THE RELATIONSHIP BETWEEN THE INTELLECTUAL CYCLE OF THE BIORHYTHM THEORY AND HUMAN MENTAL PERFORMANCE

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CHAPTER I

INTRODUCTION

Many times throughout life, every individual is placed in a testing situation of some kind. Humans, being as they are, approach the testing situation in a number of ways. Some may be nonchalant and confident, while others may be anxious and under great stress. Some may be fully knowledgeable in the area to be tested; others may be totally ignorant. Some may be at their peak physically, while others may be physically worn out. Some may feel in high spirits emotionally, while others may be experiencing depression. Still others may be mentally alert and active, while some are mentally idle. All these situations are common occurrences. In fact, many of these may occur with each individual at any given time. This disparity in individuals may account for the reason that different scores are obtained on any given test. This may also explain in part why a different score may be obtained by an individual with each taking of the same test.

Large numbers of today's youth are exposed to a variety of national standardized tests. These tests are frequently administered during the later school years.

The results of such tests may greatly influence an individual's future well-being, status, happiness, and job. It may be unfortunate if the score obtained is not a true indication of the individual's knowledge or performance, but is rather a reflection of the condition of the individual at the time the test was taken.

Since these tests are valuable assessment tools, it is important that the score associated with an individual is an accurate indication of the individual's true capability. It would be very helpful if an instrument could be developed to aid in determining whether the score received was, in fact, representative of an individual's true capability. This study was initiated in an attempt to determine if the Biorhythm Theory could be used as one such predictor.

Significance of Study

This study is significant for the following reasons:

1. Prior scientific investigations of the Biorhythm Theory, in particular the intellectual cycle, are limited. This study added to that body of knowledge.

2. Prior scientific investigations of the Biorhythm Theory often yielded contradictory findings, thus indicating a need for further research.

3. The possible use of the intellectual cycle of the Biorhythm Theory as a measurable variable of a student's shifting biological learning ability could have possible significant value in the field of education. Varied instructional methods could be scheduled to take advantage of a student's various biorhythmic phases.

Statement of the Problem

The problem for this study was to determine the effects of the 33-day intellectual cycle of the Biorhythm Theory on high school students' mental ability test scores as measured by the American College Testing Program (ACT) Assessment.

Purpose

The purpose of this study was to determine what relationship existed between the 33-day intellectual cycle of the Biorhythm Theory and performance on mental testing.

Research Questions

To accomplish this purpose, the following research questions were investigated:

1. What was the relationship between the mean ACT test scores of all students who were on a high, low, or critical day of their intellectual cycle?

2. What was the relationship between the mean ACT test scores of all students who were on a high, low, or critical day of their physical cycle?

3. What was the relationship between the mean ACT test scores of all students who were on a high, low, or critical day of their emotional cycle?

4. What was the relationship between the mean ACT test scores of all students who were on a high, low, or critical day of their intellectual cycle and who were on a high, low, or critical day of their physical cycle?

5. What was the relationship between the mean ACT test scores of all students who were on a high, low, or critical day of their intellectual cycle and who were on a high, low, or critical day of their emotional cycle?

Hypotheses

To test the research questions, the following specific null hypotheses were developed:

1. There is no relationship between the mean ACT test scores of all students who are on a high, low, or critical day of their intellectual cycle.

2. There is no relationship between the mean ACT test scores of all students who are on a high, low, or critical day of their physical cycle.

3. There is no relationship between the mean ACT test scores of all students who are on a high, low, or critical day of their emotional cycle.

4. There is no relationship between the mean ACT test scores of all students who are on a high, low, or critical day of their intellectual cycle and who are on a high, low, or critical day of their physical cycle.

5. There is no relationship between the mean ACT test scores of all students who are on a high, low, or critical day of their intellectual cycle and who are on a high, low, or critical day of their emotional cycle.

Assumptions

The following assumptions were accepted by the investigator:

1. The universe has a systematic order and this order allows predictability on a daily, monthly, or yearly basis.

2. As part of the universe, man is influenced or controlled by rhythms within the body, and these rhythms are synchronized to give order throughout life.

3. The three cycles proposed by the Biorhythm Theory are universal to all human beings, and are set at birth, and thereafter cannot be altered by experience, training, physiological intervention, or environmental inputs.

4. An average birth time of 1200 hours (noon) was used as the basis upon which biorhythmic computations were made.

5. Each individual for which biorhythmic computations were made was assumed to have been born in the United States, thereby not requiring a

birthdate adjustment due to transversing the International Date Line.

6. ACT test scores follow a normal distribution in the general population of the United States.

7. The ACT Assessment has a high degree of reliability.

8. Each ACT test was administered in strict adherence to specific standardized instructions and within designated time limits.

Scope

The scope of this study included:

1. ACT English, mathematics, social studies, natural sciences, and composite test scores for nationally administered tests under the auspices of the American College Testing Program, Iowa City, Iowa.

2. Only ACT test results from the period of October 1980 through June 1981.

3. Only the high, low, and critical days for each of the three biorhythmic cycles.

Limitations

The limitations of this study included the following:

1. Only the ACT test data that were furnished to the Oklahoma State University Registrar's Office by the American College Testing Program were used in this study.

2. Only the high, low, and critical days of the intellectual cycle were considered when observing the interaction effects of like days on the emotional and physical cycles.

Definition of Terms

The following definitions are provided to aid in the understanding of particular terms used in this paper:

Biorhythm Theory - A theory developed in the 1890's which states there are three cycles of varying length, beginning at birth and present in every human being, that influence the physical, emotional, and intellectual abilities of man.

Circadian Rhythm - Rhythms found in humans that vary in length from twenty to twenty-eight hours depending on the individual and environmental circumstances. Included in these rhythms are life function or regulatory cycles, biochemical cycles, and work-eat-sleep cycles.

Critical Day - A 24-hour period in which human performance becomes unstable. It occurs during the first day and at the midpoint of the cycle.

Crossing Points - The points at which a cycle changes from positive to negative, or vice versa. When associated with the Biorhythm Theory, a crossing point is synonymous with a critical day.

Cycle - That period of time in which one round of a regularly and continuously recurring succession of events is complete.

Double Critical Day - A day on which two of the biorhythm cycles reach a crossing point.

Emotional Cycle - The 28-day biological rhythm whose fluctuations affect man's nerves and feelings.

High - The phase at which human performance is at its best. In this study, the highs are defined as days 8, 7, and 5 on the intellectual, emotional, and physical cycles respectively.

Intellectual Cycle - The 33-day biological rhythm whose fluctuations affect man's memory and logic capabilities.

Low - The phase at which human performance is least adequate. In this study, the lows are defined as days 24, 21, and 17 on the intellectual, emotional, and physical cycles respectively.

Mental Age - The average age at which most people can solve a particular problem as used in computing IQ scores.

Negative Phase - The phase at which human performance is least adequate.

Period - The length of the cycle measured from repetition to repetition by noting successive crests or troughs or crossing points.

Phase - The particular state or stage in a recurring cycle of changes.

Physical Cycle - The 23-day biological rhythm whose fluctuations affect man's physical strength and energy.

Positive Phase - The phase at which human performance is at its best.

Triple Critical Day - A day on which all three biorhythmic cycles reach a crossing point.

Organization of Study

Chapter I introduces the study, explains its significance, and presents the problem of the study along with the purpose, research questions and hypotheses investigated. It also presents assumptions, scope, limitations, and definition of terms. Chapter II includes a review of related literature concerning the background of the Biorhythm Theory, an explanation of the Biorhythm Theory, Biorhythm Theory research studies, theory applications, and a discussion of tests of mental ability. Chapter III reports the method of data selection and collection, procedures, and a description of the statistical analyses applied. Chapter IV discusses the findings of each research question. Chapter V includes a summary of the study, conclusions, and recommendations for possible future studies involving the Biorhythm Theory.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

Since man's existence, he has been fascinated by the rhythms of Nature. It is known from drawings on cave walls that Neanderthal man observed the cycles of the moon. Stonehenge in England was an attempt by ancient priests to calculate the rhythms of the changing seasons and movements of the stars. Hippocrates, of ancient Greece, advised his associates that regularity was healthy and that irregular habits led to illness. During the Middle Ages, health, strength, and sexual power were thought to be dependent upon stages of the moon.

