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Effect of Five-Minute Exercise Induced Activation on the Cognitive Performance of Normal, Mentally Retarded and Schizophrenic Children

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EFFECT OF FIVE-MINUTES EXERCISE INDUCED ACTIVATION ON THE COGNITIVE PERFORMANCE OF NORMAL, MENTALLY RETARDED AND SCHIZOPHRENIC CHILDREN

by

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ABSTRACT

Gutin developed the theory that moderate physical exercise increases the human performance. An experiment was conducted to determine if this theory was applicable to schizophrenic and educable mentally retarded children, as well as to normal children. A total of 132 subjects consisting of 44 normal, 44 educable mentally retarded and 44 schizophrenic children were used. All of the groups were equated on mental age (M.A.) and diagnosed by staff. Three pilot studies were carried out to determine the most appropriate task. Color recognition involving memory task was selected among perceptual and labeling tasks. The study was divided into three experimental conditions: pretest, intervention, and post test. The pre and post tests each comprised of 10 problems of color recognition while the intervention was 5 minutes exercise for the experimental group and 5 minutes rest for the control groups. The result obtained indicated that Gutin's theory may be applicable only to normal subjects because the schizophrenics experienced decreases and the mentally retarded had no effect in general. The cause of the contradictory results among the schizophrenics and mentally retarded was not made explicit by the study, but most probably, another study utilizing different intensities, duration and tasks might give more insight to this affect.

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VITA

The author, Dorothy C. Nene Ogundu is the daughter of Chief and Lady Ogundu. She was born April 22, 1955 of Nigerian origin.

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INTRODUCTION

Performance on cognitive tasks and problem solving has for years proven a challenge to many researchers. The capacity of this area to elicit studies could be attributed to many reasons, although by far the most important one is that any positive advance or findings made in this area go a long way in helping students, teachers, workers in specific and the intellectual human arena in general. This being the case, researchers have left little or no stone unturn in search of means of facilitating cognitive performance.

Gutin (1973) theorized that the relationship between exercise induced activation (EIA) and human performance takes the form of an inverted "U", with performance optimal at some intermediate level of EIA. Gutin (1965), Bartz (1970 and Davy (1973) and others in their studies postulated the positive effect of moderate exercise on human performance, but their studies did not extend to the effect on abnormal subjects like mongoloids, schizophrenics, retardates, etc. Extending the theory of Gutin to the abnormal subjects, it may be beneficial in the training and rehabilitating of these mentally-handicapped subjects to investigate how this theory applies to them in respect to cognitive performance and problem solving. This author therefore decided to examine the influence of physical exercise in moderation on cognitive performance of schizophrenics and educable retardates as well as normal children.

RELATED LITERATURE REVIEW

Historical Background

A review of the related literature on this subject shows that although many studies have been done on fitness, not much has been carried out on the effect or the role of exercise on the performance of cognitive tasks. However, even before the emergence of structured schooling, man has always had a hunch that exercise is beneficial to him. It is not uncommon that among uneducated and non-sophisticated people, time is taken off for physical activity, for example, wrestling, dancing, etc. in the village squares as a form of relaxation from the intense farming and hunting. Then came schooling. Everyone that went to school would recall those few precious minutes allowed in between classes for play breaks. The fact that physical education is emphasized in schools and sometimes mandatory even up to university levels in some areas, hints that man has some idea that physical exercise is beneficial to the organism.

As early as late 1800, people were already scientifically interested in determining the relationship between muscular tension or exertion and problem solving, mental work and performance in general. Loeb (1888), Lombard (1887), Fere (1889), Dresslar (1891), Mosso (1894), Lehmann (1900), Golla (1921) and Newhall (1923) were pioneers in this field.

Although their studies were directed towards the effect of accompanying mental activity on muscular tension, it was an initial step in this area.

Lombard (1887) found that the knee-jerk was enhanced when accompanied with mental activity. Dresslar (1891) and Tuttle (1924) confirmed Lombard's hypothesis in their studies using a voluntary tapping. However, Loeb (1888) in his study found that on a dynamometer, muscular tension is negatively correlated with mental activity. Two years later, Lehmann (1900), using the ergograph, confirmed Loeb's hypothesis. On the other hand, Fere (1889) used the same dynamometer as Loeb used a year before and found that there was an increase on the subject's maximum squeeze by one-fourth when mental activity was induced. The final conclusion indicates that these studies were contradictory and dealt mostly with how to increase the muscular tension efficiency by supplying mental activity and stimuli.

It was not until 1927 that Arthur Gilbert Bills tried to reverse the focus shown in earlier studies. Instead of what the former studies had been investigating, he turned the emphasis around, deciding to examine the influence of muscular tension on the efficiency of mental work. In a paper published by Bill (1927), he reported on various experiments. The results indicated that muscular tension proved to be positively efficient as a learning condition for sense and nonsense material and improves the absolute speed and accuracy of performance in adding column digits. However, when Stauffacher (1936) tried to duplicate Bills' study, his results indicated that muscular tension is more beneficial to the poor learner in terms of increased efficiency in learning than the good learners. On the other hand, muscular tension did not significantly affect recall and relearning efficiency. Although no specific agreement was arrived at, a significant scientific advancement had been achieved by determining a means of improving mental efficiency.

Gutin's Theory

What Arthur Gilbert Bills started, Bernard Gutin seemed to have specialized and quantified. Gutin (1973) proposed a theory, based on a hypothesis first introduced by Duffy (1962), stating that the relationship between exercise induced activation (EIA) and human performance takes the form of an inverted "U" with performance optimal at some intermediate level of EIA. He hypothesized that for intellective tasks, intensity of concomitant exercise was negatively and monotonically related to performance. Light or moderate exercise that raised the heart rate to about 90/120 beats per minute elicited optimal intellective performance.

Before arriving at this theory, Gutin had carried out a number of studies on the relationship between mental, motor performances and exercise or physical exertion. Gutin and DiGennaro (1968) did a study on the effect of one-minute and five-minute step-ups on performance of simple addition. The result indicated that the five-minute group and the rest group did significantly better than the one-minute group in the speed of addition. This suggests that for the exercise to be effective, there is a critical level of physical exertion that must be attained. The possibility that different degrees of activation affect speed, intensity, coördination and accuracy of motor and intellectual performance has been suggested. Following Gutin's ideology, it appears that in general, the optimal degree of activation seems to be a moderate one, with the curve taking the form of an inverted U-shape.

