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ROBERT JEFFERY MITCHELL, SR.

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AN EXPERIMENTAL STUDY TO DETERMINE THE EFFECTS

OF INHALING PURE OXYGEN ON I.Q.

APPROVED BY

P. T. Teska

Ruth E. Elder

G. J. Monahan

W. B. Ragan

DISSERTATION COMMITTEE

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CHAPTER I

INTRODUCTION

The air which we breathe contains a clear, odorless, tasteless element known as oxygen and although this element comprises less than one fourth of the volume of air which we inhale at sea level, oxygen need is the most important of all physical needs. Man may live weeks without food and days without water, but he can survive only a few brief minutes without oxygen.

The effect of depriving a man of air has been known for some time. It is not surprising that the importance of something so vital to life as air (more technically oxygen) was impressed upon man at an extremely early period in history. It has been recorded that the Romans, at the height of the Roman Empire, became aware of the fact that miners working deep in the iron mines would die if they were not supplied fresh air (4). So man has known for more than two thousand years that to deprive a person of air results in unconsciousness and subsequently death.

As the lack of oxygen (anoxia) increases, a person's brain is affected and he begins to experience difficulties with his vision. If this condition continues, the individual becomes less and less able to think clearly or to respond to stimuli. In the event oxygen is not supplied, this secondary stage is followed by a state of unconsciousness which results in death. It is a curious fact that a person experiencing anoxia is almost never aware that there is anything wrong or that he is not functioning as he normally does (3).

It would be of interest to find out whether the opposite effect of anoxia could be produced by supplying a person with more oxygen than he normally breathes. If insufficient oxygen results in an inability to think or to reason and to retain consciousness, would a superabundance of oxygen result in clearer thinking and superior reasoning?

Researchers in physiology have found that breathing pure oxygen during physical exertion greatly enhances the ability of the physical body to withstand fatigue. Thus, inhaling pure oxygen allows a person to continue physical exertion beyond the point where he would be forced to stop if he were breathing common air (2). Therefore, it is wondered if breathing pure oxygen might also have some positive effect on intelligence, or more specifically on the intelligence quotient (I. Q.). I.Q. is herein defined as "The ratio of an individual's intelligence (determined by mental measures) to so-called average or normal intelligence for his age (14)." The concept of intelligence has an early and intriguing history. As a result of the confusion and misunderstanding which now surrounds the meaning of the term intelligence, it is necessary to review briefly the evolution of the modern concept of intelligence in order to clarify the nature of the problem under study.

History of the Concept of Intelligence

Man has been aware of the phenomenon which we now call intelligence for about twenty-four hundred years. "The Greeks were the first to develop scientific conceptions of intelligence and of mental operations. We find the beginning of their concepts in the idea of Nous as held by Anaxagoras (cir 500-428 B.C.), who first used the term in a technical sense (28)." Although the Nous of Anaxagoras is not exactly synonymous with our present day concept of intelligence, it, after being reworked by Plato (429-348 B.C.) and later by Aristotle (348-322 B.C.), came nearer to the contemporary cognition of the intelligence concept.

The Greek conception, especially the Aristotelian conception of Nous or reason, was passed on to the Romans who translated the word as intellectus. Early in modern times intellectus came to be limited to cognitive functions, and the Greek influences of feeling and willing were separated from it (28).

It was a result of the impact of such men as John Locke (1632-1704), who wrote the Essay Concerning Human Understanding in 1704, and Charles Darwin (1809-1882), whose work in evolution prompted experimentation on animal behavior, that brought psychology to the current conception of intelligence and behavior (28). Thus intelligence became a testable phenomenon.

About the close of the seventeenth century "mental tests" began to appear. However, the term "mental tests" apparently was used first by Cattell in 1890 (28).

In the fall of 1904 the Minister of Public Instruction in Paris began studying the problem of educating mentally subnormal children who were unable to profit from regular public school instruction. It was decided that special schools would be constructed for mentally subnormal children. The resulting problem of identifying subnormal children prompted Binet and Simon to devise an intelligence scale which is the father of the instrument used in this experiment (28).

So it was that the complex abstract nature of intelligence came to be assessed in simple concrete figures called I.Q. points. In reality, I.Q. is more of an artifact of intelligence than it is a synonym.

History of Oxygen

Before going further into this experiment, it is necessary to review some of the facts about oxygen. Joseph Priestley, as a result of his publication in 1775, is credited with the discovery of oxygen (29). At about the same time Carl Wilhelm Scheele, conducting experiments on the nature of fire, also discovered oxygen (31). Although in actuality Carl Wilhelm Scheele discovered oxygen some two years earlier than

Priestley, he did not publish his laboratory notes until 1777 (31). Consequently, Priestley received credit for telling the world of the existence of oxygen.

Physiology of Oxygen Inhalation

The process of supplying oxygen to the cells and removing carbon dioxide may be divided into four phases:

1. Air is brought into and removed from the lungs by means of the respiratory muscles.

2. Oxygen is absorbed from the air in the lungs (alveolar air) through the walls of the alveoli into the hemoglobin of the blood.