A renewed interest in rhythms developed from studies in medicine, psychiatry, athletics, flight, and safety. The scientists of today are investigating many different kinds of rhythms--including those in man. These include the internal monthly rhythms of changes in hormone levels and body temperature, blood pressure, blood sugar, and hemoglobin levels. Other studies are centered around mood changes and depression, jet lag, worker efficiency cycles, accident proneness, and breathing rhythms.

This chapter will discuss some of the literature about another area in which much research has been done since the late 1800's--BIORHYTHMS. The literature is presented in five categories of information related to the central theme of this study. These categories are:

1. Background of Biorhythm Theory,
2. Biorhythm Theory Explained,
3. Biorhythm Theory Research Studies,
4. Biorhythm Theory Applications,
5. Discussion of Tests of Mental Ability.

Background of Biorhythm Theory

In the nineteenth century, studies first began on certain life rhythms or cycles that were later termed "biorhythms." The word "biorhythm" comes from the two Greek words, "bios" meaning "life" and "rhythmos" meaning "a constant or periodic beat." The theory of biorhythms defines and measures three basic and important life cycles in man: physical, emotional, and intellectual. A more in depth explanation will be found in the next section of this chapter.

In his book, Biorhythm: A Personal Science, Gittelson (1977) pointed out that it is interesting to note that around the same time in the late 1890's, two men, through painstaking but independent research, arrived at virtually identical conclusions--that fevers and certain illnesses seemed to recur rhythmically. They discovered that cycles of 23 and 28 days had the power to predict their recurrence. Biorhythm theory, then, had two "fathers": Swoboda, professor of psychology at the University of Vienna, and Fliess, an eminent nose and throat specialist in Berlin.

Swoboda was apparently drawn toward biorhythms by several highly suggestive reports which appeared around 1897, the year in which he began his research. Most of these reports were concerned with unexplained rhythmic changes in mental states. Consequently, Swoboda initially concentrated in his field of psychology. From analyzing the experiences of his patients, he noticed that dreams, ideas, and creative impulses seemed to recur with a predictable rhythm. He then began to keep detailed records of his patients' complaints of pain and swelling resulting from inexplicable inflammations. He later extended his curiosity by plotting the frequency with which people suffered heart attacks and bouts of asthma. Eventually, he arrived at the idea of the 23 and 28-day rhythms.

Swoboda's discovery of these two basic biorhythms quickly led him to write a series of distinguished and widely popular books explaining and developing the idea of cycles in human life. His major work was his book, Das Siebenjahr (The Year of Seven), which contained his recording and analysis of rhythm development of families. He recorded family genealogies to verify that the relationship of the family and the major events in their lives, such as birth and death, are rhythmical.

Thommen (1973) used Swoboda's own words to sum up his research when he stated:

> We will no longer ask why man acts one way or another, because we have learned to recognize that his action is influenced by periodic changes and that man's reaction to an impression can be foreseen, or predicted, to use a stronger term (p. 14).

Gittelson (1977) related that Fliess did his pioneer work on biorhythms also in the 1890's. He was particularly concerned with children's ailments. In an attempt to discover why children exposed to the same diseases remained immune for varying periods of time and succumbed on widely different days, he began to collect statistics on the periodic occurrence of fevers, childhood disease, and the susceptibility to disease and death. He determined that these events occurred at 23 and 28-day intervals. Fliess wrote extensively about the biorhythm theory, but the mathematics and statistics used to support it were so confusing that few people bothered to understand them. He initially developed a mathematical formula to compute biorhythms. Through the years, the formula had been continually refined. Today, anyone can compute biorhythms.

While Swoboda and Fliess are recognized as the two fathers of biorhythm theory, a third researcher played a key role in the development of the theory as known today. Teltscher, a doctor of engineering and a professor at Innsbruck, Austria is credited with the third biorhythm cycle; the one associated with the intellect.

According to Gittelson (1977), Teltscher noticed that even his best students seemed to have both good and bad days. In 1920, he began to collect information about how well Innsbruck high school and college students did on examinations, the dates of the exams, and the birthdates of the students. By analyzing this data for many students, he discovered a regular rhythmic cycle that repeated every 33 days.

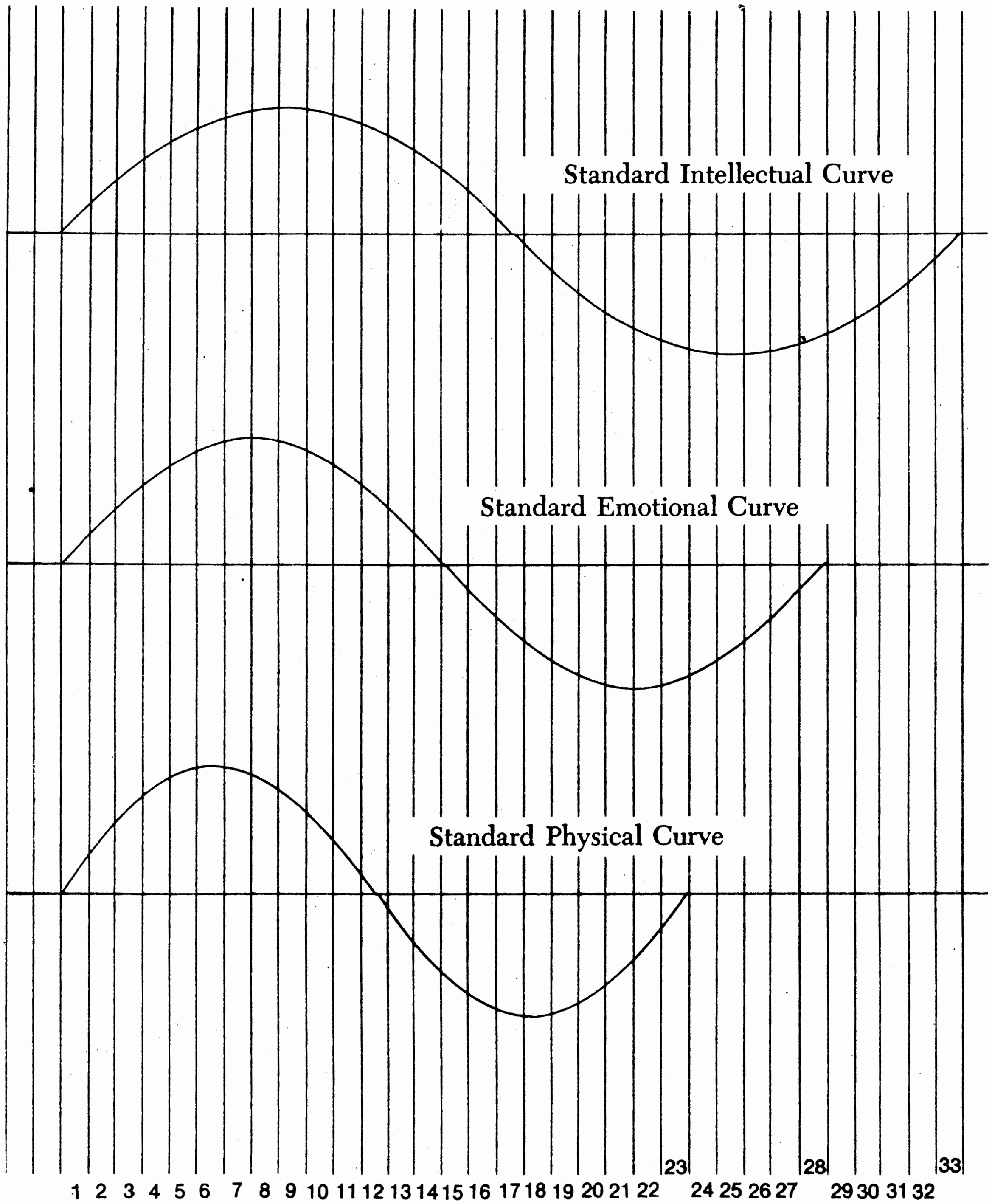
From this brief history, it can be seen that the three pioneers of biorhythm theory had only begun to develop their ideas about the roots of the phenomena that so impressed them. Gittelson (1977, p. 18) had a few words to say about this also; "Even today, the precise workings of the human mind, body, and perceptions which determine the three great rhythms of life are obscure, although some progress has been made." Smith (1976, p. 4) summed up the early works of biorhythm when he stated: "Numerous studies made since the pioneering days of biorhythms seem to indicate that these cycles exert a strong influence on all our lives and actions." Now a detailed review of the theory is in order. For a discussion of the nature of cycles see Appendix A.