Activation (Exercise Induced) and the Human Body

An examination of the effect and role of physical exercise to the body should be considered before other studies are introduced. When one exercises, the body is said to be activated. There is a difference between activating the body and physical fitness. Hart and Shay (1963) define physical fitness as the ability of a person's body to meet the demands placed upon it by his work, his way of life and the necessity to meet emergency situations. On the other hand, Gutin (1966) defines activation as energy mobilization, arousal, and excitation in tissues of the organism. Taking the individual as a "whole" organism, organismic theory posits that activity which affects part of the organism also affects the rest of the organism. Exercise is said to affect the heartbeat, i.e., cardiac activity is heightened. The increased force and rate of the heartbeat and the increated ventilation that accompanies vigorous activation is consciously felt by the subject. In addition, there are more profound organic changes that have been detected by exercise physiologists. These include changes in blood pressures, temperature and blood chemistry. A physiologist can determine activation level by a number of physiological measures, for example, electrical resistance of the skin, tension of the skeletal muscles, pulse rate, electroencephalogram, blood pressure, respiration and body temperature. Flynn (1970) indicated that among the several factors that can be influential in determining activation level are emotion, motivation, tension and physical exertion.

The effect of exercise on the brain should also be considered. Some researchers have approached this aspect of exercise from the fatigue angle, explaining that if they understood how mental fatigue relates to cognitive performance, that might shed some light on the relationship between exercise and the latter. Bills (1927) found in his study that mental fatigue results when anoxemia is induced in subjects. He also showed that the symptoms of mental fatigue may be ameliorated by administration of extra oxygen. Gutin and DiGennaro (1966) explain this relationship:

> These findings may be related to the fact that the highest level of coordination and control of human activity resides in the cerebral cortex. Since the cortex has

> the highest metabolic rate in the central nervous system, it is most vulnerable to cessation of activity due to oxygen deprivation. (p.22)

The authors further state that the "cortical activity depends on precise and delicate timing which might be upset by metabolic changes in the blood." (p.959).

Although activation level can be affected by drugs, hormones and emotional factors such as threat or excitement, the source of activation being considered here is only that of physical exercise or exertion. An attempt (without much neurologizing) will now be made to explain briefly the relationship between exertion and performance. Increases in activation tend to result in a state of central facilitation which may permit responses to be triggered faster than under less activation. In addition, there is the probability that increase in body temperature that results from exercise may increase nerve "conduction velocity" (Gutin, 1973). Gutin (1973) adequately explains this relationship:

> Thus to the extent that speed of responses is important to task success, performance may be improved. At the same time, however, the central nervous bombardment from stimuli from various muscles (cardiac, respiratory, and skeletal) increases "neural noise" and may interfere with one's ability to detect, identify and act on the relevant regulatory stimuli for the task. In addition, the facilitation caused by the exercise may make it more difficult to inhibit the many incorrect responses in favor of the one correct one. Thus, to the extent that a task involves much information processing and inhibition, high levels of activation would harm performance. (pp. 257-258)

However, Hebb (1949) maintained that neutral integration is basically a matter of timing and a phenomenon capable of being disorganized by changes in blood chemistry which result from exercise.

Another consideration is the possibility of distraction caused from deep and forced breathing and heightened cardiac activity involved in a recovery from strenuous exercise. Deese (in Gutin, 1966) suggested that these distractions may hamper performance on tasks that require a great deal of vigilance. Gutin (1973) further stated that "the fact that flicker fusion frequency, which is considered a measure of the excitability of the visual and central nervous systems, has been found to increase following strenuous exercise supports the notion that exercise affects central nervous function." (p. 258) This seems to support the idea that when a part of the body is affected, the whole organism is also somewhat affected and that if an organism were to be activated by large muscle activity, some effect on intellective and motor performance might be expected. To this Duffy added:

> various measures of activation (heart rate, systolic blood pressure, action potentials, palmar conductance, skin temperature) tend to be related so that the organism as a whole may be thought of as functioning at a relatively high or relatively low level of activation (Gutin & DiGennaro, 1966, p.82).

Noting the information above, it appears that most of the researchers agree that there is a relationship between activation and the organismic functioning.

Some researchers, such as Flynn (1970) and Gutin (1966) proposed that a moderate level of activation (metabolic activity) in the tissues of the organisms enables optimal performance of many tasks, with performance being at higher and lower levels of activation. In other words, this is to say that too high or too low an energy release from the body appears to cause a reduction in organismic functioning or human performance, whereas a moderate degree seems to enhance performance.

Exercise Induced Activation and Motor Performance

On this topic there are two types of performance referred to--motor performance and mental performance. Although the present study is on cognitive performance, a brief reference to the relationship between motor performance and activation may enhance a more clear and appreciative understanding of that relationship between activation and cognitive performance. It should be pointed out that most of the work on performance and activation was done on motor performance including the few studies on retardates to be found in the literature. For the most part, the experiments on retardates last for several weeks or months and the subjects undergo exercise or no exercise for that long instead of the moderate, breif period of a 2-5 minute range of time. Thus, these studies appear to be more evaluation of fitness than the mommentary effects of brief exercise.

For motor performance, the criterion is the efficiency of a certain musculature being measured. This could be measured in terms of steadiness, balance, etc. The effect of EIA on tasks depends on its intensity and if the task requires inhibition or not. Gutin, Jaeger and Meyer (1971) in their study found that high activation on tasks requiring inhibition such as balance and steadiness generally has resulted in a decrement in performance. This conclusion is supported in studies carried out by Mitchem (1945, 1963) where the same results were obtained. In addition, Gutin, et al., (1971) found that performance on arm steadiness worsened as the heart rate increased, being extremely poor at 160 beats per minute (bpm). A follow-up study showed that performance improved as a function of rest following the exertion, closely paralleling the recovery in heart rate, (Gutin, Fogle & Hoffman, 1973). From all indications, it appears that increases in activation above resting are harmful to performance of tasks that demand great inhibition, (Gutin, 1973). Another explanation may be that "by causing a deficiency in central nervous inhibition, high activation would have a deleterious effect on highly skilled performance, while perhaps adding strength movements which require disinhibition," (Gutin & DiGennaro, 1966, p. 959).

