of perception. The possibility of sustained reactivation obtained in this way appears suitable as well. The old and more general reactions which should stay restrained had perception represent always only actual (and unique, not general) environment, maintain intactness by this way. In other words, the perceptual principle "from general (and anxient) to concrete" grants the liveliness of long-term memory and many automatisms.

Another advantage of the phasic nature of perception is the resulting possibility to separate (differentiate) the great amount of information to the "aspects" temporally too. Due to this, these reactions which work on the basis of global information either could not be subject to interference. To fulfil the different perceptual functions at different moments successively but well is better than doing all at once at first moment but with smaller guaranty. Clearly the general orienting of observer or the spontaneous protective reactions are realized on the ground of other kind (and at the same time more "raw") of data than, say, the analysis of fine details or naming of an exotic object. Briefly, the economy of information processing and the precision of information transmission rises. Due to the phasic nature of processing the flexible running correction of perceptual errors could be possible: The wrong interpretations are not conclusive. This "negentropic" effect of microgenesis must be payed for by the world perception being late. Nevertheless a question can arise: if, at each stage, mainly one component of the basic perception components is completed, why is that we can not perceive these intermediate successive single stages subjectively? One reason is the previously touched phenomenon of backward masking. The information from each next phase becomes a leading factor and mask the previous phases, in analogy with suppression of the stored information of previous visual fixation after the moving of gaze onto the new fixation area. Furthemore, the capacity of temporal resolution of the visual system is limited and the visual events succeeding each other within the certain short interval (e.g. 100 msec) may be integrated. Another reason why it is difficult to perceive the preliminary and intermediate phases of microdevelopment appears to be the ecological expediency: Our performance is effective if at each moment attention is captured by the mental concentration, control and response preparation for a single event only. But whereas commonly just the end stage of perception is the aim of the predominant activity or the backround for it and whereas due to its complexity with regard to the represented information the endstage requires the highest capacity from interpretive processes, then just the endstage itself captures our attention. According to the contemporary standpoints of attentional psychology these processes are termed the focal attention (contrary to the preattention or to the subliminal processes).

We feel that the microgenetic research forces us to accept the idea that probably the species-specific information storage and the individual memory are more closely tied together than it seems at first moment and this might work just through the actual dynamics of perception, through the <u>intermediate</u> stages of sensing, through that which leaves itself masked for us by the clear,"contemporary" perceptual image. Hence the psychological time (including psychodynamics of ontogenetic heritage), situational time, and general (physical, paleontological, cultural,etc.) time can reveal us some curious connections just in the above-discussed context. By developing the microgenetic investigations the hope would rise to find again a bridge between the "physical" (read - "scientific") and cultural-anthropological aspects of perceptual psychology. But has this any sense is already another question.

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ГЕНЕЗ СУБЪЕКТИВНОГО ОБРАЗА

Т. Бахман

Резюме

В статье дается обзор проблемы микрогенеза перцептивного образа. Рассматриваются разные теоретические и методические аспекты данного вопроса, в том числе связь явления микрогенеза с исследованиями информационно-когнитивного подхода, психофизики, нейропсихологии. Контекст изложения - эволюционный.

TEMPORAL ORDER RECOGNITION OF VARIOUS LUMINANCE WAVEFORMS *

Milvi Tepp Jüri Allik

Abstract. The temporal order recognition of two spatially adjacent luminance excursions in the uniformly illuminated field was studied. It was shown that the constant threshold of contrast predicts the perceived simultaneity of linearly increasing luminance ramp in the comparison of instant luminance step of the same amplitude. The recognition performance was found to be dependent on the speed of the increase in luminance. The results suggested that the temporal order recognition of two short near-threshold flashes is best when temporal asynchrony between flashes is about 60 ms. It was demonstrated (by forced choice method) that the temporal order recognition remains at chance level when the detection of luminance perturbation is performed correctly in 75% cases. The performance to recognize temporal order was interpreted as an indication of the properties of the elementary visual subroutines which pick out movement information in the spatio-temporally varying luminance distribution.

1. Introduction

Sekuler and Ganz (1963) found that after adaptation to a moving high-contrast grating the contrast threshold of a test grating moving in the same direction was higher than that of a test grating moving in the opposite direction. Directionally - specific threshold elevation can be interpreted as an indication that the unidirectional moving grating presents a separable visual quality which amount can be expressed as a function of contrast. However, the after-effect of seen movement shows that the moving grating as a separable visual quality can be expressed as a function of the drifting rate (Pantle, 1974).

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In one of our studies, we were able to show that the shortest temporal asynchrony necessary for the temporal order recognition of two spatially neighbouring luminance excursions behaves very similarily to the contrast thresholds of drifting sinusoidal gratings (Allik et al., 1976; Allik, Tepp, Livshits, 1977). Adaptation to a unidirectionally shifting pattern causes selective elevation of the temporal order recognition threshold only in case of movement in the same direction as that of the test pattern. According to our interpretation, the visual system contains elementary visual subroutines describing local unidirectional movement information in the luminance distribution terms varying in the space and time. It was proposed that the elementary movement-detecting routine is a correlation device which compares luminance perturbations in two separate spatial positions over limited spatial distance (Allik, Tepp, 1978).

The goal of the present study was to extend our knowledge about elementary movement detecting routine, by having a look at its responses to various luminance waveforms. Two series of experiments were performed to find answers to the following questions: (1) How is the temporal order recognized when two different luminance excursions are presented, one of which has a linearly increasing luminance ramp and other has a form of an instant luminance step? (2) How is the temporal sequence of two short near-threshold luminance pulses recognized?

2. Temporal order recognition of two luminance ramp with different rising time

2.1. Stimuli and apparatus

The stimuli were presented on a transparent screen (the arrangement is shown on Fig. 1). The test stimuli, A and B, and the fixation point (FIX) were generated by light-emitting diodes which were placed just behind the transparent screen. The light-emitter diodes (AL 102 B) were red in colour having a maximum emission at 700 nm. From a distance of 140 cm the subject saw bright circular spots 0.14° in diameter on a larger illuminated background with the square's side 3.2°. The centre-to-centre spatial separation between stimuli A and B was approximately 0.12° (D). The fixation point was

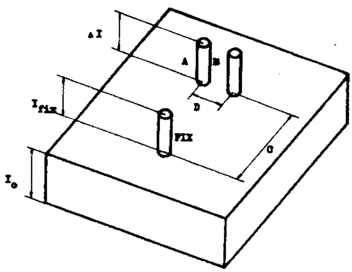

Figure 1. Schematic view of the luminance body used as a stimulus in the present study.

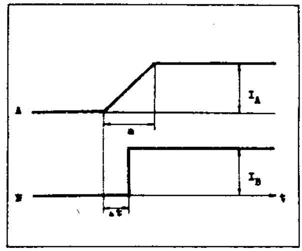

Figure 2. Waveforms and designations of the light excursions of the test stimuli.

2.4° below the main stimuli (C). The transparent screen was mounted on a considerably larger black light-absorbing background and was illuminated by an adjustable light source through the red colour filter (KC-10, transmission cut at 680 nm) from the front of the screen. The luminance of the background was I_o=35.4 nt, the luminance of the fixation point I_{FIX}=50 nt above the background luminance. The contrast of the test stimulus was defined as follows:

$$\hat{c} = \Delta I / I_o \ .$$

The envelopes of the luminance excursions, of the test stimuli above the background luminance, are shown on Fig.2. The right-hand stimulus B had an instant luminance increment step from the baseline to the amplitude I_B. The stimulus B reached its maximum level during a period of less than 0.26 ms. The other stimulus A had linearly increasing luminance increment with varying luminance rising slope , i.e. rising time (see designation(a)on Fig.2). A specially designed electronic circuit consisting of operational amplifiers was used to generate linearly increasing current. The current ramp is a ramp of controlled rising time and amplitude, the temporal onset of which is varying in time. The ramp generator had good linearity, however it began to show some kind of nonlinearity at rising times longer than 600 ms and at lower amplitudes. The onset time of stimulus B can be adjusted in relation to stimulus A so that Δt was the independent variable in the present experiment.