Biorhythm Theory Explained

The Biorhythm Theory professes that the three biorhythms begin at the moment of birth and continue regularly thereafter until death. The theory explains that the rhythms begin at birth since this is the first time the infant experiences instant trauma. It is for the first time that his senses are exposed to an unprotected environment. Also, for the first time, his basic life systems--the brain, the lungs, and the circulatory system--function without support from the mother (Gittelson, 1977). Part of this functioning is the beginning of the child's biorhythms. According to the theory, then, biorhythms are basic to our first breath.

Fliess believed that the 23-day rhythm originated in the muscular cells or fibers (Gittelson, 1977). Its fluctuations affect man's physical strength, endurance, energy, resistance, and physical confidence. The first 11.5 days of the cycle, known as a high period (see Figure 1), are the days when a person feels vigorous and when his vitality and endurance are at their best. During this time, physical work seems easier for the individual. During the second 11.5 days of the cycle, known as a low period (see Figure 1), the body is recharging and energy is being accumulated. This is a time when the body tires more readily and requires more rest. This is the most likely time for a physical slump since the body is weak and more vulnerable to disease.

It is important to note that the second half of the cycle is not the "bad" half and the first half the "good." Neither portion is necessarily better or worse than the other. A low period is no worse than a low indication of the amount of gasoline in an automobile. It only serves as a



A "high" is the left half of the graph above the horizontal axis, while a "low" is the area below the horizontal axis. The "critical" days are where the sine-wave crosses the horizontal axis of the graph.

Source: Smith (1976, p. 30).

Figure 1. The Standard Biorhythm Curve

warning that it would be wise not to plan to drive very far until more fuel is added. When referring to the low period of the physical cycle, it is an indication that the body requires rest. "A low period that is observed and used wisely can nourish the body" (Ward, 1971, p. 161). A high period may not necessarily be a blessing either. Although more can generally be accomplished in the first half of the cycle, the body can be exhausted by over-exertion. However, a lot depends on individual physical condition.

The two important points in this rhythm are the first day, when a new cycle begins, and the halfway mark (11.5 days), when the body's energy switches from the discharge to recharge stage or vice versa. These days are known as the "critical" days (see Figure 1). It is during the critical days that the body becomes relatively unstable and less resistant to stress. It is important to point out that the days themselves are not critical. It is merely a period when the person's condition may bear watching.

The 28-day rhythm, known as the emotional cycle, governs the nervous system. It is convenient to think of the emotional cycle as having a positive phase (high) of 14 days and a negative phase (low) of the same length. It too has a critical day starting the cycle and one at the midway point. During the first 14 days, a person is more inclined to be cheerful and optimistic. This period favorably influences creative endeavors, feelings, love, cooperation, and all coordination that is connected with the nervous system.

The last 14 days of the cycle represent the recuperative period during which a person is likely to become irritable and negative. The emotional rhythm during this phase can have very dangerous results. Since feelings affect judgement, the days when we are recharging our emotional powers can be poor ones on which to perform dangerous tasks that call for swift reactions and sound judgement.

The critical days of this cycle leave us open to self-inflicted harm, violent arguments, and general unpleasantness. An emotionally critical day, particularly when it is combined with a critical day in either the physical or intellectual cycle, definitely calls for all available precautions (Gittelson, 1977).

An interesting condition exists with the 28-day emotional cycle. Since 28 days make up four seven-day weeks, the critical days of the cycle occur every two weeks after the day of birth. This "same-day" syndrome makes it convenient for testing the Biorhythm Theory for oneself. Additionally, the emotional cycle is the easiest of the three for an individual to keep track of himself since he is usually a better judge of his feelings than of his body and mind.

Thommen (1973) and Gittelson (1977) agreed that since the emotional cycle is a powerful and continuing one, it can modify the physical and the intellectual cycles more than one might expect. For example, in a period of a physical low combined with an emotional high, an athlete's performance may be up to par, simply because of a highly positive attitude. The strength of the emotional rhythm's influence is also apparent in intellectual and creative endeavors.

> It is reasonable to think that during the negative part of the intellectual cycle, it will be difficult to achieve any major insights or to produce ideas. However, if that same period is one of an emotional high, the ideas and insights may flow in a virtual tidal wave. This is a matter of attitude and of releasing the emotional sources of creativity (Gittelson, 1977, p. 21).

The 33-day intellectual rhythm apparently originates in the brain cells. Teltscher's associates and other doctors ascribed the phenomenon to a secretion of the thyroid gland. Little else is known about the intellectual cycle today since this one has been the least studied. It has been determined that during the first phase of 16.5 days, a person's mind is more open, memory is more retentive, and the ability to put together separate ideas to achieve an understanding is at its best. This positive phase is a good time for encountering new or unfamiliar situations that call for quick comprehension and understanding. Efforts at self-improvement through reading and studying will be more fruitful during this time.

The second half of the cycle does not make the person become stupid or dull. Rather, the individual is simply less inclined to deal openly with new subjects or situations. During this time, it is somewhat more difficult to absorb new ideas, do creative thinking, or to perform mental exercises requiring great concentration, memory, or quick mental response. This phase is probably best suited for the review of previously learned concepts, the practice of items to be learned by rote, or the editing of papers previously written.

The critical days of this cycle (1 and 17) may be days where important decisions may best be delayed. If a major matter or some other problem must be faced on one of these days, the person should allow a little extra time and take more care in thinking it over.

No part of life needs to come to a halt just because it is a critical day or the low part of a cycle. If we know in advance what our biorhythms will be, we can devote more effort to properly preparing for an upcoming task and possibly prevent despair, financial loss, and even the agony of a tragedy. In other words, how we behave and what actually happens to us depends on the setting or on particular environmental factors and events. The critical days, then, may be considered the "switch-point" days. A person should be more careful during these critical days because his system seems to be in a state of flux and to have a considerable degree of instability. To point out once again,

> critical days in themselves are not dangerous. Rather, they are days during which the individual's reaction to his environment may bring about a critical situation. Biorhythm does not, and should not be expected to, predict future behavior or accidents, for the way a person acts depends on what is happening to him, as well as the condition he happens to be in physically, emotionally, and intellectually at a particular time (Thommen, 1973, p. 57).

It is a general agreement among proponents of Biorhythm Theory that the relative strength of the physical, emotional, and intellectual rhythms varies among individuals. It seems that heredity and talent may do much to explain these differences. For instance, an athlete places much more emphasis on the physical cycle than most people do. We could then assume that the athlete's physical rhythm is more powerful than the others and that the physical cycle will have more important effects on his life and work. In other words, what an individual is, through inherited characteristics, will strengthen one or another of one's biorhythms. What one does because of one's talents will give that rhythm more opportunities to affect one's life.

Smith (1976), in his book The Complete Book of Biorhythm Life Cycles, expanded on the concept of individual cycles. He cautioned that, although everyone born on the same day in the same year will have identical cycles. They will obviously not have identical lives.

> Not only will their circumstances be different, but their inborn and learned reactions to events will also differ sharply. All three cycles will change with age: a young person's are likely to peak more sharply, an older person's to flatten out. Health, temperament, character, and probably heredity will influence the steepness of the curve and the way one responds to fluctuations in his potential (p. 16).

It is interesting to note that Biorhythm Theory experts do not generally recognize the possibility of biorhythmic fluctuations. They profess that biorhythms do not fluctuate, but are fixed throughout the life of each individual. Smith (1976), however, devoted an entire chapter to explain how be believed that biorhythm cycles may be adjusted. He explained several possible reasons for wanting to adjust or shift the cycles. He suggested it may be desirable to shift the cycles one day in either direction to compensate for those whose frequent travels may have them cross the International Date Line. Other possible reasons might be to compensate for the hour of birth when that time is close to the midnight hour; or to compensate for radical changes in environment or climate. Smith even suggested that an individual's cycles may be reset as a result of a serious physical, emotional, or mental illness and an appropriate adjustment in one or more cycles may be necessary.