However, the numerous studies cited did not show an inverted-U curve as that obtained in mental performance with different intensities. According to the observation of

Pack, Cotten and Biasiotto (1974), motor performance is more susceptible to deterioration under stress than sensory and intellective functions. Gutin, et al. (1966) explains this finding by stating:

> Perhaps this indicates that the central nervous activity required in the performance of motor skills is more complex and requires more precise timing and vigilance than is required during paper and pencil tasks. . .also possible that some peripheral rather than central factor causes motor skills to be more affected by exertion than paper and pencil tasks. (p.959)

On the other hand, optimal level tasks requiring little or no movement is relatively low, yet high for tasks requiring speed of movement, (Gutin, 1973). Levitt (1972) and Lybrand, Andrew and Ross (1954) conducted studies in which subjects performed a simple speed movement (i.e., releasing one button and depressing another five inches away) while walking a treadmill at the heart rate of approximately 80 (at rest), 115, 145 and 175 respectively. In both studies, movement speed improved linearly with an increase in activation. It is important to note that in both studies the speed task was done while exercising instead of immediately following exercise as in the other studies cited. The above results support the hypothesis that performance of tasks that depend on disinhibition is improved by increases in activation. Despite the fact that it has been theorized that the optimal level for performance on most tasks is toward the center of activation continuum, most of the comparisons still concentrates between very high and relatively low activation levels.

Few studies have varied the duration of the exercise and utilized several activation levels instead of comparing just the low and very high activation levels. Babin (1966) in his study varied the duration of exercise in a systematic pattern. His result indicated that when subjects pedaled a bicycle ergonometer for 3, 4, 5, 6 or 7 minutes, RT performance was best after the 3, 4 and 5 minute exercise and poorest after the 7 minute exercise. Levitt and Gutin (1971) extended the experiment conducted by Sjoberg. The subjects walked on a treadmill at a heart rate of about 80 (standing still) 115, 145, and 175 bpm. This procedure allowed the workload to be adjusted to the subject since the more fit person ordinarily develops a lower heart rate than an unfit person for the same workload. (This control, according to Astrand and Rodahl (1970), is very essential because of the individual physiological differences.) After several minutes of walking at the specified heart rate, the subject performed a five-choice RT task. The results showed a curvilinear relationship between activation and five-choice RT with optimal performance at 115 bpm and poorest performance at 175 bpm. But they also stated that the improvement at 115 bpm over the rest condition was not significant. The reasons for this notation could be that some subjects were used in all different heart rates. In addition, all the treatments were administered the same day and only several minutes were allowed between treatments for the heart rate to return below 90 bpm. Finally, the rest treatment was often the second, third or fourth treatment of the day, suggesting a probability that the subjects were not fully "deactivated" during this treatment.

Based on these findings, Levitt (1972) conducted another experiment, but this time, each treatment was given on separate days. In addition to the task (five-choice RT) used by Levitt and Gutin (1971), the subjects also performed a simple RT task and two-choice task. He conducted the experiment in such a way that some participants performed simple tasks while other performed either a two-choice or five-choice task. This way he eliminated using each subject for more than one task. In simple RT task, only temporary inhibition is required whereas in choice RT, both temporary and spatial inhibitions are essential. Although the results did not indicate any significant interaction between type of RT task and optimal level of activation, there was a clear-cut superiority of RT at the heart rate of 115 and 145 bpm as compared with performance at resting (80) and very high (175) heart rate.

Exercise Induced Activation and Cognitive Performance

Although it appears well established that strenuous exertion has a deleterious effect on motor skill, the relationship between exertion and tasks not requiring motor skill (cognitive tasks) is not clear. Unlike the relationship found in the performance of motor skill and exercise, that of the cognitive skill or task generally takes the shape of an inverted "U" when plotted. Bills (1927) found that a moderate degree of activation seems to have a positive effect on performance of certain intellectual tasks. McAdam (1967) conducted a series of experiments to determine the effect of light exercise on performance of a letter-symbol substitution task. The results showed that there were no significant differences between groups which rest or undergo light exercise between the pre-test and post test. The explanation given for this result was that light exercise may not cause sufficient arousal excitation in the tissues of the organism to elicit significant differences between rest and exercise conditions. This appears to support Gutin's theory that the relationship between activation and cognitive performance (including problem solving) takes the shape of an inverted "U", i.e., at rest or very light activation (exercise) the heart rate is still low, causing the subject to perform just like someone at rest.

A study conducted by Gutin and DiGennaro (1968) which utilized one and five minute step-ups at the rate of 30 step-ups per minute, found that performance of simple addition was not significantly affected by these levels of exertion. But the results indicated that there was a tendency for physically conditioned subjects to improve in accuracy as a result of five minute step-ups, whereas the physically unconditioned subjects tended to do less well. It appears that the effect of light and moderate exercise on simple paper and pencil tasks has yet to be clearly established. On the other hand, Lybrand and others (1954) conducted a study to investigate the effect of prior exertion on perceptual organization. A five-mile walk at 120 steps per minute carrying a forty pound pack seemed to warm up rather than fatigue the subjects. This was deduced from the superior performance on problem solving and manipulative tasks after exercise. This raises the question of warm up.

Many studies have been done on the effect of warm up on the human body and performance, but no one study has been able to give a clear-cut significant result. Despite such ambivalent results, humanity almost universally accepts the concept that warm ups are beneficial. Thus, one could always observe warm ups before games, sports and breaks for young children to go out and play in between classes. However, not many studies have been done on exercise and cognitive task performance and not much is known about it. Unlike motor skill performance and exercise, Gutin's work stands alone as an effort to determine the effect of exercise (conditioning) on the ability to perform complex mental tasks. For up until Gutin's work, there had been no systematic reporting on attempts to quantify differences in the ability to learn or perform cognitive tasks as a result of exposure to exercise (McAdam & Wang, 1965). While no significant differences resulted between a group which had participated in a twelve-week conditioning program and one which had not, in terms of their performance on any cognitive tasks, Gutin (1965) did find significant relationships between the changes in fitness and the changes in mental performance by individuals within those groups.