2.2. Procedure and definitions

The observer's head was placed on chin rest and was fixed by forehead support. The observer looked at the adaptation field for approximately 5 min, at which time the trial sequence began. Every trial sequence was performed with one of three fixed contrast levels ($\Delta I_A = \Delta I_B$), namely $\hat{c}$ was equal to 1.61, 2.32 either 3.14. For every trial sequence, one of the seven possible values of the rising time (a) of stimulus A was chosen. Possible values of (a) were: 0 , 100, 200, 300, 400, 500 and 600 ms. Before the main series, a preliminary trial was performed to determine the temporal asynchrony of the perceived simultaneity of two different luminance excursions and the appropriate range of values of Δt round the point of the perceived simultaneity. On the basis of these preliminary trials, 9 values were chosen to cover the whole range of uncertainty of the temporal order recognition. In the main trial sequence, the different temporal asynchronies Δt were presented in a random order. Each value of Δt was repeated 20 times. Thus the observer saw 180 trials in a sequence. Since there were 7 different rising times (a) and 3 different levels of contrast ($\hat{c}$) the observer went through the sequence of 3,780 trials.

2-alternative recognition task. For any single trial, the observer was told to classify one of 9 potential signals into one of two response classes ("LEFT" or "RIGHT").

It is important to note that the response category described the perceived direction of shift of the whole stimulus configuration rather than the sequence of the stimuli appearance.

Response probability(p). Response probability p is the probability that the observer answers "RIGHT" to some of the 9 signals of similar type. Of cource, 1-p is the probability that the observer uses another category (i.e. "LEFT"), since other response categories were excluded.

A given value Δt for the constant rising time (a) and contrast ($\hat{c}$) was empirically associated with the observer's response probability p. We have made a search for the best psychometric function fitting the observers's responses in 2-alternative recognition task over the predetermined values of Δt. These empirical distributions were approximated with an exponential function of the following form:

$$p(\Delta t) = 1/\{1 - \exp(\alpha \Delta t + \beta)\} \quad ,$$

where α and β were parametres; $p(\Delta t)$ was probability that the response "RIGHT" was given in response to the given value of Δt.

Perceived simultaneity. Obviously the perceived simultaneity of two luminance excursions can be defined as temporal asynchrony between two envelopes when the psychometric function $p(\Delta t)$ takes a value $p = 0.5$. The perceived simultaneity was marked as $\Delta t_{p=0.5}$.

Slope of the psychometric function. The slope was defined as the variable α of the psychometric function which apparently shows the width of the uncertainty interval of temporal order recognition.

To clarify the given definitions, Fig. 3 presents an example of two empirical probability distributions of the observer T.L. and the best fitting curve based on the least square approximation of psychometric functions for that distribution.

2.3. Subjects

Two highly experienced observers with acuity vision corrected to 20/20, took part in the present series of experiments. The observer T.L. was female and the other A.L. -male. Their both had been acting as subjects in the previous experiments of similar kind (see Allik et al., 1976; Allik, Tepp, Livshits, 1977).

2.4. Results

The perceived simultaneity as a function of the rising time and amplitude of luminance ramp are shown on Fig. 4. According to the definition, the perceived simultaneity is a moment of time when the psychometric function (i.e. re-

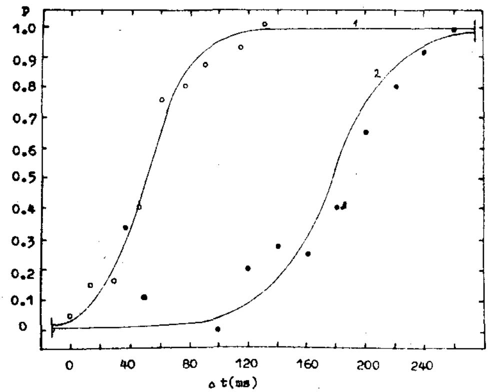

Figure 3. The response probability p plotted upon temporal asynchrony Δ t , for the observer T.L. The best fitting curves of the approximated psychometric function p (Δ t) are shown as curves 1 and 2. The curve 1 and empty circles (∘) correspond to the rising time a=100 ms; the curve 2 and filled circles correspond to rising time a=300 ms. Contrast: $\hat{c}$=2.32. Approximation goodness: r=0.92 and r=0.89 respectively.

sponse probability) reaches the equiprobability value p=0.5. Computed values $\Delta t_{p=0.5}$ are shown on Fig. 4 as filled circles ($\hat{c}$=1.61), opened circles ($\hat{c}$=2.32) and filled squares ($\hat{c}$=3.14). There clearly exists a linear relationship between perceived simultaneity and rising time a of linearly increasing luminance ramp. The numerical results of the linear regression analysis are presented in Table 1. The correlation coefficients (r) obtained show that for every contrast perceived, simultaneity depends linearly upon the rising time. The best fitting regression lines according to the Table 1 are plotted on Fig.4 (A and B) as a stright lines designated by arabic numbers 1, 2 and 3 corresponding to the contrast ($\hat{c}$=1.61, 2.32 and 3.14 respectively).

Table 1. The results of linear regression analysis showing the relationship between perceived simultaneity ($\Delta t_{p=0.5}$) and the rising time (a) dependently on the contrast ($\hat{c}$): $\Delta t_{p=0.5} = \gamma a + \delta$, where γ and δ are regression coefficients

Observer	Designation on Fig.4	Contrast	γ	δ	r	$\hat{c} \cdot \gamma$
A.L.	4A (1)	1.61	0.593	2.17	.99	0.955
	4A (2)	2.32	0.496	1.71	.99	1.151
	4A (3)	3.14	0.358	8.95	.99	1.124
T.L.	4B (1)	1.61	0.534	29.16	.98	0.860
	4B (2)	2.32	0.418	22.79	.97	0.970
	4B (3)	3.14	0.325	32.19	.94	1.021

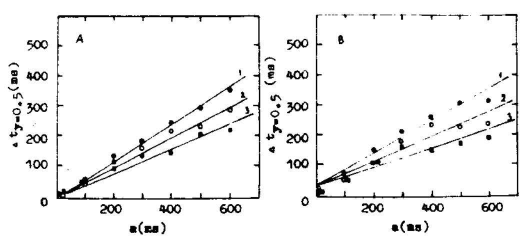

Figure 4. Dependence of perceived simultaneity ($\Delta t_{p=0.5}$) upon the rising time (a). Contrast $\hat{c}$=1.61 (• and line 1); $\hat{c}$=2.32 (° and line 2); $\hat{c}$=3.14 (▪ and line 3). Two observers: A.L.(A) and T.L. (B).

The present results suggest that, on a given contrast level, the lengthening of the rising time (a) makes it necessary to increase the temporal asynchrony proportionally (coefficient γ) which is needed to achieve perceived simultaneity. If we presume that slowly rising luminance ramps of different rising times are superimposed on one another in a way that $\Delta t_{p=0.5}$ determines the relative temporal lag on the time scale, then obviously there is a unique point where all rising luminance envelopes intersect. There is a fixed level of contrast ($\hat{c}_o$) which is taken as a departure point for the temporal order recognition. The threshold contrast ($\hat{c}_o$) can be expressed in the following way:

$$\hat{c}_o = \hat{c} \cdot \gamma \quad ,$$

where $\hat{c}$ is the level of contrast and γ is a linear regression coefficient (Table 1 and Fig. 4). The last row in Table 1 presents the computed values of the threshold contrast $\hat{c}_o$ for two observers and three different levels of contrast. The inspection indicates that the threshold contrast $\hat{c}_o$ varies - with the increase of the amplitude of the luminance excursion, the product $\hat{c} \cdot \gamma$ also grows.

Figure 5 shows the relationship between the psychometric function slope (α) and linearly increasing luminance ramp rising time (a). In addition to empirical values α , least square approximations with an exponential function are shown in continuous lines (1, 2 and 3). The increase of the rising time (a) leads to the decrease of the psychometric function slope. It is quite possible that the accuracy of the temporal order recognition depends upon the speed of the luminance growth.