3. The oxygenated blood (oxyhemoglobin) is transported to the tissue by means of the cardiovascular system.

4. The oxygen passes from the blood into the cells (20).

These four phases are understood better when it is realized that oxygen which is taken into the body possesses a slight pressure or tension. The oxygen in the lungs is at a higher pressure than that in the blood. The higher pressure in the lungs causes the oxygen to pass into the blood. The oxygen in the blood, possessing a greater pressure than the pressure in the tissues, therefore passes into the tissues (1, Pp. 7-8). It is this way that oxygen in our atmosphere is supplied to the tissue of our body.

The air which man normally breathes contains 20.96% oxygen, and at sea level 95% of the arterial hemoglobin exists as oxygemoglobin, while the dissolved oxygen in the plasma amounts to 0.24%. Inhalation of pure oxygen by a normal individual results in 100% of the hemoglobin existing as oxyhemoglobin, and the plasma oxygen reaches 2.2% (16).

Physiologically the effects of inhaling pure oxygen produces complex chemical and physical changes throughout the body which are highly technical and, for the most part, are outside the concern of this experiment. It is pertinent, however, to review the effect of inhaling pure oxygen as it may relate to the brain.

Physiology of the Brain Related to Oxygen Inhalation

Oxygen Metabolism of the Brain

It has been found that the oxygen metabolism of the brain as a whole is very stable. There has been no change found in the rate of brain oxygen consumption during muscular exercise (21), moderate anoxia (18), extreme hyperoxia (20), or the breathing of low concentrations of CO_2 (18) (33). It is believed, however, that any changes in neuronal metabolism would be very small and very difficult to detect. It must also be remembered that this assumption is in regard to the brain as a whole. Intellective functions do not use the entire brain, and little is known of the metabolism of its separate parts. It has been established that in certain parts of the brain, *e.g.*, the visual cortex, a functional activity will increase the blood flow in that specific area. But it is not known whether there is an increase in the oxygen metabolism of that area (3). Therefore, it is uncertain as to whether the brain utilizes more oxygen when it is involved in a functional activity than when it is not or whether having an excess of oxygen available would increase the efficiency if it did utilize it.

Cerebral Blood Flow

It is known that the inhalation of pure oxygen at sea level produces a constriction of the blood vessels in the brain (18) (20). This is opposite of the dilating effect of anoxia (23) (27). Until recently, this constricting effect was thought to be a direct result of the high PO_2 (oxygen tension) in the blood. It is now believed to be an indirect action caused by a lowering of the PCO_2 (carbon dioxide tension). This occurs when the PO_2 is raised, a result of inhaling pure oxygen (3).

Review of Literature

In the area of oxygen research most of the experimentations have been conducted on the effects of anoxia. These experiments have touched on muscle and sense organ functioning as well as some aspects of mental functioning. A sample of these studies is produced here to show what previous researchers have found as to the effects of anoxia on the body. These studies are pertinent to this experiment as a familiarization with the effects of hypoxia so that the clinical curiosity as to what effect hypoxia may have on I.Q. can be understood better.

Effects of Anoxia

Mental Function

Gellhorn and Joslyn found that the effect of oxygen want, produced by having Ss breathe air with 7% to 9% oxygen, and hypernea, which causes an excess of CO_2 in the blood, are similar. They both make it necessary to use more time to perform number cancelations and the Kraepelin addition test.

When the Ss were returned to common air, the effects disappeared but the Ss practicing hypernea experienced a short period of better than normal functioning. The authors believe this effect may be a result of circulatory changes (11).

Egorov conducted a study which was concerned with the decrease of oxyhemoglobin in the blood as a function of mental tasks. The study was conducted by asking the Ss to hold their breath while they did the following mental tasks: to think about a calm summer day, to think about the difficulty of holding one's breath, and to do mental arithmetic. Oxyhemoglobin was checked in relation to each task as it was performed.

Egorov found that the nature of the task affected the rate of decrease of oxyhemoglobin in the blood. The rate of increase in hypoxia was increased when the Ss were thinking of the difficulty of holding one's breath and decreased by thinking of a calm summer day (9).

Kraines investigated the effect of hypoxia on intelligence. By use of the Army Alpha test he determined that there is a definite drop in intelligence when the subject is breathing air with only 10% oxygen. The amount which the score decreased corresponded closely with the increase in the number of errors and varied considerably from examinee to examinee. In regard to the variability among Ss, it appeared to the examiner that pyknic persons showed the least drop in intelligence and asthenics the greatest (19).

It is interesting to note that people with different physiques may react differently to anoxia. If this is true, it may add credit to the generally rejected theories of such men as Kretschmer or Sheldon who tried to correlate body type with psychological type. Researchers have found that personality and oxygen apparently have mutually dependent aspects.