McAdam and Wang (1965) conducted a study in which 108 male college students were divided into four treatment groups. The treatments were exercise, typical classroom instruction and lying down on mats, resting to soft music, and taking an immediate retest of a simple cognitive task. Prior to the treatment phase, all groups were administered a symbol substitution test for ten minutes. Following the ten minute treatment period, each group took the alternate form of the cognitive task test in the original setting. The results indicated there were no significant differences in performance on the simple cognitive task by the four groups. However, there were trends in favor of the exercised and rest groups performance. The researchers hypothesized that the lack of significance might be due to the short exposure to the cognitive task and a longer exposure should be tried.

The study by Gutin and DiGennaro (1965) indicated that numerical accuracy is hindered when it is preceded by extremely heavy muscular exertion whereas numerical speed is not affected significantly. One of the interesting studies on the relationship between physical exertion (activation) and mental performance was conducted by Davey (1973) who investigated the problem of why people in a state of fatigue make wrong decisions. Subjects pedalled a bicycle ergometer for varying periods of time and were tested for mental performance after different amounts of physical exertion. The result was in support of Gutin's theory of inverted "U" shape relationship. It showed that a submaximal amount of physical exertion improved mental performance on the Brown and Poulton test of attention which relies heavily on short term memory. However when the exertion was increased over longer periods of time, the graph showing the relationship of mental performance to physical exertion followed the form of an inverted "U". Davey (1973) explains that physical exertion affects mental performance by raising the level of arousal.

Lovaas (1960), Spence, Taylor and Ketchel (1956), and Mohsin (1954) do not agree totally with Davey on this issue. Mohsin (1954), in his study, illustrated that although frustration raises the level of arousal, it also interferes with learning. So it might be more appropriate to suggest that physical exertion affects cognitive performance by raising the level of arousal, but the extent to which this arousal evokes other irrelevant responses capable of interfering with mental performance must also be considered.

Gutin, in his review, argued that concomitant exercise seems to cause a decrement in numerical performance which is relatively linearly related to increasing intensities of exercise. For the average person, it seems that mental performance starts tapering off when the heart rate is in excess of 160 bpm. However, several studies (Flynn, 1972; Greenwood 1969; McAdam & Wang, 1967) found no significant variation in intellective performance following various intensities of exercises. Therefore, there might be a critical difference between prior and concomitant exercise. Gutin sums it up as follows:

> Increasing intensity of concomitant exercise seems to present an increasingly greater degree of interference to the processing of numerical information, but effects do not seem to persist long after the exercise. . .the EIA level (indicated by HR) drops rapidly after exercise and may pass from a high through an optimal state while the subject is completing the problems. Perhaps intellective tasks are not as precise in measurement nor as sensitive to changes in EIA as motor tasks making it more difficult to show variations due to EIA. (This is perhaps the best explanation for the null results often obtained. - ed.) (Gutin, 1973, p. 263)

However, despite various contradictory results, some studies (Davey, 1973; Gutin, et al., 1965, 1966) have actually shown results that indicated the hypothetical inverted "U" function. This conclusion strongly suggests that there must be a critical point, i.e., the intensity, timing and duration of exercise must be approximately exact to produce the maximal intellectual performance. In this connection, the relationship of drive with performance should also be considered. Most studies (Courts, 1942; Malmo, 1959; Sarason, 1956) have tried to relate physiological indicants of drive with performance measures. Burgess and Hokanson (1964) have criticized most of these studies stating:

> Typical of these studies has been a minimum of speculation as to what hypothetical innter processes are taking place under increased drive, whether brought about by deprivation, induced muscle tension, or some form of frustration. The attempt has simply been to demonstrate the functional relationship between measurable indicants of drive level and performance. (p. 85)

On the other hand, although Malmo (1962), in his review, did not completely explain the inner processes taking place under increased drive, there was a suggestion that the relationship takes the form of an inverted "U" function. In other words, a positive correlation between drive and performance at low to moderate activation levels and a negative correlation at moderate to high levels would exist. It may not be a mere coincidence that both drive and activation levels' respective relationship to mental performance take the form of an inverted "U" function.

To test this hypothesis, Burgess and Hokanson (1964) carried out an experiment in which heart rate was raised and the subjects performed three standard tasks: the Digit Symbol Subtest of the Wechsler Adult Intelligence Scale (WAIS), the Symbology Subtest of the School and College Ability Test (SCAT), and a simple reaction time task. Unlike most studies (Hokanson & Burgess, 1962a, 1962b; Hokanson, Burgess & Cohen, 1963), this study has the advantage of a physiological classification which offered an observable and relatively measure of drive level and consequently, made it possible to equate two different types of arousal procedures--frustration and physical exertion. This combination allowed a comparison of the performance effects of these two manipulations (frustration and physical exertion). It is interesting to note that the result did not only show that the relationship was that of an inverted "U" function, but also that low drive-high frustration (LD-HF), high drive-low frustration (HD-LF), and the low drive-physical (LD-P) conditions formed a cluster representing the most improvement in performance, whereas LD-LF, HD-HF, and HD-P conditions represented the least improvement in performance. However, the hypothesis (contention) that heart rate increases can lead to increment or relative decrements in performance was explained by Burgess and Hokanson (1964) as based upon the basal drive level. They explain:

> It is predicted that those subjects who habitually operate at higher heart rate levels will have poorer performance after either frustration or physical exertion because these subjects will have passed the theoretical point of optimal drive intensity. Those subjects who habitually operate at lower heart rate levels will show an improvement in their performance after frustration or physical exertion because they will be approaching this optimal level of drive intensity. (p. 86)

Although these studies suggest that both drive and physical exertion have effects on performance, there is always the probability that there are more things influencing performance in conjunction with those already mentioned. Finally, more studies are certainly required to investigate and determine exactly how this effect takes place.

Cognitive Abnormalities, Problem-Solving and Conceptual Behavior

It is very difficult to predict the effects of focused injuries to the brain. Although there is some localization of function and damage to a particular area may cause severe impairment of function, the brain's great back-up resources may be able to compensate for the deficiency. The sheer number of neurons or nerve cells in the brain (10-12 billion) provides a redundancy of capability within each given area to offset some cell loss. Also, the interaction of all parts of the brain in receiving and transmitting information will often permit an area sharing similar information to compensate for loss of function in a damaged area. In addition, the brain has some capacity for the repair of damage. The limits of these resources, however, can be reached and while damage in some areas may lead only to a temporary loss of function, destruction in other areas, as well as extensive damage to any brain area, may result in complete loss of given functions (Coleman, 1976).