Invariably, the question of proof arises next with respect to the Biorhythm Theory. Smith (1976) addressed this too:

> Frankly, it is difficult to prove. One reason is that science has had little success with proof in areas where human values are involved. On the one hand, valid mathematics are used to arrive at its results; on the other hand, one must interpret those results in psychological terms. Consequently, it is possible to agree with the validity of the mathematics, but disagree with the interpretations (p. 5).

Biorhythm Theory Research Studies

Throughout the years, numerous studies have attempted to prove the Biorhythm Theory. Gittelson (1977) divided these studies into two large categories. The first category was retrospective studies. The second was called experimental studies. The retrospective studies concentrate on analyzing past events to see how well they correspond to the theory. These types of studies, however, include few of the experimental controls or laboratory safeguards that scientists like to set up before doing a rigorous study of any theory. Nevertheless, the results of retrospective analysis have been very impressive.

The experimental studies method involves applying the Biorhythm Theory first, and then checking the results as events take place. The big advantage of experimental studies, as opposed to retrospective ones, is that they allow before and after comparisons. This is usually a good way of making sure that the results have been influenced by biorhythm and not other factors. Another advantage is that experimental studies leave much less latitude for manipulating the results. Since there is a significant element of interpretation in reading biorhythm charts, it can be all too easy for even the most honest researcher to bend his interpretation to fit the case. The researcher's knowledge of what has happened in the past may, even completely unconsciously, bias his interpretation.

The amount of retrospective research far outweighs the number of experimental studies. Gittelson (1977) attributed this to the fact that retrospective research is much easier and cheaper to conduct. There is, however, a trade-off between quantity and quality of work regarding retrospective studies. Consequently, the results of these types of studies must be viewed with more suspicion than the results of experimental studies. A few of the retrospective studies will be discussed next.

One of the better known researchers in the retrospective type studies was Schwing, a candidate for a doctorate degree in natural science from the Swiss Federal Institute of Technology in Zurich. Schwing actually performed two studies combined into one. For his first study, he assembled data provided by insurance companies and the Swiss government. The data consisted of the date of birth of 700 people involved in serious accidents, along with the date of the accidents. He related this data to critical days for the victims. His second study involved similar data on about 300 people who had died in Zurich. Again, he related this information to the occurrence of critical days in their physical and emotional rhythms. According to Thommen, (1973, p. 191) the pioneer of biorhythm in the United States, "Schwing's research report, in the form of a 78-page treatise, is probably one of the most precisely recorded analyses of the subject."

Briefly, Schwing's method consisted of determining how often single and double critical days occur within one biorhythmic life-span. A double critical day is one in which two of the three biorhythms for a given individual reach a critical day at the same time. Schwing identified a biorhythmic life-span as a period of 58 years and 66 or 67 days from birth, depending on the number of leap years. This is the precise time when the three biorhythms begin a new cycle. Schwing calculated that on slightly more than 20 percent of the days within the average biorhythmic life-span, at least one, and often two, of the biorhythms have critical days. The remaining 80 percent are characterized by mixed rhythms. Schwing also found that critical days for only the physical and emotional rhythms accounted for slightly more than 15 percent of the days in a biorhythmic life-span, while the remaining 85 percent were mixed-rhythm days. He concluded that if accidents and deaths occur randomly, and are not related to biorhythms, then only 15 to 20 percent of all such events will fall on critical days. It followed that if this was true, then the vast majority of random accidents and deaths (80 or 85 percent) would occur on mixed days.

Schwing excluded serious accidents such as two-car collisions in which it would be difficult to determine which driver was at fault. He also excluded those cases involving mechanical failures. Instead, he concentrated on cases such as single-car accidents, in which the judgement, reflexes, and mood of the driver most likely played a decisive role. He next determined how many of these events occurred on critical days. "He found that of the 700 accidents, a total of 401 had occurred on singly, doubly, or (a once-a-year rarity) triply critical days; the balance of 299 accidents had occurred on mixed rhythm days" (Gittelson, 1977, p. 31). In other words, 57 percent of the people who had experienced serious accidents were undergoing a critical day, and only 43 percent were experiencing mixed rhythms.

> Chance would predict figures of 20 percent and 80 percent, respectively. Put another way, Schwing's results show that serious accidents are five times more likely to occur when you have a critical day than when you have a day of mixed rhythms (Gittelson, 1977, p. 31).

Schwing's calculations for deaths in Zurich were even more impressive. When he evaluated the 300 deaths, he found that 197 or 65.7 percent occurred on a day that was either physically or emotionally critical or both. The remaining 34.3 percent occurred on days of mixed rhythms. The result, then, was that death seemed to occur almost 11 times more frequently on a critical day than on a mixed-rhythm day.

Schwing's astounding results led other European researchers to examine biorhythms closely. Some of them even reported more impressive evidence supporting the Biorhythm Theory. One of these was Bochow of Humboldt University in Berlin. Bochow's most interesting study was a biorhythmic analysis of 497 accidents involving agricultural machinery. His methods were essentially the same as Schwing's. He found that 24.8 percent of the accidents occurred on triply critical days. These days only make up 0.3 percent of all days. 46.5 percent of the accidents were found to occur on doubly critical days. Pure chance would indicate a figure of only about 3.3

percent. Twenty-six point six percent occurred on singly critical days which account for only 14.2 percent of all days. A total of only 2.2 percent of the agricultural accidents happened when the victims were experiencing days of mixed rhythms. This data worked out to show that the agricultural accidents studied by Bochow were an astounding 171 times more likely to happen on critical days than on non-critical days (Gittelson, 1977).

Other European biorhythmic research involved studies of civil aviation airplane crashes and accidents of sanitation workers; all showing similar results. The findings of these studies showed that from 70 to 83 percent of the accidents studied occurred on critical days.

Biorhythmic research in the United States frequently centered around the medical profession. According to Gittelson (1977), Sansouci, a consultant to a state mental hospital in Rhode Island, found that his patients often displayed behavior that synchronized exactly with what their biorhythm charts predicted. Also, Willis, of the Department of Psychology at Missouri Southern State College, conducted two studies involving death by heart attack around the Joplin, Missouri area. His results were remarkably consistent. He determined that 63 percent of the people who died from heart attacks did so on a critical day.

Numerous other studies have been conducted throughout the United States, Europe, and Japan. These studies involved the deaths of well known personalities, suicides, traffic accidents, airplane crashes, and industrial accidents. Also, much interest has been centered on athletic performance and competition. The various studies resulted in findings ranging from no significant relationship between observed phenomenon and biorhythms to a strong suggestion of an influencing relationship. A summary of recent studies and their findings may be seen in Table I.

TABLE I

SUMMARY OF RECENT STUDIES RELATED TO BIORHYTHM THEORY

Source	Type of Data	Number of cases	Findings
Berube (1977)	Measured Performance in College Students	51	No significant relationship
Harley (1978)	Nursing Activity	74	No significant relationship
Kauth (1976)	Acute Myocardial Infarction	3079	No significant relationship (.05)
McPhail (1976)	Performance on Selected Skills Test	100	No significant relationship (.05)
Burstein (1975)	Perceived Emotional States	21	Support 23 and 28 day cycles
Johnson (1974)	Football Injuries	164	No significant relationship (.05)
Yates (1974)	Students in Fraternities and Sororities	80	No significant relationship (.05)
Mance (1976)	Motor Performance	39	Supports 23 day Cycle for "fine" motor skills but not for "gross" motor skills (.05)
Chase (1976)	Performance of Professional Women Golphers	26	No significant relationship
Latman (1977)	Motor Vehicle Accidents	260	Supports the theory
Neil (1976)	Information Processing Task	3	Supports existence of biological rhythms, not necessarily biorhythm theory (.05)
Kahlil (1977)	Accident Occurrence and Performance	397	No significant relationship (.05)

TABLE I (Continued)

Source	Type of Data	Number of cases	Findings
Hendrick (1977)	Aircraft Accidents and Incidents	100	Supports 23 day cycle (.025)
Carvey (1977)	Industrial Accidents	360	No significant relationship (.05)
Wolcott (1975)	Aircraft Accidents	4279	No significant relationship (.10)
Sacher (1974)	Aircraft Accidents	4346	Some support when age of pilot considered
Nett (1975)	Industrial Accidents	400	No significant relationship (.05)

Source: Howe (1978, p. 11).