Personality

Moravek reports an experiment in which more than 500 Ss were observed in a low pressure chamber in which the reduced oxygen pressure was equivalent to an altitude of 4,000-7,500 m. It was reported that the behavior of the Ss resembled that seen in psychosis, e.g., obstinate clinging, perseveration, loss of ability to evaluate critically one's own condition, and a complete disintegration of the functions investigated (26).

Hertzman and Orlansky report the results of administering a Rorscharch to 40 Ss while at a simulated altitude of

18,500 feet. They found that there is a relationship between personality and an individual's ability to withstand stress caused by lack of oxygen.

Rorschach protocols of Ss showing the least tolerance of anoxia were characterized by shading shock, failing to give a response for a blot, and giving zero or only one human movement response. The authors interpreted this as a confirmation of earlier findings which stated that psychoneurotics tolerate anoxia poorly.

Himwich and Fazekas attempted to determine what relationship, if any, exists between brain metabolism and mental deficiency. Samples of arterial blood entering the brain were analyzed for oxygen and compared with venous blood leaving the brain in Ss classified as undifferentiated mental defectives, mongoloids, cretins, and phenal pyruvic oligophrenics. It was found that the undifferentiated mental defectives were the only ones who showed no difference from normals in the amount of oxygen utilized by the brain. All the other groups utilized considerably lower amounts of oxygen. It was also found that the oxygen difference between cerebral arterio-venous blood increased progressively in the undifferentiated mental group between the ages of 6 and 29, but in the monogoloid group this increase had stopped by age 19 (17).

Doust reports an experiment which was conducted in 1952 on 183 patients with a control group of 112. It was found that constitutional schizophrenics have chronic anoxemia, paranoid schizophrenics have a normal percent of blood oxygen but become anoxemic under stress, neurotics have a lower than normal percent of blood oxygen, and patients with organic neurological involvement have a higher than normal percent of blood oxygen (28).

These findings are in general agreement with a publication which Doust presented the preceding year (1951). In the earlier study the oxygen content of the blood was compared among several groups (e.g. 146 healthy control Ss, 75 Psychoneurotics, 22 patients with character disorders, 26 depressed patients, 87 patients with schizophrenia, and 13 patients with various neurological conditions) to determine if a relationship existed between oxygen metabolism and psychiatric disorders. It was found that while normal Ss showed little variation in their percent of blood oxygen, neurotics showed wide variations and the "constitutional" schizophrenics showed a consistent blood oxygen deficiency. This suggests that emotional stability is related to the maintenance of sufficient constant levels of blood oxygen (6).

However, not all researchers find a difference between neurotics and normals in relation to oxygen. In a study by Waldfogel, Finesinger, and Verzeano in which psychomotor tests were administered to a group of psychoneurotics and a control group breathing 21% oxygen at sea level and again breathing 10% oxygen at 17,600 feet, it was found that the average performance of both groups dropped significantly, and no difference was found between the performance of the two groups (37).

Speech and Hearing

Just as there is a generally decreased physical functioning which a human being experiences from anoxia there is also a generally decreased effective functioning of the specific abilities of speech and hearing. Smith and Seitz conducted a study on the effect of verbal intelligibility of speech in relation to the degree of anoxia. It was ascertained that the intelligibility of speech decreases as anoxia increases (32)

In a study done by Hartman on hearing and anoxemia, a low pressure chamber was used to produce a continually decreasing oxygen pressure during which time the S was being assessed on the upper limits of his hearing. Results obtained from 35 Ss showed that as anoxia increased, the sensitivity of the ears decreased (24).

The Eye

Hecht, Hendley, Frank, and Haif studied brightness discrimination in Ss under conditions simulating oxygen conditions found in the atmosphere from sea level to 17,000 feet. The authors point out that only cone vision was studied. It was found that brightness discrimination is detectably impaired by oxygen concentrations equivalent to as low as 8,000 feet, and at 15,000 feet the contrast must be increased 100% over that recognized at sea level before it can be distinguished (13).

Livingston, studying the effect of rod sensitivity in the eye as affected by anoxia, found that sensitivity decreases very rapidly as anoxia increases. At simulated altitudes as low as 18,000 feet, Ss lack of rod sensitivity became quite pronounced (24).

Fisher and Jongblood report a study in which three Ss were evaluated on their visual adaption to darkness at sea level, at 6,000 meters, and again at 6,000 meters while breathing oxygen. They found that the adaption time of the Ss at 6,000 meters without additional oxygen was considerably longer than that of the other two groups (10).

Effects of Oxygen

In reviewing the psychological literature, one is struck by the lack of studies which have been done on the effects of breathing pure oxygen. It is true that researchers in physiology and medicine have gathered a wealth of knowledge in this area but, for the most part, this knowledge is concerned with physical functions and effects and is only of indirect interest to researchers in psychology.