2.5. Discussion

The present findings suggest that the first appearance of the luminance perturbation is determined at the moment when the contrast exceeds a certain amplitude value. This threshold amplitude of contrast ($\hat{c}_o$) is about 1.0. for the present stimulus conditions. However, it is important to mention that the threshold of contrast for the temporal order recognition slightly increases with the amplitude of the luminance step. The contrast threshold for the temporal order recognition is obviously different from the simple threshold of the luminance perturbation detection. The luminance threshold is certainly lower since the spot having contrast about 1.0 is clearly visible on the same background luminance (I_e). Usually, the models of temporal order

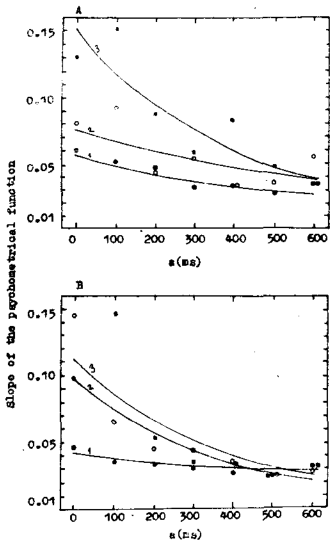

Figure 5. Dependence of the slope of the psychometric function (α) on the rising time (a). Conventional signs are the same as on Fig.4.

recognition are based on the assumption that the observer makes his judgements about temporal order on the time difference between arrival of the two signals (Sternberg , Knoll,1973). Generally, the psychometric function of temporal order recognition can be representated by the convolution of a decision function with arrival latency difference distribution. This concept, of course, implies that the arrival latency distribution for both light perturbations is known. It is common to use the luminance envelopes of similar form with the instant luminance rising or falling time in the studies of temporal order recognition. In the present experiment, the luminance envelopes of the two signals are different. In this case we have been able to show that the arrival latency as well it's distribution variance change with a change in the form of luminance excursion. More precisely: the arrival time of the signal is determined by a constant level of contrast; and the distribution of the arrival latencies is determined by the speed with which the luminance exceeds that level of contrast.

3. Temporal order recognition of two low contrast luminance flashes

3.1. Stimuli and apparatus

The stimulus configuration completely concurs with that in the previous section (2.1.).

3.2. Procedure

2-alternative forced choice method. Two temporal intervals are defined by the fixation point off-on turning duration of about 0.7 s. The duration of the temporal interval embedded between fixation point off-on periods is about 1.5 s. One of two subsequent intervals contains the signal and the other one is blank. Which of two intervals contains the signal is randomly determined by a microprocessor which forms the signal to drive the display. The signal consists of two short 5 ms light flashes which occured in the middle of 1.5 s time interval. Temporal asynchrony between flashes is 75 ms. The temporal order (i.e. direction of displacement) is also varied randomly so that the left-right sequence has the same average frequency of occurence as the right-left sequence. In any single trial the observer was told to make two decisions: first, which of the two intervals contains the signal (let us call this the detection task) and, second, what is the temporal order of two flashes (recognition task). In other words, the observer's behaviour can be described by a four-field response matrix in which the correct and incorrect interval determination is orthogonally associated with the correct and incorrect displacement direction recognition. The luminance of the adaptation field (I_e) and the contrast of the luminance pulses ($\hat{c}$) was selected in consideration to achieve about 75% level of the correct detection by the subjects.

3.3. Subjects

Three female observers with normal or corrected vision took part in the present experiment.

3.4. Results

The results are presented in Table 2. The detection task was solved correctly in 75% (E.P.), 79% (I.T.) and 76% (T.T.) cases of single trials. At the same time, the correct recognition of the displacement direction remains approximately on chance level. The direction of displacement is recognized correctly in 58% (E.P.), 58% (I.T.) and 61% (T.T.) cases of singel trials. The results suggest that the recognition task can be solved correctly in this case only if the interval containing the signal was correctly detected. If the interval indication was wrong, then the observer can only guess the direction of displacement. The per cents of correct and incorrect recognition in the case of incorrect detection are follows: 12% versus 13% (E.P.), 11% versus 10% (I.T.) and 12% versus 13% (T.T.). There are no doupts that in the case of wrong detection the observer only guess the temporal order of stroboscopical flashes.

In addition, Fig. 6 presents results of the recognition experiments over the larger scale of temporal asynchronies. Fig. 6 A, B and C correspond to the results of the same three observers, E.P., I.T. and T.T. respectively. The filled circles mark the contrast $\hat{c}$ = 1.6 and the unfilled circles mark the contrast $\hat{c}$ = 1.1 (I_o = 32 nt). The duration of the test stimuli is 2 ms. Fig.6 show that the response probability (see definition in section 2.1.2.) vary dependently upon the temporal asynchrony. The temporal order recognition reaches the maximum and minimum values of the response probability on the temporal asynchronies somewhat below 100 ms. It seems that there is a relatively narrow temporal "window" within which the recognition task can be performed successfully. For the near-threshold flashes, the increase of the temporal asynchrony leads to the deterioration of the recognition performance.

Table 2. The results of 2-alternative forced choice experiments on the simultaneous detection and recognition tasks. The duration of flashes is 5 ms and asynchrony is ± 75 ms. Three observers: E.P. and I.T. ($\hat{c}=0.18$; $I_0=104$ nt); T.T.($\hat{c}=0.2$; $I_e=80$ nt). Number of single trials is 300 per observer.

Subject E.P.		Interval Correct	Interval Incorr.	Subject I.T.		Interval Correct	Interval Incorr.	Subject T.T.		Interval Correct	Interval Incorr.
Direction	Correct	0.46	0.12	Direction	Correct	0.47	0.11	Direction	Correct	0.49	0.12
Direction	Incorr.	0.29	0.13	Direction	Incorr.	0.32	0.10	Direction	Incorr.	0.27	0.13

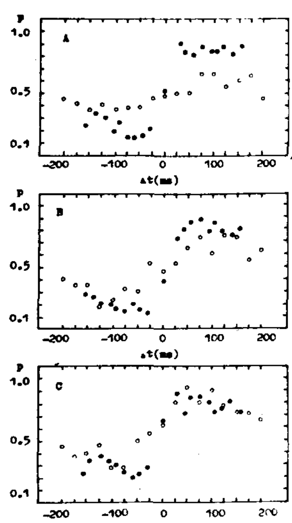

Figure 6. The response probability (p) as a function of the temporal asynchrony between two flashes (Δt). The duration of the test stimuli is 2 ms. The background luminance is I_e = 32 nt. The levels of contrast: $\hat{c}$ = 1.6 (•) and $\hat{c}$=1.1. (○). The results of three observers: E.P. (A); I.T. (B) and T.T. (C). Every point is an average of 60 individual trials. Note: p is the probability that the observer answers "RIGHT" to the presented temporal sequence.

3.5. Discussion

The experiments allow us to arrive at the following conclusions:

1) the 2-alternative forced choice experiment suggests that the detection of the luminance excursions from the baseline relies upon different stimulus features than the recognition of the temporal sequence of two flashes. It was demonstrated that the detection of two-flash alliances is performed on a sufficiently lower level of contrast than is necessary for the correct temporal order recognition of the same two-flash sequence. The two perceptual tasks are solved independently and the probability that they are both solved correctly is at chance level. The results demonstrate that the stimulus features which form the bases for temporal order recognition are not yet manifested on the level of contrast what is necessary for the detection of two-flash sequence. It is plausible to assume that the above-mentioned stimulus features represent properties of the spatio-temporal luminance distribution which are measured ("picked-out") by specialized visual routines for the movement direction coding. As it was demonstrated previously, the visual movement detection models are correlational (Poggio, Reichardt, 1973; Buchner,1976). This means that the observer's answers are based on some kind of correlation between two luminance excursions.

2) In our previous paper we showed that the temporal order recognition in two-flash configurations is strongly limited by spatial separation between the flashes (Allik,Tepp, 1978). Our present finding extends this conclusion to the time domain. Fig.6 presented the results which demonstrate that the temporal order recognition tends to deteriorate with the increase in temporal separation between the flashes. The data averaged over three observers show that the optimum temporal order recognition falls within temporal asynchronies of $\pm$60 ms. Beyond this optimum value, the performance of temporal order recognition becomes progressively worse. There exists some kind of limitation in the time domain (cf. Thorson,Lange, Biederman-Thorson,1969). Assuming that observer reaches a conclusion about a temporal

sequence of two flashes after performing the correlational analysis of luminance distribution, the optimal temporal asynchrony must be in some relation with time constants of the correlation model. This assumpion was tested by a simple computer model and the results show that the peak of the recognition performance approximately corresponds to the time constant of input filters which grant the asymmetrical filtering of the correlated signals (cf.Buchner, 1976). The output function of the minimal correlation model in the response to asynchroneous luminance pulses has a form very similar to the one shown on Fig. 6. We propose that temporal order is recognized by means of finding the correlation between two spatially separate luminance perturbations.