Considering the variety of areas studied with use of the Biorhythm Theory, one would think that several studies would be found in the area of the classroom. Surprisingly few have been documented. One of the better known studies was one conducted by Neil (1974) of the Naval Postgraduate School in Monterey, California. Neil's study is one of the few that may be classified as experimental in nature. According to Gittelson (1977), Neil was most concerned with testing the general validity of the Biorhythm Theory rather than the predictive powers of any particular configuration of biorhythms. Neil felt that, due to the subjective interpretation of previous biorhythm research, the results had not provided sufficient information upon which to evaluate the theory or the concept it represented.

Neil (1974) and his associates collected data from four graduate students in the Operations Research Curriculum at the Naval Postgraduate School. The students' performance data were collected from 15 different courses over a 14-month period. All the courses selected were highly quantitative in nature, thereby eliminating subjective grading influences. "Neil developed a six-point rating scale, ranging from 'well above average' all the way down to 'critical'" (Gittelson, 1977, p. 51). Average referred both to the class average and to the individual's average. Additionally, Neil had his subjects rate the challenge of each examination to take into account the differences of intellectual ability.

To evaluate the data, Neil (1974) took the following approach. He first charted the distribution of real-life performance, then matched that chart with the subjects' biorhythms. Next, he measured how closely the actual performance corresponded with the distribution predicted by the Biorhythm Theory.

Armed with a battery of statistical tests, Neil analyzed the relationship of the observed academic performance to the performance as predicted by biorhythms. The "above average" category indicated that biorhythms were an influencing factor on academic performance. The "below average" performance, however, did not correlate as highly, leading Neil to conclude that "poor" performance may represent a more complex form of behavior than either "average" or "above average" performance (Giannotti, 1974). The results also displayed evidence that biorhythms would have an affect on intellectual performance if the situation presented a great enough challenge to the individual.

There has been much criticism of the results of the numerous biorhythm studies conducted. Persinger (1978) insisted that there have been no experiments clearly demonstrating the presence of unalterable and long-term 23, 28, or 33-day cycles in human organisms. He explained that the human cycles already known, such as the circadian and menstrual rhythms, are subject to cycle-length variations and marked environmental influence. He pointed out what he felt is a glaring discrepancy in the Biorhythm Theory. There is a lack of mortality or accident proneness in the population in general when a person is 58 years and 66 or 67 days of age. This is the age for all people at which all three cycles presumably get back in sequence (a triple critical day) and begin a new cycle.

Other opponents of the Biorhythm Theory agree that learning, intellectual competence, and emotional stability do have their peaks and valleys, but contend that these cycles seem mostly unrelated to the 23, 28, and 33-day cycles of the Biorhythm Theory. They profess that there are no laboratory studies suggesting there is a "critical" period at the midpoint between the "ups" and "downs" during which performance of any kind is exceptionally dysfunctional. Indeed, just the opposite seems true.

> Almost every psychological and physiological experiment in the literature suggests that human performance should be at an optimum near the midpoint between zenith and nadir. ... To most medical and behavioral scientists, Biorhythm Theory would be much more tenable if it were restated to make 'critical days' occur on peak-negative and peak-positive days when the direction of the performance curve changes rather than when the curve crosses the 'zero' line and hence changes sign (but not direction) (McConnell, 1978, p. 20).

Another major criticism of past biorhythm research was the idea that many investigators "fudge" somewhat in deciding what days are really critical. Gittelson (1977) remarked that many people born close to the end of a day show rhythms more typical of the next day than of the actual day on which they were born, while people born just after midnight may show rhythms more typical of the previous day than of the day they were in fact born. Many investigators therefore routinely calculate two or even three sets of critical days for each person they investigate. The additional calculations are based on the days just before and after the person's "official" birthday. However, by doing so, the statistical expectancies are inflated by a factor of three or more.

Biorhythm Theory Applications

As previously mentioned, there have been few controlled laboratory studies in the past. In spite of this, corporations in the United States and elsewhere appear to have turned to the theory in ever-increasing numbers. Both Gittelson (1977) and Thommen (1973) avowed that in Switzerland, municipal and national authorities appear to have been applying biorhythms for many years. One of the best known of these groups is Swissair which reportedly has been studying the critical days of its pilots for over a decade. Another group, the Zurich Municipal Transit Company, has also been using biorhythms to warn its drivers and conductors of critical days (Karlins, 1975).

While the Swiss have been actively involved in the application of the Biorhythm Theory, the Japanese have surely been the first nation to apply biorhythms on a large scale. To date, more than 5,000 Japanese companies now use biorhythms to control their accident rates. Many of these companies are among the leaders in their fields. Some of the most prominent include Fuji Heavy Industries, Mitsubishi Heavy Industries, Hitachi, and Bridgestone Tire. Additionally, several of Japan's largest fire, auto, and life insurance companies have discovered that they can reduce the accident rates of their customers by issuing biorhythm charts to covered clients (Gittelson, 1977). The heaviest users, however, have probably been the Japanese transportation companies.

"Much of the success the Japanese have had with biorhythm--and much of the reason for the theory's broad adoption in Japan--can be tied to the ingenious ways in which the Japanese have applied the theory" (Gittelson, 1977, p. 55). Biorhythm charts are frequently used as a promotional tool for selling anything from automobiles to insurance. Most inventive, however, are the ways in which the Japanese transportation companies have encouraged their drivers to take extra precautions on biorhythmically critical days. Some companies hang a color-coded folded paper design from the dashboard of the vehicle as a reminder of a critical day in one of the three biorhythms. The Japanese mail and telegraph services fly small color-coded triangular flags from the front fenders for motorcycle deliverymen operating on critical days. These flags act as a reminder to the driver and a warning to other drivers and pedestrians that extra caution should be taken. A few taxi companies hang a color-coded, but empty, candy box from the rear-view mirrors for drivers on their critical days. If the driver finishes his shift without an accident, he can trade in the empty candy box for a full one as a gift for his family (Gittelson, 1977).

The Japanese traffic police and other safety organizations also actively employ biorhythms in their daily activities. As a result, biorhythms have become a prominent feature of the motoring scene in Japan.

Because of the Japanese and Swiss experience, it seems somewhat peculiar that the American government and industry have not been quicker to experiment with and adopt biorhythms. The United States certainly has not been touched by the biorhythm "craze" experienced in Japan. Gittelson (1977) explained that the American government and industry have been reluctant to reveal whether they have been experimenting with the Biorhythm Theory. This does not mean that they are not in fact trying out the theory. Some of those known to have performed studies include the National Safety Council, National Aeronautics and Space Administration (NASA), the United States Air Force Tactical Air Command, the National Institutes of Mental Health, Bell Telephone Laboratories, and Proctor & Gamble. United Airlines and Allegheny Airlines actively employ biorhythms with their ground maintenance teams.

Another area in which the Biorhythm Theory may prove useful is in the education arena. Knowledge of biorhythmic data may aid instructors in determining the most opportune time to introduce new concepts or to review existing knowledge. It may also assist them in the scheduling of examinations.

Discussion of Tests of Mental Ability

According to Eysenck (1974), the origins of the concept of intelligence are lost in antiquity. He stated it is known that

> Plato and Aristotle drew a distinction between the cognitive aspects of human nature (those concerned with thinking, problem solving, meditating, reasoning, reflecting and so on) and the hormonic aspects of human behavior (those concerned with emotions, feelings, passions, and the will). Cicero later coined the term intelligence (p. 11).

The term intelligence is still used to refer to a person's cognitive powers and intellectual abilities. There is generally thought to be two types of intelligence: fluid and crystalized. Fluid intelligence is thought to be the ability to solve problems that can be applied to any situation. Crystalized intelligence, on the other hand, draws upon knowledge and information previously acquired. Crystalized intelligence, then, is thought to be more likely acquired by intelligent persons than by dull ones.

Tests of mental ability usually measure both fluid and crystalized ability. One might expect these two tests to have a low correlation because problem-solving ability and acquired knowledge seem to be entirely different entities. On the contrary, the tests correlate quite highly, as do all tests of fluid and crystalized ability. According to Eysenck (1974),

> The reason is very simple. If you have a high degree of fluid ability, then, other things being equal, you are likely to acquire a greater degree of knowledge than someone with less fluid ability. You will tend to acquire a better vocabulary. This is partly because you are more likely to be interested in a wide range of information, will read more newspapers, journals and books, and will listen to more lectures and programmes of cultural or scientific interest (p. 29).