A review of the psychological literature over the past twenty-eight years yielded only three studies on hyperoxia which are pertinent to this experiment. The review of literature was stopped with publications of January, 1937, because the test used as the instrument to derive I.Q. was put on the market during that year, and any previous study would have had to use an I.Q. test of dubious reputation and/or value. At best, any other test or even the earlier form of the same test would place emphasis on some aspects that were not used and neglect others that were used in the 1937 revision of the Stanford-Binet. In toto, very few studies have been done on the effects of hyperoxia on mental functioning, and nothing has been done on the effect pure oxygen would have on I.Q. as measured by the 1937 Stanford-Binet.

Miller studied the effect of breathing pure oxygen for over four hours at atmospheric pressure upon the central and peripheral visual fields and upon the visual acuity as tested by a tangent screen, perimeter, and a Clason Acuity Meter. The results, checked against a control group breathing air instead of pure oxygen, showed that vision is unaffected by inhaling pure oxygen at atmospheric pressure for over four hours (25).

Von Berkesy performed a study which showed that oxygen intake which reduces blood flow through the head causes temporary changes in directional hearing. Further experimentation showed similar results (36).

Usou did a study in which he found that the degree of weakness of the nervous process appeared to be all important in determining the effect air containing 40-50% oxygen has on the higher nervous activity of the very old. Strengthening of the cortical stimulatory processes, second signal system, and activity of the autonomic centers appeared to occur where senile changes were not greatly pronounced.

In those Ss with pronounced senile changes, the air oxygen mixture seemed to produce a tranquil state even to the point of inducing deep physiological sleep with subsequent increasing of excitability of the cerebral cortex with the autonomic functions moving in the direction of normalacy. In the senile Ss judged to have "weakness of the mind" resulting from old age, the oxygen had no effect on conditioned-reflex activity (35).

In an experiment by Dunn, conducted on 70 male Ss working on the U.S.A.F. S.A.M. Multidimensional Pursuit Test--CM813E for four consecutive hours, he found that variations in nitrogen partial pressure produced no variation in performance. When the partial pressure of oxygen was increased, the Ss ability to resist work decrement was increased (8).

Laroche found the capacity of rats to do work diminishes as oxygen lack increases. Oxygen relieves fatigue faster than would occur in air alone. The working capacity of a muscle is increased by inhaling oxygen when substances such as benzedrine and strychnine do not improve test performance (22).

CHAPTER II

STATEMENT OF THE PROBLEM

Introduction

It has been found that oxygen lack in a human being decreases the ability to function. The extent of decrease in functioning is directly related to the degree of oxygen lack (anoxia). If the anoxia is severe and prolonged for more than two or three minutes, the decreased functioning quickly results in irreversible consequences, *i.e.*, brain damage or death. The extreme susceptibility of the brain to anoxia arouses a clinical curiosity as to what effect an abundance of oxygen might have on its functioning.

Inhaling oxygen has an effect on the performance of some physical tasks which is in direct opposition to that produced by Anoxia and significently better than that produced by common air. It is wondered what effect inhaling oxygen would have on mental tasks, *i.e.*, mental tasks such as those measured by the Stanford-Binet test of intelligence.

It was the purpose of the study herein reported to determine whether or not there were any significant differences in I.Q.'s obtained while breathing pure oxygen and those obtained while breathing common air. In order to investigate this thoroughly, it was also determined what effect oxygen would have on the following aspects of test range: level at which a basal age was established, number of levels covered, and level at which the test was terminated.

Hypothesis

In order to determine the differences, if any, which inhaling oxygen would have on the I.Q. and test range, the following null hypotheses were tested:

Hypothesis One. There are no statistically significant differences in the I.Q.'s obtained by form *L* of the 1937 revision of the Stanford-Binet when the examinee is breathing common air and those obtained by form *M* of the same test when the subject is breathing pure oxygen.

Hypothesis Two. There are no statistically significant differences in the number of levels completed in form *L* of the 1937 revision of the Stanford-Binet when the examinee is breathing common air and those obtained by form *M* of the same test when the subject is breathing pure oxygen.

Hypothesis Three. There are no statistically significant differences between the level at which the test was terminated on form *L* of the 1937 revision of the Stanford-Binet when the examinee is breathing common air than obtained by form *M* of the same test when the subject is breathing pure oxygen.

Hypothesis Four. There are no statistically significant differences in the basal ages obtained by form *L* of the

1937 revision of the Stanford-Binet when the examinee is breathing common air and those obtained by form _M_ of the same test when the subject is breathing pure oxygen.

CHAPTER III

PROCEDURE

Introduction

The purpose of this experiment was to determine whether or not the inhaling of pure oxygen has any effect on intelligence. The tool used to measure the effect, if any, was the 1937 revision of the Stanford-Binet test of intelligence.

The Subjects

The criteria which served as a basis for the selection of subjects for this study were age, sex, intelligence level, and physical and mental health. The rationale for the selection of this criteria is set forth in the following paragraphs.