Extensive damage or destruction to brain area is often the cause of mental retardation. Although mental retardation has been acknowledged and written about for centuries, no single, universally-accepted definition has been developed.

Some definitions emphasize the sociological aspects of mental retardation. For example, the President's (U.S.A.).

Panel on Mental Retardation defined it like this:

> The mentally retarded are children and adults who, as a result of inadequately developed intelligence, are significantly impaired in their ability to learn and to adapt to the demands of society....The term "mental retardation is a simple designation for a group of complex phenomena stemming from many different causes, but one key common characteristic found in all cases is inadequately developed intelligence. (1962, pp. 1,4)

On the other hand, in Russia, mental retardation is not defined only in terms of characteristics, but in terms of causation. Luria's (1963) definition states:

> Mentally retarded children...have suffered from serious brain pathology during intrauterine or early life and this has resulted in their whole mental development remaining anomalous....They are anomalous children and all their behavioral deficiencies are a survival of an early disorder which has caused the underdevelopment of the brain and serious defects of mental activity. The mentally retarded child is sharply distinguished from the normal by the range of ideas he can comprehend and by the character of his perception of reality. (pp. 5, 10)

Thus, specific problems may arise due to the fact that problems such as encephalitis, birth injury and organic changes in the brain not only cause neurological signs, but also psychic changes. There is support for the theory that pathological organic processes may impair intellectual capacity. After encephalitis in infancy (other than encephalitis lethargica) and brain injury, there exist all types of intellectual impairment, from borderline deficiency to idiocy (Schilder, 1964).

In the past, emphasis had been on the type of problems the retardate is incapable of solving. According to Schilder:

> It should not be asked which are the problems that the deficient person cannot solve, but rather, which are the problems that he can solve, and in what way can he be educated to make social use of his faculties, whatever they may be. (p. 195)

Research has shown that the thought, organizational processes and the process of perception of surrounding objects proceeds at a considerably slower rate for the mentally retarded child than for his normal peer and, as a rule, it does not extend so far beyond immediate sensations (Luria, 1953). Efforts should be made to determine how the mentally retarded child could maximize the limited potential he possesses. For example, House and Zeaman (1960b) carried out a study on transfer operations in mentally retarded subjects. The results showed that the subjects found colorform pattern discriminations difficult while color-form object discriminations were easy. In noting this the researchers found that when the easy object discrimination was used to focus attention on the relevant color-form dimensions, attention was transferred strongly to the difficult pattern problem.

Attention and arousal have often been used to account for psychological deficit in schizophrenia. McGhie, as cited by Spohn, et al., (1970), has stated the case for the role of attentional processes most directly by asserting that many of the symptoms of cognitive dysfunction seen in schizophrenic patients may be traced back to an initial failure in the selection and processing of information. In another study, according to Spohn, et al., (1970), McGhie found evidence that "on tests examining the effects of distraction on perception and immediate recall. . .schizophrenic patients were on the whole more distractible than normals." (p. 113)

Prior research has indicated that there are reliable differences both in the level of arousal and in the physiological reactivity to stress between schizophrenics, normals, and mentally retarded subjects. If this is true, the difference may have important effects on cognitive functioning of the three groups, especially their problem-solving behavior. Payne (1961) explains that problem-solving involves a number of probably independent processes, namely: "Perception is involved in the recognition of the data of the problem. Memory span is required to hold certain facts in mind temporarily while they are manipulated." (Eysenck, 1961, p. 250). It appears from all evidence that the normal schizophrenic and mentally retarded subjects differ in their utilization of these processes. Different "constellations" of cognitive abnormalities are a result of several and maybe unrelated abnormalities. Payne also states that disorder of perception may be the most basic of these abnormalities. He argues that with an error in perception of the data, the whole process of problem-solving is interfered with, right from the start, which will result in error in solution. However, he fails to give any plausible reason for this disability. He suggests that the disability may be due to other misconceptions, for example, hallucinations, unreality feelings or even feelings of depersonalization.

On the other hand, Johnson (1950) stressed among other things, the involvement of complex stimulus situations, varied behavior, and solution processes in problem-solving behavior. Skinner (1953) offered a definition of problem-solving. Problem-solving is the behavior which, through the manipulation of relevant conditions, facilitates the occurrence of the strong responses in question. According to his view, a problem situation arises when 1) conditions exist which prevent or interfere with the occurrence of responses which are at high strength in an individual, and 2) there are no responses in the behavioral repertoire which will immediately alter the problem situation. Ellis tried to explain this view with an example: "If candy eating is at high strength in a child and candy is suspended from a ceiling by a string, box stacking may be the problem-solving behavior which permits him to obtain the candy" (Ellis, 1963, p. 440). Again, this ability to manipulate the relevant conditions is not as strong among mentally retarded subjects and schizophrenics as amongst their normal peers.

In addition to misperception, Payne (1961) also argued that among the mentally retarded and the subjects suffering from psychosis, the mechanism of attention itself seems to become defective. He stated:

> Whatever filtering mechanisms ensure that only the stimuli (internal or external) that are relevant to the task enter consciousness and are processed, seems no longer able to exclude the irrelevant. This has numerous repercussions. Thinking becomes distracted by external events. It also becomes distracted by irrelevant personal thoughts and emotions which may even become mixed up with the problems. Selective perception becomes impossible, so that instead of dealing with the essence of the problem, irrelevant aspects are perceived and thought about. Problem-solving becomes slower for that reason. (p. 251)

According to Payne, this process will then result in learning an overinclusive concept. He offered that it becomes an advantage, however, on those occasions when normal people mistakenly screen out certain aspects as irrelevant to a problem (adaptive rigidity) and fail to solve it, whereas overinclusive individuals at least obtain all of the data.

Payne proceeded to explain this disability in terms of extraverted and introverted personalities. According to his views, extremely extraverted people are less able to learn when the data are too numerous. Such people, he explained, tend to be less persistent and more impulsive so that they tend not to check their thinking, tending to be fast but inaccurate. On the other hand, extreme introversion is said to produce the opposite effect. The thought process is slowed, resulting in increase in accuracy. However, such people are said to display "adaptive rigidity" as they quickly build up a set which may blind them to certain possibilities.