4. Conclusions

By these experiments, we were able to demonstrate the importance of the f o r m o f l u m i n a n c e e n v e l o p e for the recognition of temporal order. The response probability systematically varies with the rising time of the luminance ramp. A general rule which can predict the perceived simultaneity is formulated in terms of basic amplitude ($\hat{c}_0$), exceeding of which is taken as a departure time moment for the temporal order judgement. The constant contrast threshold rule does not necessarily mean that the observer builds his answer, applying the sophisticated principles for the analysis of the luminance distribution.It is more natural to assume that there exists a hard-wired visual routine for computing the output values on the basis of some measurements of the luminance distribution in time and space. The direction of displacement can be recognized, in that case, by a simpler rule, e.g. dividing the scale into two parts. The most plausible candidate to the role of the visual routine which can extract information about the direction of the displacement is a correlation device. But the complete identification of the system which performs the analysis of the luminance distribution in order to solve the recognition task is beyond the scope of the present study.

The second series of experiments confirms the conclusions derived from the first one. It was demonstrated that the recognition of the temporal order is a different psychophysical task than simple detection of luminance perturbation in a homogenous field. We proposed that there exists a specialized visual routine for the description of local movement in the visual field. The correlation model may be the most general expression of the routines which are able to perform the directionally specific analysis of the luminance distribution (see Poggio, Reichardt, 1973; Buchner, 1976). A simple simulation model shows that the response of the minimal correlation model is very similar to the response probability function obtained in the psychophysical experiments.

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ОПРЕДЕЛЕНИЕ ВРЕМЕННОЙ ПОСЛЕДОВАТЕЛЬНОСТИ ПРИ РАЗЛИЧНЫХ ФОРМАХ СВЕТОВОГО СИГНАЛА

М. Тепп Ю. Аллик

Р е з ю м е

Изучали закономерности определения временной последовательности двух расположенных рядом световых стимулов. Искали ответы на следующие вопросы:

1. Как определяется временная последовательность двух световых вспышек, имеющих разную форму прироста яркости (одна с линейным приростом, другая с прямым малым приростом яркости до определенного уровня)?
2. Как определяется временная последовательность двух околопороговых световых вспышек?

Результаты показывают, что для определения временной последовательности двух световых вспышек с разной формой прироста яркости зрительная система нуждается в определенном уровне контраста, превышение чего принимается в качестве исходной точки для определения временного сдвига. Предполагается, что точность определения временной последовательности зависела от скорости прироста яркости.

С помощью двух-альтернативного метода вынужденного выбора выяснили, что обнаружение стимулов и определение временной последовательности двух околопороговых световых вспышек являются независимыми процессами: обнаружение происходит при уровне контраста, значительно более низком, чем определение временной последовательности.

IDENTIFICATION AND DETECTION OF SPATIAL POSITION IN ONE-DIMENSIONAL PATTERN

Marika Rauk Aavo Luuk

Abstract. Three experiments were conducted to investigate the accuracy of spatial localization in one-dimensional dot patterns. The first two experiments used identification paradigm. The results revealed a M-shaped localization error function in the presence of visible reference scale. Two main characteristics of that function are discussed : the specific shape, and general size of mean error. This function was modified in the experimental conditions without reference system or with partial exposure of the scale. The last experiment showed the specific M-shaped detectability function, which was insensitive to pattern complexity and stimulus delay.

1. Introduction

Every visually perceived object has its subjective spatial location for an observer. There does not exist any "absolute" object location, but is always possible to localize and refer to an object in relation to some other objects , i.e. to make relative judgments on the basis of spatial relations. In spite of the manner of performing the localization task, some reference system (external or internal) for the observer should exist to help to localize or to identify the object in certain spatial position.

Two of the most popular localization tasks are discrimination and identification. In a discrimination task, the observer is required to decide whether two visual objects have the same spatial coordinates (lay at the same spatial locations or in symmetrical from some central plane points, on the same axis, at equal distances and in same direction from any point, etc.) or they didn't. When identifying the

* The authors wish to thank Mike Miil for his help in construction of the equipment and Dr. Jüri Allik for writing computer programs and helpful discussion.

object's location in space, the observer's task is to name the location of the object within any reference system. For example, the reference system may be given in the form of dots on a linear scale. Usually, the performance in discrimination task is considerably higher than in identification task. As it is known from G. Miller (1956), correct identifications score within a linear string of stimuli is one of the highest among various identification tasks. It is limited, first of all, by the number of categories that must be coded (cf.Hake, Garner, 1951;Klemmer, Frick, 1953).

Among the commonly used paradigms in visual information-processing study, the full-report and partial report techniques should be mentioned. In the case of full-report paradigm, the observer is required to report all the items which he had seen during the stimulus exposure. Partial report techniques require the observer to report a part of a large stimulus array,e.g., to name one item in a display , which was exposed at the location, marked by a letter, number,bar-marker, etc. before, during, or after the whole stimulus-array exposure. Typical for the group of partial report studies is the work of Averbach and Coriell (1961), who exposed a horizontal array of random letters and asked the subjects to report one letter from display, specified by a bar-marker. The results revealed a position localization curve, which indicated better performance for central and extreme-end items rather than for items occupying intermediate positions. That positional effect became evident in a number of letter-rows processing experiments with partial report technique (Averbach, Sperling, 1961; Crovitz, Schiffman, 1967; Haber, Standing, 1969; Merikle, Coltheart, Lowe, 1971; Merikle, Coltheart,1972; Merikle, 1974; 1976; Merikle, Glick, 1976; Butler, Merikle, 1973; Butler, 1975; Lefton, 1974;Lowe, 1975; Mewhort, 1966; Hearty, Mewhort, 1975; Mewhort, Campbell, 1978; Smith, Ramunas,1971; Townsend, 1973; White,1970; 1976). A number of stimulus variables, such as exposure duration, stimulus familiarity, interelement spacing, retinal stimulus location, determine the shape of letter span function, i.e. the plot of identification error against stimulus position within the row (White, 1976). As it was concluded by White, when attentional sets and eye movements are properly controlled, the M-shape error function appears within a fairly broad range of variable values, and is also insensitive to order-of-report effects (Bryden,1967). Comparing the data collected with full-report and partial report techniques, one can see, that the ability to extract information from brief visual presentations, at least, reproduction is higher using the partial report paradigm (Averbach,Sperling, 1961).

Localization procedure with letter rows, however,raises the question about the relative weights of identification the letter and localization of it's spatial position in the row. In order to distract these two characteristics in letter-row processing, experiments were conducted where the observer's task was to report the location of a marked letter without identifying it (Lowe,1975; Hearty, Mewhort, 1975). As a result, symmetrical M-shaped position curve was obtained. Obviously, the M-shape curve appears as a special property of the spatial localization process. Since in studies with letter identification in a row results have revealed M-shape function, it is very probable that in that case the spatial localization task must be implemented.

The existence of specific function for spatial identification task is supported by the following data. Using partial report technique in localization tasks, M-shape error function appeared excellently in experiments with nonalphabetic stimulus material (Klemmer, 1963; Camp,Harcum , 1964; Harcum, 1970a,b; Rauk,Luuk,1978).

General M-shape curves show that in absolute identification experiments the percentage of localization errors is lowest at the fixation point and at the extreme end positions of the string. It seems that there exist two main characteristics for that function: 1) special shape, and 2) general magnitude of errors. Presumably, under any circumstances, changes in these qualities of the function should appear. It was the purpose of our experiments to find out the conditions that would modify the shape and amplitude of the M-shape curve in a spatial localization task. The first two experiments are dedicated to the study of that question. It was expected that the shape and the magnitude of the curve are dependent upon the defined reference system.

The third experiment was designed with the purposes to determine the possibility of M-shape positional curve in other psychophysical tasks, for instance, in a detection task. If this function is not only a special characteristic of localization accuracy in absolute identification task, it was expected to appear also with the detection task.