Age. Each subject used in this study was within twelve months of his thirteenth birthday. The chronological age of thirteen was chosen because it was necessary to have subjects who were old enough to cooperate and accept the apparatus which was used to administer the oxygen, yet not old enough to basal at the extreme upper end of the scale, thereby producing a test range of only two or three levels. A short test range in a test retest situation could hide differences which would become apparent in longer test ranges. If the subject established a basal age somewhere near his chronological age of thirteen this left approximately six levels in which to establish a zero age and produce a test range which was long enough to be analyzed. It was necessary to extend the age limit to twelve months preceding or following the thirteenth birthday in order to obtain a sufficiently large sample of subjects.

Sex. All subjects were of the same sex, thus eliminating the possibility of findings which might be deemed sex determined or influenced. Male instead of female subjects were selected because females enter puberty at approximately thirteen years of age; males usually do not mature to this extent for another year. Furthermore, as a result of the onset of the menarche, puberty is more emotionally loaded for females. For these reasons male subjects were considered to be more desirable than female subjects.

Intelligence. All subjects were average or above average in intelligence. This requirement was made in an effort to control for influences that mental deficiency might have on any data which the study produced. The guidance counselor employed by the school screened the subjects to determine their intellective level. She used the Ss cumulative record folders which contained intelligence scores as well as achievement scores obtained on each subject throughout his school history. All boys suspected of having below average intelligence were eliminated.

Health. All the subjects used in this study were free of any physical handicap and appeared to be in good physical condition. All but three of the subjects were enrolled in physical education. This attested to their good physical health. Questioning of these three boys revealed that they were exempt from physical education for reasons other than physical. Mental health was also a factor considered in the selection of subjects, and some of them were excluded after the first testing resulted in an excessive test range.

The Test Instrument

The instrument used in this study to determine the intellectual level of each subject was the 1937 Stanford revision of the Binet-Simon intelligence scale. This test was chosen because of its high reliability (34, Pp. 33-51) and its general acceptance as a tool for measuring intelligence. Another prime factor which influenced the decision to use this test was that it possessed two almost equivalent scales which could be used in a test retest situation. The reliability between these two scales when computed separately for the twenty-one age groups on which it was standardized was found to range from .85 to .95 with a median of .91 (34, p. 47).

The Procedure

The enrollment records of a Junior High School were used to select all the male pupils who were within twelve months of their thirteenth birthday. This list of names was then given to the school guidance counselor and by carefully evaluating the school records, she determined which ones were of average or above average intelligence. A list was thus compiled which named boys with adequate qualifications for the experiment. These boys were divided into two groups of approximately twenty each that met with the examiner in a vacant classroom. The study was explained to the boys and any questions they had were answered. They were then informed that their participation in the experiment would be on a voluntary basis. Those who volunteered were given a note to be signed by their parents granting permission for each child to participate in the study. Of twenty-six boys who returned signed permission notes, four were eliminated for health reasons.

The twenty-two Ss which remained were tested individually in a comfortable, quiet, well-ventilated, and well-lighted vacant classroom. Each subject was informed of the testing time with a note delivered by an office girl. The note stated that he was to come to the experimental room immediately following the dismissal of the class which was then in session. Each subject was tested during his physical education period or, in the case of the few who did not take physical education, during the period in which they were to meet for an elective subject.

Upon entering the experimental room, each subject was seated at the corner of a desk, to the left and at a right angle to the examiner. While the subject breathed common air, he was administered form L of the 1937 revision of the Stanford-Binet.

Eight of the subjects breathed common air from a metal tank through a plastic mask which covered their nose and mouth. The air was administered at the rate of 6 liters per minute.

After each subject completed the form L test, the examiner established the time for administration of form M. The time interval between the two tests varied from one to several days, the same as the time interval used in the standardization of the two forms L and M.

At the previously appointed time the subject was met by the examiner and transported by automobile to another building where the oxygen equipment was stored. The experimental room which contained the oxygen equipment was a small, comfortable, quiet, well-ventilated, and well-lighted room. Thus, the conditions under which the second test was given closely paralleled the original setting. In this situation, however, the subject breathed pure oxygen from a metal tank. The oxygen was administered through a plastic mask which covered his mouth and nose at the rate of 6 liters per minute. Such an oxygen flow produces an oxygen concentration of 100%. It was under these conditions that the subjects were administered, individually, form M of the 1937 revision of the Stanford-Binet.

The Obtained Data

The data obtained on form M for each subject breathing pure oxygen from a metal bottle at the rate of 6 liters per minute through a plastic mask which covered his nose and mouth included intelligence quotient, level at which a basal age was established, number of months of mental age earned at each level, total number of months of mental age earned, level at which the test was terminated, and the number of levels utilized.

The data obtained on form _L_ for 14 subjects breathing common air was intelligence quotient, level at which a basal age was established, number of months of mental age earned at each level, total number of months of mental age earned, level at which the test was terminated, and the number of levels utilized.

The data obtained on form _L_ for 8 subjects breathing common air from a metal bottle at 6 liters per minute through a plastic mask which covered the nose and mouth was intelligence quotient, level at which a basal age was established, number of months of mental age earned at each level, total number of months of mental age earned, level at which the test was terminated, and the number of levels utilized.