Extreme excitability and distractability obviously produce poor performance. Since Payne's study, many studies (DeWolfe & Youkilis, 1975; Hirsch & DeWolfe, 1977; Spohn, et al., 1970; Fowles, et al., 1970) have shown some evidence that schizophrenics are higher on excitability and distractability levels than normal subjects. These characteristics tend to place schizophrenics at a disadvantage in solving problems under activation. They may produce an extreme slowing of cognitive processes. Williams (1976) suggested that this effect could be because one of the many effects of schizophrenia is a conceptual deficit partly due to an inability to process incoming information effectively.

Most of the studies that tried to decipher the effect of physical education on mentally retarded and schizophrenic subjects were carried out on a long time basis. For example, Katsimpalis (1968) investigated the effects of isometric exercises on the educable mentally retarded after a six-week exercise program. However, no findings were reported on intelligence. Stoner (1972) carried out a two-day study to determine the effect of two levels of pre-task exercise upon the performance of a gross motor task by educable mentally retarded children. The results showed that the exercise period on the bicycle ergometer was not strenuous enough to affect either performance or learning on the stabilometer. Geoffrey (1969) in his study in which physical education was taught and practiced for six weeks, found that the children's motor, intellectual and emotional behavior changed more positively than that of the control group. Hussey, Maurer and Schofield (1976), in their study, evaluated the effectiveness of one-hour daily sessions of exercise for three weeks. Exercised subjects improved or gained in performance on their physical coordination, activity level, attention-seeking and social behavior. However these behavioral improvements during the sessions did not generalize to the workshop setting. It might be appropriate to state that the process of solving problems proceeds quite differently with the school child-oligophrenic. For him, direct impression and not special meaningful analysis plays the leading role in such "intellectual" operations (Luria, 1953.)

HYPOTHESES

The present experimental study was designed to explore the following hypotheses:

1) Normal children who undergo moderate exercise show more improvement in their cognitive performance than normal children who have no exercise.

2) Schizophrenics who were exercised will perform better on their mental task than the non-exercised group.

3) The edcuable retardates that were exercised will show more improvement on the mental tasks than those who did not get any exercise.

4) The normal subjects do better than the schizophrenics while the schizophrenics do better than the trainable retardates on pretest and post-test measures.

METHOD

Subjects

A group of 224 Nigerian children were randomly selected using the name call register from a public primary school, the Auxillary School for Educable Retardates and the Rehabilitation Centre Institution. The subjects were comprised of 90 normal children, aged between 5-6 years old; 70 schizophrenics, aged 7-9 years old; and 64 educable mental retardates, aged 7-12 years old. The schizophrenics and retardates were diagnosed by staff, and all subjects were equated on their mental age (using the equivalent grade level and staff diagnosis), but not on chronological age.

All subjects went through medical and optometric examinations to exclude those subjects who had physical problems which might confound their performance on the experimental task. The principals of the Auxillary School, public primary school, and Rehabilitation Centre, after reading the procedure, granted their permission to use the school facilities and to let the children participate in the experiment.

Materials

All of the following materials were used for conducting the study: colored alphabet blocks, toy animals, trees and flowers, toys on flat wood, digits in different colors, draeings on thick cards (black figures on white cards), music, balls and ropes. These were obtained from the schools' game rooms or play/therapy rooms. The music was for the benefit of the retardates and schizophrenics who were said by staff to rest better with a musical background.

Procedure

The experiment was carried out in the form of studies which attempted to define the relationship between physical activation and mental performance. Three pilot studies and one main study were conducted in which cognitive performance was recorded as the subjects worked on a different task for each of the respective studies. The purpose of the pilot studies was to find that task for the three different groups of children (normals, schizophrenics, and retardates) which would be best suited for the larger main study.

Pilot Study I

This study involved color matching, a perceptual task. Ten subjects each were placed in an experimental and control group for each of the respective subject groups, Normals (N), Schizophrenics (S), and Retardates (R). The expermenter placed ten objects on a table at which each subject was seated and asked each subject to match each of the objects with the appropriate color. The experiment was divided into three phases. All of the subjects participated in pre- and post-tests and in between, the experimental groups were subjected to five minutes of physical exercise while the control groups rested in a spacious room with some low, quiet music in the background. The exercise consisted of two 30-meter dashes after three knee bends, some soccerball, netball or jump rope, according to what each subject liked best. However, all of the subjects participated in the 30-meter dashes. The results showed that this task was considerably easy for the subjects, and probably too easy for the normal children; hence, no significant difference could be attributed because of exercise.

Pilot Study II

This study followed exactly the procedure outlined for Pilot Study I above, except that a memory task (color recognition) was used. Again, there were ten subjects in each individual group and three phases (a pre- and post-test and an intervention period with either exercise or rest). The subjects were asked to recognize a color already shown to them. For example, the subject was shown a card with a tree painted green. After sixty seconds, the subject was then asked to pick out a color form a collection of different colored cards that matched the one the experimenter had just shown him, while in the meantime, the experimenter had hidden the original card from the subject. Each subject did this for ten cards (pre-test) and ten cards (post test). This proved more of a challenge to the normals, schizophrenics, and retardates than Pilot Study I. That is, the task was difficult enough so as to permit a fair amount of within groups and between groups variance.

Pilot Study III

The same procedure was applied here as in the other two pilot studies. However, a labeling task was utilized whereby subjects were asked to name the colors. This was the only task that required verbalization from the subjects. It consisted of the experimenter displaying a set of ten different color cards and asking the subjects for the correct color name for each card presented. It is probably significant to note that the retarded children found this most difficult and perhaps too difficult and did more poorly here than in the other two tests, while the schizophrenics, and especially the normal children found it to be the easiest of the three tests. The scoring scale was also 0-10.

Main Study

Pilot Study II - Memory Task was chosen as the adequate task to be used for the main experiment because it proved to be more of a mental challenge to all of the three groups.

The procedure followed exactly as outlined for the memory task pilot study except that more subjects were used here: 35 normal subjects each in an experimental and a control group; 25 schizophrenic subjects in each of the two groups; and 25 educable retardates each in the two groups. However, some subjects dropped from the retarded groups; thus all of the groups were adjusted to contain 22 subjects each. The most difficult problem was captivating the attention and cooperation of the schizophrenic children. The educable retarded children and the normals were eager and happy to help.