2. Experiment I *

There was one particular hypothesis for conducting this experiment, derived from previous work of the present authors (Rauk, Luuk, 1978), and also discussed in other studies (Harcum, 1958a,b; 1964a): What will be the effect of spatial density changes in reference-dot pattern upon the accuracy of localization of separate dots within the pattern? It must be noted that Harcum did not apply any complementary reference system, but varied the angular subtense with a change in the number of elements and without it in a stimulus array and found, that the means of positional errors increased with the number of elements (Harcum, 1964a). As it is known, the number of accurately identified elements in a linear pattern is constant from any certain level in increasing the number of elements in array (Miller, 1956). The difference in our arrangement is, that we added the complementary dot pattern in relation to which the identifications would be given in a linear pattern (Miller referred only to a single linear string in visual field). The density changes took place only in the reference system, and not in the stimulus pattern.

2.1. Method

S t i m u l a t i o n. The stimulus array consisted of two horizontal rows of dots each of 13 elements in the row. They were located on black background, one above the other. Thus, there was biunique correspondence between the positions of the upper and lower rows. The distance between these dot rows was 0.5° at the viewing distance of 114 cm. A red fixation point was continuously exposed under the central position, 0.25° from the lower row. Light-emitting diodes

* We thank Vello Putk for data collection for this experiment.

including two 3-5 minute rest periods. A practice series was given before the main trials. The room was dimly lighted during the experiment.

S u b j e c t s. Three subjects with normal vision participated in the experiment. All were male students 20-23 years old, two of them students of psychology. The subjects were naive as to the purposes of the experiment.

2.2. Results and Discussion

The data of this experiment are summarized in Figures 1 and 2. Since very similar general tendencies appeared in the reports of different subjects, the errors were averaged over the subjects. Thus, the mean values given in the Figures were obtained as a result of measuring 90 times per element position in each series.

In Figure 1 the curves represent the means of localization errors per element position on display. As we can see, a localization error was revealed which increases with the growing distance from the central fixation. A typical and very important characteristic of this effect is, that the error decreases again at the extreme end positions (except at the right-most position in the third series). Thus, we found, that the localization error function has a characteristic M-shape (see Rauk, Luuk, 1978) - a result which has been also decribed in other experimental investigations using different methods (Averbach, Coriell,1961; Averbach, Sperling, 1961; Haber, Standing,1969; Harcum, 1964a,b; 1970a,b; Lefton, 1974; Lowe, 1975; Merikle, Coltheart, Lowe, 1971; Merikle, Coltheart, 1972; Merikle,1976; Merikle,Glick, 1976; Hearty, Mewhort, 1975; Mewhort, Campbell, 1978; White, 1970; 1976; Butler,1975).

A different spatial localization curve became evident in the fourth series (particularly, at the left-side positions) - in a condition, where the reference scale was mostly absent and only central and end-points were exposed. Also, in this series the least errors were obtained at the central and extreme outer positions in relation to other parts of display. The decrease of the mean error is apparently caused by the decrease of the general variability of absolute identification. Figure 2 shows the variance of the absolute idenwith luminance about 30 nt served as elements in the rows and the fixation point. Spatial separation between the two adjacent elements in the row was 0.5°, thus the length of the row i.e. the area for possible target appearance subtended 6° horizontally. In the present experiment, the lower row of dots was used as the reference scale for an observer to localize the target. The scale was illuminated during target exposure. In a single trial, one random element from the upper 13-dots row appeared as a target for 0.5 ms. The experiment was carried out in four series which differed in the number of illuminated points in the lower, reference scale row: (1) in the first series all 13 scale-points were illuminated; (2) in the second series 7 points of the scale were visible, so, that one position between each two points was always skipped; (3) in the third series, the reference system was once more changed and two positions between the scale points were skipped, so 5 points only were illuminated (1.,4.,7.,10. and 13. as counted from the left); (4) in the fourth series only a central and the both extreme scale-points were exposed. In all series, each of the 13 possible target locations (in the upper row) was used.

The stimulation was fully controlled by the microprocessor (type 15 VSM-5) through a special interface and real-time clock. The subject's answers were stored by the computer and processed results were printed out after the whole sequence of trials in a session.

P r o c e d u r e. The subject was sitting at the distance of 114 cm in front of the stimulus display with the head fixed using a chin-and-forehead rest. He was asked to fixate the fixation point binocularly. Before getting the instruction, the subject was acquainted with the stimulus array and was told to assign the locations in horizontal row with the numbers from 1 to 13 as counted from the left to the right. The subject was required to perform absolute identification task: to report the number of the location where the target had been seen. Microprocessor was programmed to produce the randomized sequence of the target location in separate trials through the series of experiment. The number of trials for each target location was 30. One series of experiment was conducted daily, it lasted approximately 1 hour;

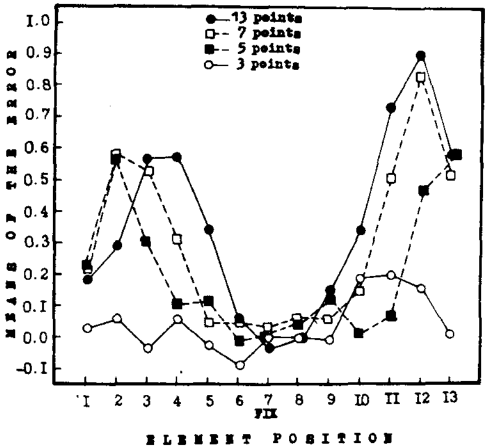

Figure 1. Spatial localization curves for Experiment I. Error value 1.0 on the vertical axis corresponds to the distance between two adjacent locations on the row. Positive mean error indicates, that the errors were made in the direction of the fixation point, negative value indicates the tendency to commit an error towards the extreme points of the scale. The parameter on the figure is the number of illuminated scale-points.

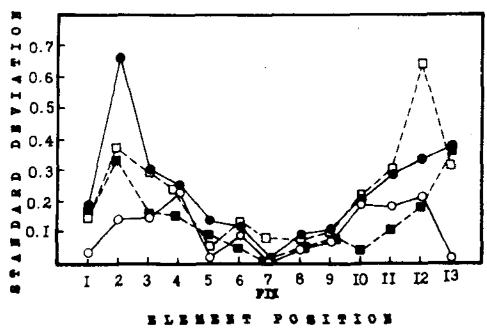

Figure 2. Mean values of SD for the corresponding mean errors (exposed on Fig.1) in Experiment I.

tification performance. It is quite clear, that curves of variance repeat the form of the mean error curves.

The difference of the results in the fourth series was significant in comparison to the other ones - $F (3,48) = 12.25$, $p < 0.01$. There were no significant differences between the position curves of the first, second and third series. Nevertheless, there exists an apparent tendency in the mean error to increase when the number of illuminated points in the reference scale is increased. Decreasing the number of scale-points makes the curves more flat in shape, compared with the whole-scale condition, and reduces their maxima. The mean errors for the positions on the more central area of display (from 4.-5. to 10.-11.) all were approximately at the same level in the second and the third series. The last phenomenon was also revealed in the fourth series but for the element positions 1.-9. Here we must note an important additional indicator in our localization error curves. While in most studies the mean errors of position localization or percentages of correct responses for various positions had been presented, only very few authors had paid attention to the d i r e c t i o n of these errors (Hearty, Mewhort, 1975; Estes, Allmeyer, Reder, 1976; Rauk, Luuk, 1978). We found, that in most cases the means of the errors were s h i f t e d t o w a r d s t h e c e n t r a l f i x a t i o n p o i n t (positive error values in the Figures) and only in the fourth series, especially at the left-side positions, the error means were negative. In other words, there exists a general tendency to estimate the position of an object as if it was more centrally located than it actually was. Such effect attained it's maximum at the intermediate positions between the central and end positions (positions 2.-4. and 10.-12.). At the extreme end positions, where the size of estimation error had decreased already, the main direction of errors had maintained its sign. In the last case, it is easy to understand, that for the most extreme positions there was only one direction (towards the fixation point) in what the erroneous estimation was possible. It's more surprising, that at intermediate positions such a strong effect of error direction became evident. As we can see, only in the fourth series the direction of errors wasn't firmly established. In that series, the most accurate estimations were obtained (see the variance in Fig. 2). But yet , the errors, directed to the fixation point appeared at the right-side positions. For left-side positions the mean error fluctuated around the 0-value, having both positive and negative values. It means that considerable amount of responses were given with the error to the leftward (outer) direction from the real location of the object.