CHAPTER IV

THE RESULTS

Introduction

A group of twenty-two Junior High School boys was tested by the 1937 revision of the Stanford-Binet intelligence scale. The test had two equivalent scales, form *L* and form *M*. Form *L* was administered to each subject as he breathed common air; from one to several days later, form *M* was administered to each subject as he breathed pure oxygen. It should be noted that eight of the subjects being administered form *L* breathed common air through an apparatus identical to one later used to supply the pure oxygen which they breathed during the administration of form *M*. The purpose of the investigation was to determine the effect, if any, which oxygen had on the I.Q. or test range.

Difference in I.Q.

The I.Q. of each subject was computed for both forms of the test (see table one). The *t* test for related N's was used to calculate the probability of the individual difference in the I.Q.'s between form *L* and form *M*. The formula was as follows:

$$t = \frac{\Sigma D}{\sqrt{\frac{N\Sigma D^2 - (\Sigma D)^2}{N-1}}}$$

In this study, the symbols of this formula represent the following: ΣD, the sum of the individual differences; N, the total number of subjects used; and N-1, the degrees of freedom for this particular test. For the present study the confidence level was set at the .005 level. The *t* for all twenty-two subjects was equal to .2066 which, according to Table A-5 of reference five, is not significant at the .005 level of confidence.

The same *t* test when applied to the differences between form *L* and form *M* I.Q. scores of the 14 subjects who were administered form *M* as they breathed common air without the mask showed *t* = .3719. This also was not significant at the .005 level of confidence (5, Table A-5).

This *t* test was then used to analyze the difference in form *L* and form *M* I.Q. scores of the 8 subjects who were administered form *L* as they breathed common air through a mask. The result showed *t* to be equal to .4099 which was not significant at the .005 level (5, Table A-5).

Therefore, it was concluded that the inhalation of pure oxygen does not significantly affect the I.Q. of an individual. Thus, null hypothesis number one was accepted. This hypothesis stated, "There are no statistically significant differences in the I.Q.'s obtained by form *L* of the 1937 revision of the

TABLE 1

IQ Scores

	Chronological Age	I.Q. Form L	I.Q. Form M	Difference Form M
1.	12-1	127	115	-12
2.	12-5	115	111	- 4
3.	12-4	137	137	0
4.	12-0	131	136	+ 5
5.	12-8	97	110	+13
6.	12-10	112	118	+ 6
7.	12-4	118	114	- 4
8.	12-1	149	167	+18
9.	13-9	93	86	- 7
10.	13-5	109	117	+ 8
11.	13-7	129	110	-19
12.	12-8	97	91	- 6
13.	13-5	101	92	- 9
14.	13-7	125	122	- 3
*15.	13-8	121	114	- 7
*16.	13-9	115	121	+ 6
*17.	13-10	128	135	+ 7
*18.	13-0	143	146	+ 3
*19.	13-9	128	124	- 4
*20.	12-10	112	110	- 2
*21.	13-10	118	123	+ 5
*22.	13-10	126	124	- 2

All Form M's given with pure oxygen through a face mask.

All Form L's given with common air.

* Form L's given common air through a face mask.

Stanford-Binet when the examinee is breathing common air and those obtained by form _M_ of the same test when the subject is breathing pure oxygen." (It was noted that the three _t_ scores previously stated were not significant at the .005 level or at the .05 level (5, Table A-5).

Difference in Range

The number of age levels which each individual used on form _L_ was compared with the number of levels which he used on form _M_. It appeared that the subjects used a larger number of levels on form _M_ than on form _L_. In order to determine if this were true, the difference in number of levels from form _L_ to form _M_ was analyzed by using the _t_ test for related N's. It was found that _t_ was equal to 4.7619, thereby producing significance at the .005 level (5, Table A-5).

The same _t_ test was then applied to the amount which form _M_ test ranges increased over form _L_ test ranges in the group of 14 subjects who did not breathe common air through a mask during the time form _L_ was administered. It was determined that _t_ was equal to 5.3719, and this was significant at the .005 level (5, Table A-5).

The _t_ test for related N's was then applied to the amount which form _M_ test ranges increased over form _L_ test ranges in the group of 8 subjects who took form _L_ while they breathed common air through a mask. The _t_ for this group was found to be 2.1186 which was not significant at the .005 level (5, Table A-5).

TABLE 2

LENGTH OF TEST RANGE GIVEN IN NUMBER OF AGE LEVELS USED

	Form L	Form M	Form M Difference
1.	6	8	+2
2.	6	8	+2
3.	5	8	+3
4.	5	8	+3
5.	6	7	+1
6.	3	7	+4
7.	9	8	-1
8.	4	5	+1
9.	8	9	+1
10.	7	8	+1
11.	5	8	+3
12.	7	10	+3
13.	7	9	+2
14.	4	5	+1
15.	5	7	+2
16.	4	5	+1
17.	5	4	-1
18.	5	5	0
19.	4	5	+1
20.	3	7	+4
21.	5	5	0
22.	5	8	+3

The conclusion drawn from this was that the significant increase in test range found for the group of 14 subjects who wore the mask only while breathing oxygen was caused by the mask and not the inhalation of oxygen. If it had been caused by the oxygen, the group wearing the mask for both the common air and oxygen would have showed a significant difference. Therefore, null hypothesis two was accepted. This hypothesis, stated, "There are no statistically significant differences in the number of levels completed in form L of the 1937 revision of the Stanford-Binet when the examinee is breathing common air and those obtained by form M of the same test when the subject is breathing pure oxygen."