The variables were structured by a 2 x 3 design, using three different diagnostic groups (normals, schizophrenics, and retardates), each divided into two treatments, exercise and rest for five minutes. The dependent variable was that of memory-color recognition.

RESULTS

The data were analyzed using a 3 x 2 factorial ANOVA, (Winer, 1962). The factors were diagnosis and exercise. The results of the analysis of variance are reported in Table 1.

The main effect for diagnosis was significant, F (2, 126) = 68.93, p .001 as was the diagnosis and exercise interaction, F (2, 126) = 58.55, p .001. The interaction is portrayed in Figure 1. The interaction was probed using the Newman-Keul's technique, (Winer, 1962). The probing yielded the following results:

1. Normals increased in memory task following exercise (R_2 tabled = .78, R_2 observed = 2.28, p .01).
2. Mentally retarded children showed no change following exercise (R_2 tabled = .78, R_2 observed = 0.00).
3. Schizophrenics decreased following exercise (R_4 tabled =.94, R_4 observed = 2.32, p .01).

The results of probing the diagnosis and exercise interaction led to acceptance of Hypothesis 1 which states that normal children who underwent moderate exercise (five minutes) will show more improvement in their mental performance than the control groups who rested. However, Hypotheses 2 & 3 were rejected.

Table 1

Analysis of Variance Summary Table

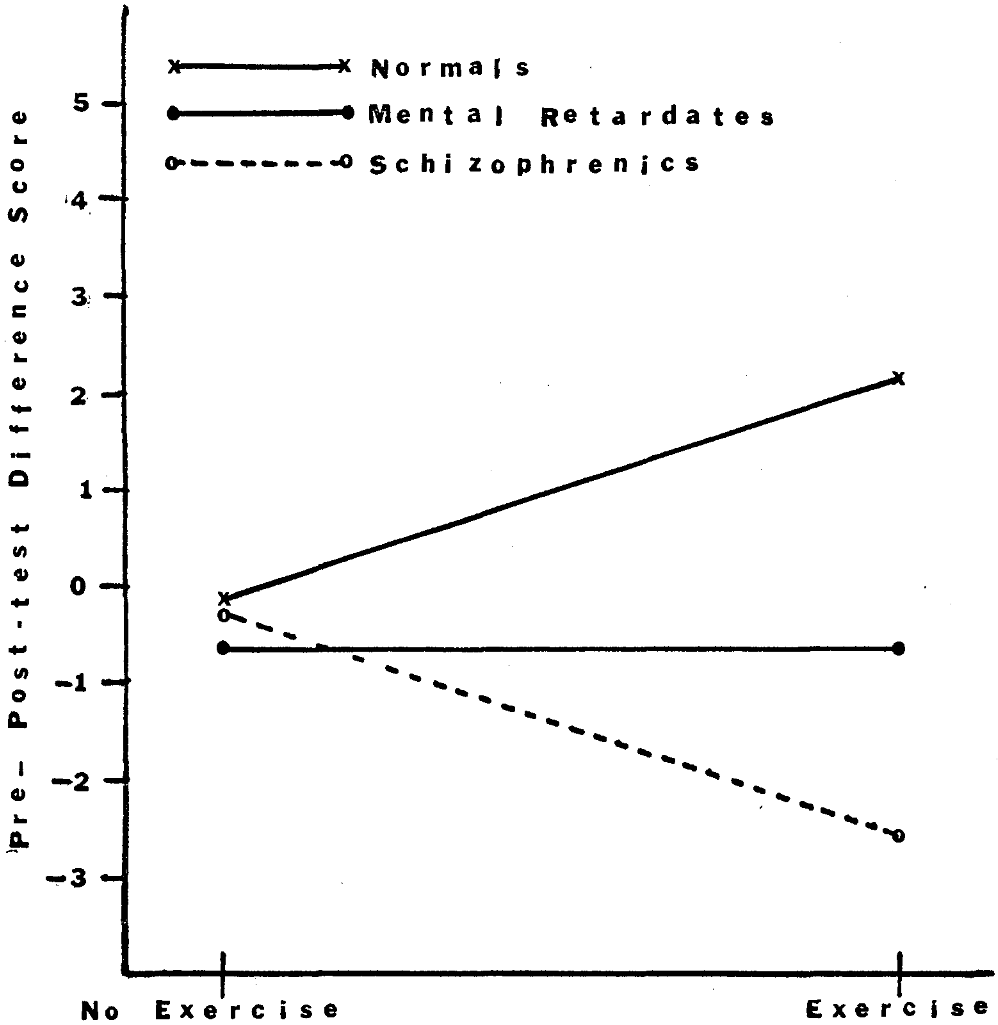
for the Effect of

Exercise and Diagnosis on Cognitive Performance

Source of Variation	SS	df	MS	F	P
A (category of patients)	136.47	2	68.24	68.93	.001
B (exercise vs. no exercise)	0.01	1	0.01	0.01	N.S
A x B	115.92	2	57.96	58.55	.001
Within cell (error)	124.41	126	0.99		
Total	375.81	131			

FIGURE 1

The Relationship Between Diagnasis Exercise and Cognitive Performance



These state that (1) Schizophrenics who were exercised will perform better than the control group. The reverse was actually found to be the case; schizophrenics that had rest and no exercise performed better than those who had exercise. The exercised group deteriorated more in performance.
(2) The exercised educable retardates will show more improvement than their non-exercised counterparts. Again, this was not the case. There was no significant change between the exercised or non-exercised groups.

Hypothesis 4 stated that the normals will do better than the schizophrenics who will in turn be better than the educable mental retardates, indicating that the mental retardates will do worst in all levels.

The result does not support Hypothesis 4. Although the normal subjects performed best, mentally retarded subjects performed better than the exercised schizophrenic subjects.