Although it seems, that there exists little predominance of the right visual field as to the mean size of errors, however, this difference still remains nonsignificant.

To conclude, one can say that subjective localization of the test-object was executed in relation to the reference frame. The central and the two most eccentric points of stimulus area are most effective in this reference pattern. These end points, or "anchor" points constitute the most important part of the reference frame beside the fixation point. Increased number of reference points in the visual field impaires localization accuracy (the positions were identified in relation to these "anchor" points as before). However now it was more difficult to localize the end-points. This explains why the error, directed towards the fixation point, was increased in case the complete scale was used .

3. Experiment II*

This experiment was designed to study the question about the role of presence or absence of the visible reference system during target exposure in a localization task.

3.1. Method

S t i m u l a t i o n. The stimulus display was identical to that used in Experiment I, except that it was turned 90°, to the vertical orientation. Thus, the fixation point was 0.25° to the left from the central point of the vertical scale (beside the 7. point as counted from upward to downward direction) and targets were exposed on the vertical row 0.5° to the right of the scale-line. Complete referent scale with 13 illuminated points was applied throughout the experiment.

*Gratitude is expressed to Jüri Saar for help in data collection in this experiment.

The difference between the two series of this experiment consisted in the temporal offset of the reference scale during the stimulation in a single trial: (1) In the first series, at the beginning of the trial, the scale was exposed for 1.4 s, then, with 250 ms delay from the scale offset the target was presented for 0.5 ms. (2) In the second series, the reference scale was exposed at the moment of the target exposure and switched off 250 ms later than the target.

P r o c e d u r e. In this respect the study was identical to that of Experiment I. The subject reported the number of the scale-point as counted from upward to downward.

S u b j e c t s. Three subjects with normal vision were used: all female students 20-23 years old.

3.2. Results and Discussion

The data of Experiment II, summarized over three subjects are exposed in Figure 3.

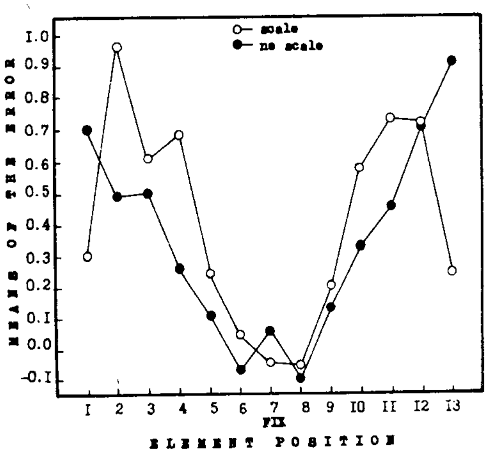

Figure 3. Spatial localization curves for Experiment II. A unit's value and sign on vertical axis is same to that is commented for Fig.1. The parameter in the figure is the presence or absence of the illuminated scale during target exposure.

The curves demonstrate the means of localization errors per element position in the vertical row at the display. Except for vertical orientation, viewing condition in the second series of this experiment ("scale") were very similar to that applied in the first series of Experiment I. In both cases, whole reference scale was exposed at the moment of target exposure. As in Experiment I, the position curve in the second series of Experiment II had two maximums and three minimums. The maximum values fell on one of the intermediate positions between the central and extreme peripheral locations in both sides. The error revealed its relative minima near the fixation point and the upper-most and lowermost positions. Harcum (1964b) had noted as one main result from his long series of experiments about perceiving linear dot patterns in various orientations, that the greatest localization accuracy should be achieved along horizontal plane of the visual field, and least accuracy should occur in case of the stimuli along vertical plane of the visual field (Harcum,1964b; Experiment 15). Harcum called the factor, which produces such meridional differences a"sensitivity factor" (not to be confused with retinal sensitivity as measured by conventional test-objects). According to Harcum, it involves predominantly spatial interaction and localization effects (versus reading factor, which reveals hemifield differences). As our results demonstrated, there were no significant differences in localization accuracy between the results of the two planes. The position curves in Experiment I and in the second series of Experiment II were very similar to each other both in shape and in size. One possible explanation of this difference in results is based on the differences in subject's task in Harcum's and our experiments, although the results are in a good agreement in several other respects. In any case, we can conclude that absolute identification paradigm (when locating a single object at the linear row) does not involve essential differences and difficulties for performing the task when the linear reference patterns are exposed at various orientations. The strategies of performance were not altered in these orientations as we know from subjective reports of the subjects . Rather,it is the density characteristic of the reference system, which alters the strategy of building up reports : the results of the fourth series in Experiment I differ significantly from the other series in Experiment I, and also from the results of Experiment II.

Thus, we must conclude, that general M-shape position curve is not only convenient to characterize the localization process in horizontal orientation, but in vertical orientation as well.(However, there exists a task condition, which can alter this M-shape even in horizontal orientation.)

A somewhat different shape of the curve was obtained from the data in the first series of Experiment II. It was the condition where the illuminated reference scale was absent at the moment of target exposure. Here one can see only one, but nevertheless essential departure from the results of the second series: the position curve was now V-shaped rather than M-shaped. The differences in the values of mean error scores between the two series were not significant. As it was stated by Averbach and Sperling (1961) and Mackworth (1963a,b), the duration of the visual image is about 0.25 s, but also may last up to 1-2 s. In our condition the target was switched off 250 ms later than the scale, so the great accuracy of localization without reference system in comparison with "scale"-condition may obviously be due to a high level of visual image utilization and usage of information from iconic memory. It is known from the experiments with item localization in letter rows, that a delayed cue for letter recall may have little effect upon the position curve. So, with simultaneous cue, the localization is better. Nevertheless, the M-shape of the curve (or W-shape, when expressed in correct response percentage) is not affected (Butler, Merikle, 1973; Townsend,1973; Lefton, 1974). In our experiment, the curve was altered in it's shape, having two maxima at the most eccentric positions and a minimum near the fixation. It is obvious, that the absence of the scale influences the more eccentric locations of the display, particularly the upper-most and lower-most positions. In relation to the second series, now the subject was required to perform a genuinely absolute identification at the moment of target appearance. Fixation was the sole reference point in the visual field. This may explain the minimum of errors near the fixation point (which is never equal to 0). Around the fixation point the process of lateral masking had presumably taken place, and due to this errors at the positions 6. and 8. were made prevalently towards periphery and errors at the central 7. position fluctuated around the 0-value.

Our V-shaped localization curve is most similar to that obtained by Lowe (1975), when a single bar-marker localization task was performed, only along horizontal plane. Our results in the first series ("no scale") agree excellently with Harcum's data for localization accuracy at various target eccentricity locations along the vertical meridian (Harcum, 1964b). In the "no scale" condition no marker of the boundaries of the possible target exposure area in the visual field was present. Thus, the localization error was continuously and increasingly made towards the fixation point with increasing distance from fixation. It seems, that such continuous increment of error is a result from the absence of any visible reference frame,rather than a simple outcome from the target delay. Thus, the "end-segregation" effect (Harcum, 1964a,b), which so fairly became evident in Experiment I and in the second series of Experiment II, was entirely reduced in the "no scale" condition of Experiment II. The reduction of the end-segregation effect is usually achieved with continuous patterns, which extend so far from the fixational center, that the ends are beyond the range of effective vision (Harcum, 1969). The distribution of the data using 21, 28, or more element patterns, subtended approximately 13-14°, reveal the best performance for elements around fixation, having the values on chance level already at the fifth element position to either side of fixation (Klemmer , 1963; Harcum, 1969). We found, that the effective perceptibility was maintained upon the sixth (incl.) position on either side of fixation, which occupies 6° in the visual field versus 4.5° approximately in the experiments refered to above . Thus, for vertical orientation the area of effective localization is somewhat larger. However,it is very probable,that if we had exposed the continuous vertical pattern without reference frame, mean error at chance level for more eccentric positions would have been obtained.

4. Experiment III

It is our goal to clear up the possibility of the regular localization function appearing in other psychophysical tasks. The detection procedure was chosen for this experiment to find the position localization curves.