Eysenck continued by stating,

> It is also, and equally important, because your intelligence will help you to understand and remember, in an ordered sequence, the items of information, including vocabulary, you come across. You will, in other words, develop more crystalized intelligence (p. 29).

Eysenck (1974) explained that Spearman, a Professor of Psychology at University College, London, theorized the possible existence of some all-around, all-embracing cognitive ability which enabled a person to reason well, solve problems, and generally do well in the cognitive field. If this was in fact true, Spearman believed that it should be possible to construct many different problems, of varying difficulty, to put this ability to the test. In other words, Spearman thought it possible to demonstrate that some people are better at all types of cognitive tests than others simply by giving large numbers of tests to a random sample of people, and then comparing the results by a correlation process.

At around the same time Spearman was developing his theory, Binet in France and Ebbinghaus in Germany were devising such tests. Hundreds of studies using these tests and others have since demonstrated that Spearman was correct. The results showed that cognitive tests of any kind correlate positively when the tests are carried out on people chosen at random from the population (Eysenck, 1974).

Kamin (1974) briefly summarized some historical facts about intelligence testing. He explained that the first widely used intelligence test was created in France in 1905 by Binet. The test Binet put together consisted of different sets of questions appropriate for children of different ages. Many of the questions depended on the child's general knowledge, and some were intended to measure how well the child could reason and the soundness of his judgement. The basic idea was that, in general, older children would be able to answer more difficult questions than younger children. Thus any given child could be assigned a "mental age", depending on which questions were correctly answered.

In recent years, the process of mental testing has undergone much criticism for reasons of bias. Most people usually think of bias only as unfair discrimination that favors or disfavors members of particular groups. According to Jensen (1980), in his book, Bias in Mental Testing, unreliability and invalidity of measurement are sources of individual bias that involve all persons on whom tests are used. He also argued that when such tests are used for selection, invalidity and unreliability contribute to group biases in selection and rejection, even when the tests are completely fair and unbiased in all other respects. He explained that testing bias can only be minimized, but can never be completely eliminated.

Validity indicates whether a test measures what it was designed to measure in the particular population of persons who took the test. Reliability on the other hand, refers to the consistency of test scores over time. It is determined by the correlation between scores obtained on the same test given to the same group of persons on two occasions separated in time. A test may have high validity, but have very low reliability, or vice versa.

Of the numerous factors that can reduce a test's validity, some of those most often recognized are:

1. Dissimilarity in the experimental backgrounds of persons taking the test.

2. "Tricky" or "catch" questions.

3. Wording of test items.

4. Inadequate or faulty directions.

5. Accidental factors such as breaking a pencil or interruptions and distractions.

6. Subject variables such as lack of effort, carelessness, anxiety, excitement, illness, and fatigue.

In spite of the above factors and others, it is remarkable that the validity of most mental tests are as high as they are. According to Jensen (1980), most mental tests average over 90 percent validity.

Stability is also a vital consideration in mental testing. Stability refers to the consistency of an individual's test scores over time. When a person's test score is obtained, one would like to have some assurance that the person's score is likely to be very similar if tested again in the future. Like with validity, several factors affect stability. Some of these factors are physical, maturational, psychological, and situational in nature. Practice and coaching on similar tests may also influence stability, though only slightly (generally 3 to 6 IQ points) (Jensen, 1980). It is interesting to note that mental test scores become increasingly stable over time as the chronological age of the subjects increases. With regards to stability, in the words of Wechsler (cited by Jensen, 1980), a noted psychologist,

> There is a vast amount of data and literature on this subject, although not all in agreement. On the whole, the findings show that for the most individuals an IQ once adequately obtained, does not change markedly (p. 54).

Wechsler explained that the average test-retest change amounts to only about 5 IQ points. Larger discrepancies than the 5-point differences do occur, but are not common. He cautioned that definitive classification should be avoided on the basis of a single examination. When a subject's IQ score appears inconsistent with his past academic performance, an obvious step should be to retest him, possibly with different instruments. A large discrepancy is always suspect and should be explored (Jensen, 1980).

The entire concept of intelligence and intelligence testing can be summed up by stating that different people have different abilities for solving intellectual problems, and that particularly important among these abilities is general intelligence. There are also specific abilities to deal with specific types of problems whether verbal, numerical, mechanical, or cognitive in nature. These abilities tend to remain relatively stable over time. Tests designed to measure these abilities are made up of many individual items varying in difficulty and differing in specific abilities required to solve them. Such tests are generally considered to have high validity and reliability. The next segment of this section will provide a brief explanation of the mental performance test used in this study--the ACT Assessment.

The ACT Assessment

The ACT Assessment provides educational planning information helpful to students, parents, secondary schools, and post secondary institutions. It is primarily designed to help students consider the many educational options available to them. High schools use ACT Assessment data in academic advising and counseling. Colleges use the ACT Assessment results to design and provide instructional and extracurricular programs that match the characteristics and needs of their students. The ACT Assessment is administered by the American College Testing Program, Iowa City, Iowa.

The ACT Assessment consists of four tests that are designed to give estimates of the current level of educational development in the knowledge and skills often required in college course work. The four areas of testing include: English usage, mathematics usage, social studies readings, and natural sciences readings.

The English usage test measures understanding of the conventions of standard written English and the use of the basic elements of effective writing. Much emphasis is placed on the usage of punctuation, grammar, sentence structure, diction, style, logic, and organization. The test does not measure memory rules of grammar, but stresses the analysis of effective expression.

The mathematics usage test measures mathematical reasoning ability.

The test emphasizes quantitative reasoning, rather than memorization of formulas or computational skills. In general, the test involves the solution of practical quantitative problems and includes a sampling of mathematical techniques covered in high school courses.

The social studies reading test measures reading comprehension skills and the ability to draw inferences and conclusions, and to examine the interrelationships of ideas. Additionally, it assesses the ability to extend given concepts to new situations, make deductions from supplied data, and the effectiveness of problem solving skills in social sciences situations.

The natural sciences readings test measures skills necessary for the understanding of natural science material as well as knowledge that has been gained in natural science courses at the high school level. The test involves a variety of scientific topics and problems, including descriptions of experiments and discussions of scientific theory. The test assesses the ability to understand and distinguish among the purposes of experiments, and to examine the logical relationships between experimental hypotheses and the generalizations that may be drawn from experiments. The test also measures the ability to predict the effects of ideas on new situations and to propose alternate methods of conducting the experiments.

On each of the four tests, the number of questions answered correctly is counted to obtain a raw score. The scores are converted to standard scores using a scale from 1 (low) to 36 (high). A composite score is also recorded for each student. The composite score is simply the average of the four standard scores. It provides an overall estimate of the level of educational development in the areas tested.

Summary

The Biorhythm Theory is still in the earliest stages of its development. Much has been done since the work of Swoboda, Fliess, and Teltscher in accumulating evidence to support it. Rigorously controlled experimental studies are underway to further test the theory's reliability. The possibilities for the future of biorhythmic theory are vast. Regardless of what the future has in store, biorhythm analysis has proven to be most useful thus far.

Awareness of our weak and our strong times should help us to plan, use, and develop our potential. In addition, the knowledge that we all have similar patterns, but that each of us uses ours differently, should give us an appreciation of the complexity of our individual existence. In other words, knowledge of our biorhythms opens up the possibility of gaining a better understanding of ourselves and our daily lives.

Tests of mental ability provide a means by which our potential may be measured. It must be remembered, though, that these tests are actually a measure of what the individual can do at the time of taking the test, and not necessarily what he was born with or what he could do under other conditions or at some future time. The performance in any situation is dependent upon numerous variables, including the demands of the task; situational factors affecting the person's effort, willingness, and persistence; and the past acquired knowledge and developed skills that he brings to the task, as well as internal organismic factors.