Difference in Terminal Levels

A test range can be lengthened in two ways, lowering the basal age or raising the zero age (level at which the test was terminated). The first of these to be investigated was the terminal level.

The difference in months of mental age between terminal levels or, if terminal levels were the same, the difference in months of mental age earned on the final level from form L to form M was analyzed by use of the t test for related N's. It was found that t was equal to 1.5590. This was not significant at the .005 level (5, Table A-5).

The t was then computed for the 14 subjects who did not use a mask on form L. This t was found to be 1.3739 which

TABLE 3

LEVEL TERMINAL AGE WAS ESTABLISHED

	Form L	Form M	Form M difference in months of mental age
1.	SAII	SAII	0
2.	SAI	SAII	+ 8
3.	SAIII	SAIII	0
4.	SAIII	SAIII	0
5.	AA	SAII	+14
6.	SAI	SAIII	+15
7.	SAIII	SAII	- 5
8.	SAIII	SAIII	+18
9.	SAI	SAI	0
10.	SAIII	SAIII	0
11.	SAIII	SAIII	-12
12.	AA	SAII	+ 4
13.	SAII	SAII	0
14.	SAIII	SAIII	0
15.	SAIII	SAIII	- 6
16.	SAII	SAIII	+16
17.	SAIII	SAIII	+ 6
18.	SAIII	SAIII	- 6
19.	SAIII	SAIII	0
20.	SAI	SAII	+ 4
21.	SAIII	SAIII	0
22.	SAIII	SAIII	0

TABLE 3

LEVEL TERMINAL AGE WAS ESTABLISHED

	Form L	Form M	Form M difference in months of mental age
1.	SAII	SAII	0
2.	SAI	SAII	+ 8
3.	SAIII	SAIII	0
4.	SAIII	SAIII	0
5.	AA	SAII	+14
6.	SAI	SAIII	+15
7.	SAIII	SAII	- 5
8.	SAIII	SAIII	+18
9.	SAI	SAI	0
10.	SAIII	SAIII	0
11.	SAIII	SAIII	-12
12.	AA	SAII	+ 4
13.	SAII	SAII	0
14.	SAIII	SAIII	0
15.	SAIII	SAIII	- 6
16.	SAII	SAIII	+16
17.	SAIII	SAIII	+ 6
18.	SAIII	SAIII	- 6
19.	SAIII	SAIII	0
20.	SAI	SAII	+ 4
21.	SAIII	SAIII	0
22.	SAIII	SAIII	0

was not significant at the .005 level (5, Table A-5). The *t* for the group of 8 subjects who used a mask on form *L* was found to be .6948 which was not significant at the .005 level (5, Table A-5). It was noted that not one of these three *t* scores was significant at even the .05 level. Thus, the third hypothesis was accepted. This hypothesis stated, "There are no statistically significant differences between the level at which the test was terminated on form *L* of the 1937 revision of the Stanford-Binet when the examinee is breathing common air than obtained by form *M* of the same test when the subject is breathing pure oxygen."

Base Age Difference

The second way in which a test range may become larger is by lowering the basal age. The investigation of this was accomplished by computing the difference in months of mental age from the base age of form *L* to the base age of form *M* for each subject and applying the *t* test for related N's to the difference. The *t* for all twenty-two subjects was found to be 3.8835, which was significant at the .005 level. This was evidence that the basal age for the entire group showed a significant lowering on form *M*.

Next, the same *t* test was conducted on the difference in months of mental age between base levels on form *L* and form *M* in the group of fourteen subjects taking form *L* who did not use a mask while breathing common air. It was found that, the *t* for this group was 4.3784 which was also significant at

TABLE 4

LEVEL BASAL AGE WAS ESTABLISHED

	Form L	Form M	Form M difference in months of mental age
1.	XII	X	- 4
2.	XI	X	- 6
3.	XIV	XI	- 8
4.	XIV	XI	- 6
5.	X	XI	+ 4
6.	XIV	XII	- 4
7.	X	X	0
8.	AA	AA	0
9.	IX	VIII	- 2
10.	XII	XI	- 4
11.	XIV	XI	- 8
12.	IX	VIII	- 6
13.	XI	IX	- 6
14.	AA	XIV	- 6
15.	XIV	XII	- 6
16.	XIV	XIV	0
17.	XIV	AA	+ 6
18.	XIV	XIV	0
19.	AA	XIV	- 2
20.	XIV	XI	-10
21.	XIV	XIV	0
22.	XIV	X	-12

the .005 level. This also was evidence of a significant drop in base age on form M.