4.1. Method

S t i m u l a t i o n. The stimulus array consisted of 13 dots in horizontal row (the upper row of light-emitters in Experiment I). The fixation point was 0.75° below the central point of the row at the viewing distance of 114 cm.

P r o c e d u r e. While the logic of this experiment was somewhat different from the previous ones, there were also variations in stimulus exposition and subject's task. In the beginning of a single trial, a random configuration of 4, 6, or 8 dots from among 13 possible points was illuminated. Offset of this random configulation was followed by a blank period lasting 100 or 1000 ms. It was interrupted by the onset of one of 13 possible luminous point as a probe stimuli. The subject was asked to treat this point as a question: does that point belong to the configuration presented , or not? Exposure time of the target was unlimited, but the subject was asked to make a decision as quickly as possible. In one half of the trials the questioned point belonged to the configuration and in other half it did not. Thus, the subject performed YES - NO detection task and consequently, it was possible to compute from hits and false alarm probabilities sensitivity measure d',as it is conventionally used in the Signal Detection Theory (Green , Swets, 1966).

There were two conditions varied for stimulus presentation: (1) the number of dots in configuration - 4, 6, or 8; and (2) delay between the configuratsion offset and target onset - 100 or 1000 ms. Six different series corresponded to 6 different combinations of these variables. One series formed two experimental sessions. Each subject received 30 YES and 30 NO trials per each target location in each series.

S u b j e c t s. The subjects were two female persons of normal vision,20 and 25 years old.

4.2. Results and Discussion

The results of Experiment III are summarized in Figures 4 and 5 . In Figure 4, as well as in Figure 5, mean d's across the subjects as a function of target position in horizontal row, are presented. One of the variables in this

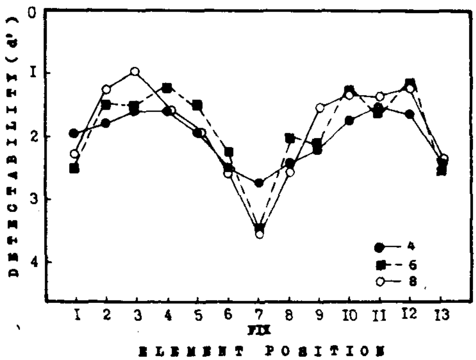

Figure 4. Spatial localization curves for Experiment III. Mean values of d'reflect the effectiveness of target localization at different spatial positions. The parameter in the figure is the number of dots in configuration preceded the target exposure.

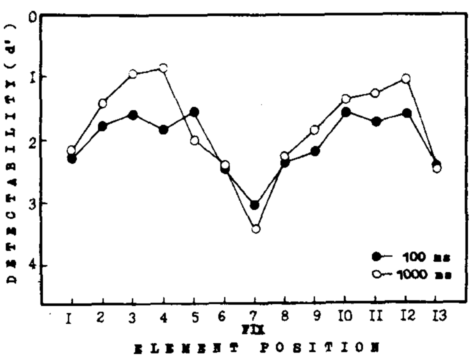

Figure 5. Mean d' as a function of element spatial position and target delay (parameter on the figure)in Experiment III.

experiment was the number of illuminated points in the row exposed before the target onset. In Figure 4, the position curves, dependent upon the number of dots, are given. There were no significant differences between the series with different number of dots in configuration in occasion of various target delays,so , the data in Figure 4 are summarized across the separate target delay values. As one can see, the position localization curve has a M-shape. The average d'was greatest at the central position (in the Figures the axis of d' values is inverted, making it more plausible to compare it with the results of previous experiments). There is a considerable drop in d' , moving off the central point,but the ends are again more accurately perceived than intermediate positions. Our results agree with Brännström's (1973) data. In his experiment, the display consisted of letters in various horizontal locations of a masking stimulus,but the task was identical to our's (YES-NO paradigm and probe technique).As a result, the effect of spatial factors upon the accuracy of visual information processing during a single fixation was expressed using d' characteristic. In that experiment, d' reflected the decreased clarity for peripheral retinal positions, but for the four-element sequence (with maximum mask delay), considerable improvement in accuracy at the most eccentric positions in both sides of fixation appeared.

In Figure 5, there were no significant differences between the data from series with different target delay.Again M-shaped localization curves appeared, almost identical to that in Figure 4 in their minimum and maximum points. Consequently, the general M-shape of the curves was affected neither by different number of dots in configuration, nor by different target delays in the case of YES-NO paradigm in a detection task.

This experiment showed, that the performance was independent of the complexity of the test configuration (with 4 points in the configuration there would be 715 different combinations, with 6 points - 1716 possible combinations in the row). Consequently, every position was coded independently of it's belonging to configurations at different complexity levels.

Sperling (1960) described the phenomenon of gradual loss in short term memory. We found, that the detectability performance does not alter significantly with intervals 100 and 1000 ms. Consequently, the variability in detection performance d'over all positions is not connected with the processes that induce progressive deterioration with increased delay.It is necessary to stress, that visual position discrimination performance is progressively impaired, with an increase in temporal interval between compared signals (cf. Allan,1968).

It may be that the positional variability is caused by some kind of attention process, which determines the degree and accuracy of inner representation of different spatial positions. M-shaped curves make it very plausible that the positions are coded not in absolute terms but rather in relational terms. However, detectability, or "degree of attention" given to certain spatial position, is determined by the distance of that point from the extreme positions of the string and the central fixation point.

5. Conclusions

The present experiments demonstrated some interesting laws of object position identification and detection in the visual field with partial report techniques.

From the first two experiments, it became clear,that in the presence of a visible reference system, in relation to which the objects were localized, a certain kind of localization error function appeared. This M-shaped function shows best performance for the fixation and the extreme positions of the reference points. Obviously, these positions have greatest significance for the subject in localizing any object in the field. The most accurate identifications for central positions are obviously due to the greatest retinal aquity at these positions.At the same time, this perceptual clarity in central area caused subjective shifts of more peripheral locations towards the fixation point. This effect is stronger with more exact exposure of the range of stimulation. Consequently, the M-shaped positional function was caused by the well-defined range of stimulation (reference system).If it was absent, as in the 4. series of Experiment I and the 1. series of Experiment II, the M-shaped position localization curves disappeared or were modified.

The subjects attempted, first of all to localize the boundaries of the stimulated area accurately i.e. the extreme "anchor" points, due to this they paid more attention to these points than to the remaining parts of the array.In the presence of the whole reference scale, at least, with the scale of more than three reference points, the intermediate points do not facilitate identification. That result (cf.Rauk,Luuk, 1978) confirms the importance of "anchor" points. When the reference system was absent at the moment of stimulus exposure, the localization error curve was V-shaped. Consequently, without a defined region for stimulus appearance, there exist tendencies to shift involuntarily the "inner" representation of the boundaries to the more central positions. As a result, a continuously increasing centripetal error appears with more eccentric locations.

Position localization in other psychophysical task (detection task in Experiment III) revealed the M-shape positional function. This detectability function confirms, that the error functions, obtained in Experiments I and II, were not due to the naming of different spatial locations. The most adequate explanation for these localization error functions, both in identification and in detection tasks, seems to be connected with some kind of attentional processes. The greatest attention was paid to central and boundary regions of the stimulus array. The "anchor" effect, described above, needs further study.

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ИДЕНТИФИКАЦИЯ И ОБНАРУЖЕНИЕ ПРОСТРАНСТВЕННОГО ПОЛОЖЕНИЯ В ОДНОМЕРНОМ ПАТТЕРНЕ

М.Раук А.Луук

Р е з ю м е

В экспериментальной работе исследовалась точность пространственной локализации в одномерном паттерне точечных стимулов . Использовались два разных метода: идентификация и обнаружение местоположения в ряду. Результаты показали характерную М-образную функцию ошибок локализации в обоих условиях.

INTERAURAL PHASE SENSITIVITY TO SIGNALS WITH DIFFERENT SPECTRAL COMPOSITION

Aavo-Rein Tereping Jüri Allik

Abstract. Interaural phase sensitivity was measured with signals of different spectral composition (pure sine-tone, 1/3 octave-wide band of noise and 1 octave-wide band of noise). 1/3 octave-wide band of noise was more effective than pure sine-tone in the task of interaural phase detection. The interaural phase of pure tone and 1/3 octave-wide band of noise were not detected when the frequency exceeded 1250 Hz. Phase detection, however, was possible above this limit when the 1 octave-wide band of noise signals were used. The interaural phase threshold was about 70° for 1 octave-wide band of noise with the medium at 6300 Hz. It is proposed that the differences in interaural phase sensitivity to signals with different spectra can be accounted for by combination of tones which arise in complex signals.