The next chapter of this paper will detail the process of determining the effects of the 33-day intellectual biorhythm cycle on human mental performance as evidenced by the ACT Assessment of mental ability.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this chapter is to explain the procedure used to determine if a relationship existed between the intellectual cycle of the Biorhythm Theory and human mental performance as evidenced by ACT test scores. The chapter will cover the following areas:

1. Data Selection and Collection,
2. Procedures,
3. Description of Statistical Analysis.

Data Selection and Collection

The data used in this study were provided by the Oklahoma State University Registrar's Office. The data were obtained from the ACT Magnetic Tape Student Record for the October 1980 through June 1981 testing period. The tape contained information on 17,603 students from across the United States who requested that ACT Assessment scores be sent to Oklahoma State University. Only seven items of information from the tape were used for this study. The seven items were:

1. Date of Birth,
2. Test Date,
3. English Usage Test Score,
4. Mathematics Usage Test Score,
5. Social Studies Readings Test Score,

6. Natural Sciences Readings Test Score,

7. Composite Test Score.

Care was taken to not compromise the anonymity of individual students. Additionally, there was no separation of student data due to sex, race, or national origin.

Procedures

Extraction of Data

The procedures followed to analyze the data consisted of many steps. The first step involved extracting the desired data from the tape. A computer program was developed to extract the desired information from the tape as it was read into the computer. The extracted data was ultimately stored to disk for future use if needed. As the information from each record was read, simple mathematical calculations were performed on the birth date and test date fields. Since the test date information included only month and year, a simple computer lookup table (cross reference) was employed to determine the date of the test. A calculation was made on each of the 17,603 records to determine the total number of days from date of birth to the date of the test. The resulting number was then used in the following equations:

$I = (X/33 - INT(X/33)) \times 33$,

$P = (X/23 - INT(X/23)) \times 23$,

$E = (X/28 - INT(X/28)) \times 28$,

where X = number of days since birth,

I = day of intellectual cycle,

P = day of physical cycle,

E = day of emotional cycle,

INT = integer value.

A total count of each I, P, and E value resulting from the calculations can be found in Table II.

The next step involved selecting the specific data upon which a statistical analysis would be performed. The next section of this chapter describes which data were used in this study.

Selection of Data

The three biorhythmic cycles are commonly represented by sine wave curves. These curves start simultaneously at the moment of birth and continue throughout the life of the individual. The first half of each cycle is designated the positive phase where the sine wave is located above the horizontal axis. The second half of the cycle is known as the negative phase since the sine wave drops below this axis. According to the Biorhythm Theory, the period of most rapid change in human performance occurs when the curves switch from positive to negative and vice versa. This corresponds to a period of flux and is therefore termed a critical period or critical day. This crossover occurs two times during each cycle. By defining the length of the critical period, and by knowing the date of birth, the Biorhythm Theory enables mathematical calculations of the expected days that would be critical (Wolcott, 1977).

The days when individual cycles are at maximum low points or troughs are supposed to represent periods when people are not performing up to their full potential. The reverse is supposed to be true when the cycles are at maximum high points or peaks. Figure 2 gives an explanation of the

TABLE II

FREQUENCY COUNT OF CALCULATED
I, E, AND P VALUES

I	Freq	E	Freq	P	Freq
* 0	544	* 0	575	* 0	783
1	494	1	639	1	777
2	538	2	631	2	802
3	514	3	641	3	754
4	550	4	689	4	772
5	501	5	632	* 5	751
6	517	6	577	6	760
7	509	* 7	614	7	747
* 8	517	8	645	8	774
9	515	9	669	9	747
10	526	10	641	10	814
11	554	11	659	*11	752
12	531	12	627	12	814
13	533	13	573	13	767
14	550	*14	608	14	738
15	563	15	604	15	775
*16	557	16	601	16	738
17	488	17	602	*17	781
18	541	18	644	18	758
19	548	19	648	19	727
20	553	20	589	20	738
21	606	*21	632	21	771
22	505	22	634	22	763
23	497	23	663	--	---
*24	546	24	668	--	---
25	546	25	677	--	---
26	566	26	628	--	---
27	503	27	593	--	---
28	587	--	---	--	---
29	521	--	---	--	---
30	551	--	---	--	---
31	510	--	---	--	---
32	522	--	---	--	---
	17,603		17,603		17,603

NOTE: * denotes values used for statistical analysis in this study.

STATE OF CYCLE			DESCRIPTION OF BEHAVIOR
P	E	I	
+	+	+	The individual should be at a peak period physically and be more apt to be creative and in a good mood.
-	+	+	The individual should be in a creative cycle and in a good mood, but be in an ebb in the physical cycle.
+	-	+	The individual should be in a peak physical cycle and be in a creative intellectual phase, but also be experiencing a stressful period.
-	-	+	The individual is in a creative cycle but is at an ebb physically and emotionally.
+	+	-	The individual is at a peak physically and in a harmonious mood while below par intellectually.
-	+	-	The individual is in an ebb period both physically and intellectually while in a positive emotional state.
+	-	-	The individual is below par intellectually, and feels stressful, but is at a peak in the physical cycle.
-	-	-	The individual is below par intellectually and physically and is in a stressful mood.

NOTE: P = Physical Cycle
E = Emotional Cycle
I = Intellectual Cycle
+ = Cycle in Positive Phase
- = Cycle in Negative Phase

Source: Thumann (1977, p. 81).

Figure 2. Combinations of Biorhythm Behavior

possible combinations of the three cycle states (except critical days) and their expected associated behavior.

For this study, the critical days were computed as being the first and middle days of each cycle. The highs were the middle day of the first half of each cycle and the lows were the middle day of the second half of each cycle. As a result, the I values of 0 and 16 represented the critical days and days 8 and 24 represented the high and low days, respectively for the intellectual cycle. Days 0 and 11 represented the critical days, day 5 represented the high day, and day 17 represented the low day of the physical cycle. The critical days of the emotional cycle were days 0 and 14. The high and low days were day 7 and day 21, respectively. A thorough explanation of the procedures used to manually compute the cycles can be found in Appendix B.

Once the days on each of the cycles were computed, the test scores for each of the tests were printed and stored to disk. A statistical analysis was next performed on the resultant data. The next section of this chapter describes the statistical analysis in detail.

Description of Statistical Analysis

To determine whether the intellectual cycle of the Biorhythm Theory is to be considered a possible causal factor for deviation of mental ability test scores, and consequently a predictor of such scores, it was necessary to determine if there was any difference between the mean test score of students whose intellectual cycles' were at varying positions at the time of taking the test. The days chosen to be investigated in this study were the high, low and critical days. The selected days were those that supposedly would show the most marked difference in performance. The statistical tests best suited for this purpose were the One-Way and Two-Way Analysis of Variance (ANOVA). The ANOVAs were computed using harmonic (weighted) means to compensate for unequal group size. Any significant findings were subjected to the Eta Squared Strength-of-Association Test to determine the amount of variance accounted for between the groups in the sample. An Omega Squared Strength-of-Association Test was also run to determine the strength of the association within the population (Linton, 1975). The manner in which these tests were applied will be discussed next. The program used for the ANOVAs was the subprogram ANOVA of the Statistical Analysis System (SAS). The analysis of the data was performed by the Oklahoma State University Computer Center. The Eta Squared and Omega Squared Strength-of-Association Tests were performed manually.

One-Way Analysis of Variance

A one-way analysis of variance (ANOVA) was run on the selected data. The ANOVA compared the mean score for each of the tests as well as the composite score of the four categories. This comparison was made only on those students with an I value of 8 (high on the intellectual cycle), or 24 (low on the intellectual cycle), or 0 (first day of intellectual cycle), or 16 (midpoint of intellectual cycle). Even though the 0's and 16's represent critical days, these critical days could be significantly different from each other. This was possible since they occur at times where the cycle crosses over from the negative phase to the positive phase and from the positive phase to the negative phase.

Two-Way Analysis of Variance

Two two-way ANOVAs were also computed on the selected data. One of these compared the mean test score of those students whose I values were 0, 8, 16, or 24 and whose E values were 0, 5, 11, or 17. The other ANOVA similarly compared the mean score of those students whose I values were 0, 8, 16, or 24 and whose P values were 0, 7, 14, or 21. Once the analyses were accomplished, the resulting F values were compared against an F table at the .05 level of significance.

Eta Squared and Omega Squared Strength-of -Association Tests

The Eta Squared and Omega Squared Strength-of-Association Tests were performed on the data that indicated significance through the above analyses.

The equation used for the Eta Squared Test was as follows:

$$\eta^2 = \frac{SS_x}{SS_{total}} ,$$

where SS_x = the sum of squares of any simple effect or the interaction effect.