Using the same t test, it was found that in the group of 8 subjects who used a mask to breathe common air on form L there was no significant drop in base age on form M. The t for this group was 1.4252 which was not significant at the .005 level. Neither was it significant at the .05 level (5, Table A-5).

The fourth hypothesis stated, "There are no statistically significant differences in the basal ages obtained by form L of the 1937 revision of the Stanford-Binet when the examinee is breathing common air than obtained by form M of the same test when the subject is breathing pure oxygen." It was accepted in spite of the fact that the group which contained fourteen subjects who did not wear a mask on form L showed a significant drop in base age because the group containing 8 subjects who wore a mask on form L showed no significant difference. It was obvious that the difference experienced by the first group was due to the mask instead of oxygen inhalation.

A t test for unequal N's was then used to analyze the difference between the means of the two groups on each area (I.Q. difference, range difference, base difference, terminal level difference). The formula was as follows: (34, P. 156)

$$t = \frac{XD_1 - XD_2}{\sqrt{\frac{Sd_1}{N_1} + \frac{Sd_2}{N_2}}}$$

The subscrips 1 and 2 in this formula refer to the above mentioned two groups: (1) the group containing 14 subjects who did not breath common air through a mask on form L and, (2) the group of 8 subjects who did breath common air through a mask on form L. Other symbols in this formula are as follows: XD, the mean of the individual differences; Sd, the standard deviation of the group; and N, the number in the group. When this t test was applied to the means of the I.Q.'s of the two groups, it was found that t was equal to 1.396. This was not significant at the .005 level. The same t test was applied to the means of the differences in range of the two groups and was found to be 6.924. This is significant at the .005 level. This t test was conducted on the means of differences in base age of the two groups and found to be 1.2339. This is not significant at the .005 level. The t test for unequal N's when conducted on the means of the differences of terminal levels showed t to be equal to 1.0294. This is not significant at the .005 level. The three t's which were not significant at the .005 level were not significant at the .05 level either. For a graphical presentation of these t scores as well as means and standard deviations, see Table 5.

TABLE 5

MEANS, STANDARD DEVIATIONS, AND
_t_ SCORES FOR MEANS

I.Q.		RANGE	BASE	ZERO
T14-8	= 1.396	6.924	1.2339	1.0294
M14	= -1.0	1.928	-4.0	3.0
SD	= 12.64	1.276	3.419	8.171
M8	= +0.75	1.25	-3.0	1.75
SD	= 5.17	1.669	3.3017	7.126
M22	= -0.3636	1.6363	-3.6363	2.5454

T14-8 is the _t_ score for unequal N's conducted on the means of the two groups.

M14 is the mean of the group containing the 14 subjects who did not use a mask on form _L_.

M8 is the mean of the group containing 8 subjects who used a mask on form _L_.

M22 is the mean of all the subjects considered as one group.

CHAPTER V

DISCUSSION AND SUMMARY

The conclusion that oxygen has no significant effect on I.Q. or test range must be accepted under the conditions which existed during this study. To change one or more of the conditions might change the conclusion. E.g., this study was conducted at a altitude of 1117 feet above sea level. It is a known fact that oxygen produces different physiological functioning at different pressures. The results which this study might produce if conducted under an increased or decreased atmospheric pressure are unknown. Consideration must also be given to the fact that only Junior High School, male subjects who were healthy (as defined earlier) were used. It is known that under certain abnormal conditions (e.g., diabetic acidosis) oxygen consumption of the brain varies (3, p. 251). It is not known, however, to what degree the results of this study might be effected if subjects with varying rates of brain oxygen consumption were used.

Although physical functioning is enhanced in some ways by breathing pure oxygen, the results of this study indicated one would be in error to assume that this enhancement carries over into intellectual functioning (i.e., the I.Q.). Nevertheless, it is of some consolation to know that breathing pure oxygen for a short time (one to two hours) has no suppressing effect on the I.Q. This is valuable information in this space age when men occasionally are required to live and function in a man-made environment. The results of this study are also of value to psychologists in that a previously dark corner of the not-well-understood phenomenon of intelligence is illuminated. Each bit of data discovered which increases the understanding of the nature of intelligence brings mankind closer to controlling the development of this phenomenon.

Summary

This study was conducted on 22 healthy Junior High School males of average or above average intelligence in an effort to determine whether or not inhaling pure oxygen had any affect on the I.Q. The experiment was conducted by dividing the 22 subjects into two groups. One group of 14 subjects was administered form *L* of the 1937 revision of the Stanford-Binet scale of Intelligence while breathing common air. Later, they were administered form *M* (an equivalent form) of the same test while they breathed pure oxygen through a mask. Another group of 8 subjects was administered form *L* of the test while they breathed common air through a mask. Later, they were administered form *M* while they breathed pure oxygen through a mask.

It was found that breathing pure oxygen had no effect on I.Q. or test range. However, wearing a mask had the effect of lengthening the test range by lowering the basal age.

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