1. Introduction

The existence of two ears is a natural prerequisite for acustical space perception. The acustical signals in two ears may differ in: interaural amplitude, time delay, phase, and difference in spectrum.

The interaural time delay and phase difference are often considered identical phenomena. However the time delay coincides with the interaural phase for a pure sine-tone only by chance. It is well known in the stereophonic sound-recording practice that interaural phase difference is perceived differently from time shifts in stereophonic channels.

Zwislocki and Feldman (1956) and Yost (1974) measured phase sensitivity to interaurally presented pure tones. They found that the phase sensitivity is highest when frequency of the pure tone is low (cf. Fig. 1A). The interaural phase sensitivity vanishes, if the frequency increases above 1300 Hz. But this is not the case with signals which have more complex spectral composition. It was noticed in stereophonic recording practice that complex high-frequency signals can be distinguished by interaural phase shift. The present study is devoted to the interaural phase sensitivity to signals which have different spectral composition.

2. Method

The observer compared two pairs of signals. The signals consisted of 1-second sound pulses with slow rising and falling times of 25 ms. There was a 1 s time interval between two pairs of stimuli. Each series of the pairs of signals was separated from the preceeding and subsequent ones by an interval of 3 s. The first pair of signals consists of two pulses which were exactly in an interaural phase. The second pair had two members which differed from each other by an interaural phase. The observer's task was to detect the presence of the interaural phase in the second pair of signals while the degree of the interaural phase was chosen randomly by experimentator. The interaural phase threshold was defined as a phase which was detected at a level of 75% correct answers. There were 6 observers taking place in the present experiments as subjects.

Three different kind of signals were used in the experiments: (1) pure sine-tone with frequencies 125, 250, 500, 1000 and 1250 Hz; (2) 1/3 octave wide band of noise which had the same medium frequency as listed above; (3) 1 octave wide-band of noise centred around the following frequencies: 100, 200, 400, 800, 1600, 3150 and 6300 Hz. The stimuli were presented through stereophonic ear-phones K 180/4 (produced by AKG - Austria). The wide-band phase rotator was designed by the first author in the laboratories of Estonian broadcasting corporation ("Eesti Raadio").

3. Results

The results are presented on Fig. 1B. For a comparison, Fig.1A demonstrates similar results from the study by Zwislocki and Feldman (1956).

4. Discussion

The present results indicate that 1/3 octave wide-band noise is the most effective for the detection of interaural phase. The thresholds appeared to be lower for 1/3 octave noise than for pure tones. Our results are in a good agreement with previous studies showing that the interaural phase sensitivity vanishes above the frequencies about 1300 Hz.

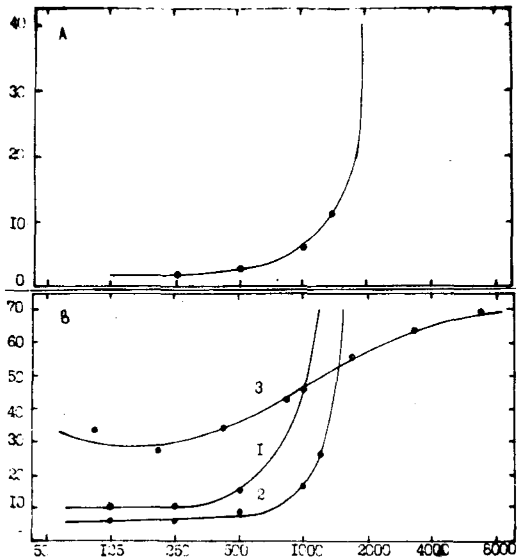

Fig.1.A. Threshold of interaural phase detection plotted against the frequency of pure sine-tone(results from Zwislocki and Feldman,1956). B. Threshold of interaural phase; dependent on the frequency characteristic of the different signals:(1) pure sine-tone; (2) 1/3 octave wide-band of noise; (3) 1 octave wide-band of noise.Average results over 6 observers.

This upper limit suits well for pure tones as well as for 1/3 octave noise and is very close to the value obtained by Zwislocki and Feldman (1956). However,Yost (1974) reported that interaural phase shift of 32° can be detected when the frequency is 2000 Hz. But we have some doubts about the phase rotation procedure which was used by Yost (1974). The phase rotation was achieved by a delay line. As he reported, temporal delay could not be noticed by an observer due to a relatively slow rise time of the sound pulses (25 ms). Nevertheless ,it is possible that two signals with the frequency of 2000 Hz were discriminated by a temporal shift and not by phase difference, as

Yost (1974) originally proposed. Indeed, the temporal delay between two ears is expressed by:

$$\Delta t = \Delta\varphi / 360^\circ f = 44 \cdot 10^{-6} \text{ s},$$

where $\Delta\varphi = 32^\circ$ is phase shift between two signals, and f = 2000 Hz is the frequency of pure tone. It is necessary to remind that Békésy (1960) measured interaural time thresholds using a train of clicks or 200 ms burst of noise and obtained a constant threshold of 19 µs. Similar results were obtained by Hafter and De Maio (1975); threshold values of interaural time difference Δt which were obtained with low-frequency (0.1-2 kHz) clicks were clearly lower than 44 µs.

However, the interaural phase thresholds obtained in the present study are somewhat higher than those reported by Zwislocki and Feldman (1956) and Yost (1974). We suppose that might be due to different experimental procedures to produce the phase shifts. It is difficult to compare our apparatus and procedure to Zwislocki and Feldman's, since characteristics of the procedure were not included in their paper. However it is obvious that Yost (1974) used the delay line for the generation of interaural phase shift of two signals. Thus it is possible that the subject's report is based on the temporal shift between onset of the signals rather than phase of pure tone.

Finally it is essential to clarify the question of why 1 octave-wide band of noise makes it possible to discriminate interaural phase differencies on higher frequencies. One possible explanation is an assumption that nonlinearities of hearing produce the occurence of the combination tone. If a stimulus is a mixture of two pure tones with frequencies f_A and f_B, then a series of combination tones is produced whose frequencies are determined by:

$$f_k = f_A - k(f_B - f_A),$$

where k is an integer (Zwicker, Feldtkeller, 1967; Plomp, 1975). It is known that nonlinearities that occur in basilar membrane mechanics generate the combination tone (Goldstein, Kiang, 1968: Pfeiffer, On Kim, 1973; Robles, Rhode, 1974). When the interaural phase shifts, the subjective phase between combination tones must change as well (cf. Buunen, Bilsen, 1974). In that case, 1-octave-wide band of noise having the medium-frequency of 6300 Hz has combination tones in the frequency range in which the phase discrimination is still effective. But it is not clear what lays behind the difference between 1/3 and 1 octave wide band of noise. The difference can not be explained by visual masking since the lower frequencies effectively mask the higher ones, but not vice versa (Zwicker,Feldtkeller, 1967). Finally,we have no answer to the question what is the most optimal band of noise to interaural phase discrimination.That should be clarified in **further** studies.

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ИНТЕРАУРАЛЬНАЯ ФАЗОЧУВСТВИТЕЛЬНОСТЬ ЧЕЛОВЕКА ДЛЯ ЗВУКОВЫХ СИГНАЛОВ С РАЗЛИЧНЫМ СПЕКТРАЛЬНЫМ СОСТАВОМ

А.-Р.Терепинг Ю.Аллик

Р е з ю м е

Измеряли интерауральную фазовую чувствительность с сигналами разного спектрального состава (синусоидальный сигнал, I/3 октавная и октавная полоса шума). I/3 октавная полоса шума оказалась эффективнее при детекции интерауральной фазы, чем синусоидальная волна при той же детекции. Восприятие интерауральной фазы синусоидального сигнала и I/3 октавного шума детектируется до частоты I250 Гц. С сигналами октавной полосы шума детекция интерауральной фазы оказалась возможной также на высоких частотах. Порог интерауральной фазы был около 70^0 для сигналов с октавной полосой шума со средним значением при 6300 Гц.

C o n t e n t s

Содержание

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