Table 2

Newman-Keul's Probing Technique

M	Sc-Ex -2.59	MR-No -0.68	MR-Ex -0.68	Sc-No -0.27	N-No -0.14	N-Ex +2.14
-2.59	--	1.91	1.91	2.32	2.45	4.73
-0.68		--	0.00	0.41	0.54	2.82
-0.68			--	0.41	0.54	2.82
-0.27				--	0.13	2.41
-0.14					--	2.28
+2.14						--

	.05	.01
R_2 =	.588	.777
R_3 =	.706	.882
R_4 =	.775	.945
R_5 =	.832	.989
R_6 =	.861	1.023

R = Shortest Significant Range

DISCUSSION

The central theme of this paper is to determine whether or not exercised induced activation facilitates or interferes with cognitive behavior, and whether such effects are influenced by the cognitive integrity (i.e., presence-absence of psychopathology of the subject). Assuming that all precautions taken to avoid confounding were effective, the results showed that the only hypothesis which was unequivocally supported is the one proposing that the experimental normal subjects improve more on their cognitive performance than the normal control group who rested. The difference in scores obtained after the introduction of physical exercise among the experimental and control normal groups could only be attributed to physical exercise. In this case, the result is in accordance with previous findings and is also supportive of Gutin's theory. Among normals, exercise tends to raise the heartbeat, pulse and blood circulation and when carried out in moderation, all of these physical processes tend to enhance problem-solving behavior.

On the other hand, the data failed to support the other hypotheses which were derived from the combination of Duffy's (1962) hypothesis and Gutin's (1973) theory when applied to the mentally retarded children and schizophrenics. Both Duffy (1962, 1973) and Gutin (1965, 1966, 1973) contended that when exercise is carried out in moderation, the mental performance of the individual is at its optimal level. In extending this theory to the mentally deficient child and schizophrentic child, results showed that although it applies to a normal child, it does not apply to the mentally deficient and schizophrenic children. Of the mentally retarded groups, neither the control nor the experimental groups improved after intervention. Both groups appeared to have suffered some slight decrease in their scores after the intervention. Probably the simplest explanation for this is that the mentally retarded subjects must have suffered some fatigue effect during the experiment. Non-significance of results in this area can, perhaps, be attributed to the fact that normal children react differently to stimuli than the mentally retarded child. Perhaps a mentally retarded child needs more than five minutes of exercise or even less than five minutes to achieve moderate activation.

Of the schizophrenic groups, the experimental group that had the exercise intervention did much more poorly than the control group that rested. When this result is compared with that obtained by the normal children, the schizophrenic groups yielded a reverse result. Although there was no increase in the mean of the schizophrenic control group in the second half, they did far better than the schizophrenic experimental group whose mean dropped drastically. The difference obtained was too great to be accounted for by mere fatigue effect. Secondly, since both groups were randomly selected from the same population pool, a fatigue effect would show in the peformance of both the experimental and control groups. There may be many explanations for this difference in results. It has been suggested in research that schizophrenics have a low attention span and are highly reactive to stimuli and indulge in over-inclusiveness. All of these factors when combined with their thinking process patterns, might explain the results obtained. For example, the exercise could have caused the schizophrenic children to become highly distractible. To the author's knowledge, since all studies in this area were done no normal subjects, it is somewhat hard to determine how the present study compares with other findings. However, other explanations appear plausible.

A number of methodological improvements could be made in the present study. One possibility is to use other tasks to enable increased general ability. Although the memory task used in the present study was selected after three pilot studies investigating the appropriate task, the experiment could be devised to utilize various types of tasks. Additionally, these tasks could encompass different facets of problems--arithmetic, drawings, etc. In respect to the exercise, instead of a five minute exercise, the subjects could be sub-grouped so that there will be groups in 2, 3, 5, 6, 7 and 10 minute activations and rest respectively. In addition, the subjects' heartbeats per hour and pulses should be taken to ensure uniformity.

Another serious problem is in the procedure, i.e., some subjects may take a longer time to return to resting rates of physiological and psychological arousal than others. In other words, when the children went through the exercise intervention, and then returned to the task, the experimenter assumed they were working under the same high heart rate obtained during the exercise. The measure may have been insensitive since it produced a single global subjective rating of activational arousal. For example, the measure may be sensitive to both normal and schizophrenic children who completed their tasks quickly and in short time after the exercise, but may not be applicable to the mentally retarded children because they were slower and took by far a longer time to come up with their responses. In which case, the heart beat rate, pulse, etc. may have returned to normal. This difficulty, however, may be overcome by shortening the task period. That is, instead of ten problems in each pretest and post test periods, the problems could be shortened to five.

It may also be palusible to use adult subjects to determine if a difference would occur and to utilize physiological measures of activation as dependent variables.

SUMMARY

This investigation of the relationship between exercise induced activation (EIA) and mental performance attempts to combine Duffy's hypothesis and Gutin's theory as it is applied to normal, schizophrenic and mentally retarded children. Gutin theorized that the relationship between EIA and human performance takes the form of an inverted "U" with performance optimal at some intermediate level of EIA. Extending Gutin's theory to Duffy's hypothesis that various measures of activation (heart rate, systolic blood pressure, skin temperature, etc.) tend to be related so that the organism as a whole may be thought of as functioning at a relatively high or relatively low level of activation, leads to the hypothesis that moderate EIA may facilitate problem-solving behavior.

A five minute exercise was used to raise the level of activation and a color recognition-memory task was used to measure efficiency in problem-solving. Subjects were 44 normal, 44 mentally retarded, and 44 schizophrenic children who were matched on their M.A. Each designated group was divided into equal numbers of subjects in experimental (exercise) and control (no-exercise) groups. The 20 problems task was divided into a pretest and post test of 10 problems each. Each group was given the pretest with five minutes

exercise intervention for the experimental group and five minutes rest with musical background for the control group. After the interventions, the post test was given. Subjects rated from a possible 0 to a possible 10. Data was analyzed by ANOVA with the effectiveness of exercise as the variable of interest.

It was expected that all the exercised groups would improve on their post test or at least do better than their control group counterparts. Data demonstrated the effect of EIA on normal children, but established it as not effective on mentally retarded children and that EIA had a detrimental effect on schizophrenic children. Data failed to support Gutin's theory when applied to schizophrenic and mentally retarded children. The contradiction may be due to difference in excitability levels of the three groups. Use of improved procedures in a replication should be helpful in further clarifying the complex relationships between cognitive integrity-pathology and EIA observed in this study.

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APPROVAL SHEET

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The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval by the Committee with reference to content and form.

The thesis is therefore accepted in partial fulfullment of the requirements for the degree of Master of Arts.

6-7-78
Date

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