The equation used for the Omega Squared Test was as follows:

$$\omega^2 = \frac{SS_x - (df_x)(MS_{error})}{MS_{error} + SS_{total}} ,$$

where df_x = degrees of freedom of the same effect as that in the sum of squares.

The above equations were used to determine the strength of the identified interaction relationships (Linton, 1975). The minimum acceptable eta squared (η^2) and omega squared (ω^2) value was .10.

CHAPTER IV

ANALYSIS OF THE DATA

This chapter is included as the vehicle through which the data are analyzed. The Analysis of Variance (ANOVA) statistical test was used to determine if there was a significant difference between the mean test scores for each of the groups. Separate ANOVAs were computed for each of the four tests comprising the ACT Assessment as well as an additional ANOVA for the composite score. The ANOVAs were computed using harmonic (weighted) means to compensate for unequal group size.

The data from each of the ANOVAs that yielded a significant F value were subjected to the Eta Squared and Omega Squared Strength-of-Association Tests to determine the strength of the identified relationships. A significant F value only shows that, at a certain probability level, the identified relationship exists to some extent in the population from which the sample had been drawn, and that this relationship is not due to the operation of chance sampling factors. In other words, a significant relationship identifies a real phenomenon, but does not indicate the strength of this relationship. With very large samples, very small effects can result in statistical significance. It seems clear, however, that intelligent conclusions cannot be drawn from data unless there is some indication of the strength of the relationship detected. It was for this reason that the Eta Squared and Omega Squared Strength-of-Association

Tests were performed. The eta squared value is a rough estimate of the strength of association in the sample, while the omega squared value is a more precise estimate of the strength of association in the population (Linton, 1975).

Each of the five research questions listed in Chapter I was tested at the .05 level of significance. The minimum acceptable eta squared and omega squared value was .10.

Assessment Tests and Composite Score Results

Intellectual Cycle

No significant difference was expected between the mean test scores of students who were on a high, low, or critical day of their intellectual cycle. A one-way analysis of variance (ANOVA) was performed on each of the four ACT Assessment test scores and on the composite test score. The ANOVAs were computed on 2,163 student test scores for the English usage test and the mathematics usage test. A total of 2,162 student test scores were used with the social studies readings test, natural sciences readings test, and the composite score. These test scores were those of the students from the population of 17,603 who were at a high, low, or critical day of their intellectual cycle. One student evidently did not take all four of the component tests.

The individual one-way ANOVA summary tables for the intellectual cycle can be found in Tables III through VII. The results for the English usage test scores are displayed in Table III. The results for the mathematics usage test scores are shown in Table IV. The results for the social studies readings test scores are indicated in Table V. The results for the natural sciences readings test scores are exhibited in Table VI. The composite test score results are presented in Table VII. None of the five ANOVAs resulted in a significant F value; therefore, the null hypothesis was not rejected.

TABLE III

SUMMARY TABLE OF ONE-WAY ANOVA FOR ENGLISH USAGE TEST SCORES FOR THE INTELLECTUAL CYCLE

Source	DF	SS	MS	F	p
I	3	39.11	13.038	.50	n.s.
Error	2160	56561.21	26.186		
Total	2163	56600.32			

$p < .05$

TABLE IV

SUMMARY TABLE OF ONE-WAY ANOVA FOR MATHEMATICS USAGE TEST SCORES FOR THE INTELLECTUAL CYCLE

Source	DF	SS	MS	F	p
I	3	23.10	7.700	.14	n.s.
Error	2160	120089.78	55.597		
Total	2163	120112.88			

$p < .05$

TABLE V

SUMMARY TABLE OF ONE-WAY ANOVA FOR SOCIAL STUDIES READINGS TEST SCORES FOR THE INTELLECTUAL CYCLE

Source	DF	SS	MS	F	p
I	3	56.62	18.891	.37	n.s.
Error	2159	109794.22	50.854		
Total	2162	109850.84			

$p < .05$

TABLE VI

SUMMARY TABLE OF ONE-WAY ANOVA FOR NATURAL SCIENCES READINGS TEST SCORES FOR THE INTELLECTUAL CYCLE

Source	DF	SS	MS	F	p
I	3	34.84	11.613	.35	n.s.
Error	2159	72584.05	33.619		
Total	2162	72618.89			

$p < .05$

TABLE VII

SUMMARY TABLE OF ONE-WAY ANOVA FOR COMPOSITE TEST SCORES FOR THE INTELLECTUAL CYCLE

Source	DF	SS	MS	F	p
I	3	18.46	6.154	.21	n.s.
Error	2159	64666.94	29.952		
Total	2162	64685.40			

$p < .05$

<u>Physical Cycle</u>

No significant difference was expected between the mean test scores of students who were on a high, low, or critical day of their physical cycle. Five separate one-way ANOVAs were computed for 374 student test scores. These test scores were those of the students from the population of 17,603 who were at a high, low, or critical day of their physical cycle.

The individual one-way ANOVA summary tables for the physical cycle can be found in Tables VIII through XII. The results for the English usage test scores are displayed in Table VIII. The results for the mathematics usage test scores are shown in Table IX. The results for the social studies readings test scores are indicated in Table X. The results for the natural sciences readings test scores are exhibited in Table XI. The composite test score results are presented in Table XII. None of the five ANOVAs resulted in a significant F value; therefore, the null hypothesis was not rejected.

TABLE VIII

SUMMARY TABLE OF ONE-WAY ANOVA FOR ENGLISH USAGE TEST SCORES FOR THE PHYSICAL CYCLE

Source	DF	SS	MS	F	p
P	3	134.55	44.849	1.72	n.s.
Error	371	9688.48	26.115		
Total	374	9823.03			

$p < .05$

TABLE IX

SUMMARY TABLE OF ONE-WAY ANOVA FOR MATHEMATICS USAGE TEST SCORES FOR THE PHYSICAL CYCLE

Source	DF	SS	MS	F	p
P	3	193.18	64.392	1.13	n.s.
Error	371	21068.55	56.789		
Total	374	21261.73			

$p < .05$

TABLE X

SUMMARY TABLE OF ONE-WAY ANOVA FOR SOCIAL STUDIES READINGS TEST SCORES FOR THE PHYSICAL CYCLE

Source	DF	SS	MS	F	p
P	3	147.20	49.068	.94	n.s.
Error	371	19389.74	52.263		
Total	374	19536.94			

$p < .05$

TABLE XI

SUMMARY TABLE OF ONE-WAY ANOVA FOR NATURAL SCIENCES READINGS TEST SCORES FOR THE PHYSICAL CYCLE

Source	DF	SS	MS	F	p
P	3	142.88	47.627	1.65	n.s.
Error	371	10732.45	28.928		
Total	374	10875.33			

$p < .05$

TABLE XII

SUMMARY TABLE OF ONE-WAY ANOVA FOR COMPOSITE TEST SCORES FOR THE PHYSICAL CYCLE

Source	DF	SS	MS	F	p
P	3	117.18	39.061	1.36	n.s.
Error	371	10681.29	28.791		
Total	374	10798.47			

$p < .05$

Emotional Cycle

No significant difference was expected between the mean test scores of students who were on a high, low, or critical day of their emotional cycle. Five separate one-way ANOVAs were computed for 276 student test scores. These test scores were those of the students from the population of 17,603 who were at a high, low, or critical day of their emotional cycle.

The individual one-way ANOVA summary tables for the emotional cycle can be found in Tables XIII through XVII. The results for the English usage test scores are displayed in Table XIII. The results for the mathematics usage test scores are shown in Table XIV. The results for the social studies readings test scores are indicated in Table XV. The results for the natural sciences readings test scores are exhibited in Table XVI. The composite test score results are presented in Table XVII. None of the five ANOVAs resulted in a significant F value; therefore, the null hypothesis was not rejected.

TABLE XIII

SUMMARY TABLE OF ONE-WAY ANOVA FOR ENGLISH USAGE TEST SCORES FOR THE EMOTIONAL CYCLE

Source	DF	SS	MS	F	p
E	3	147.92	49.307	2.00	n.s.
Error	273	6724.35	24.631		
Total	276	6872.27			

$p < .05$

TABLE XIV

SUMMARY TABLE OF ONE-WAY ANOVA FOR MATHEMATICS USAGE TEST SCORES FOR THE EMOTIONAL CYCLE

Source	DF	SS	MS	F	p
E	3	99.21	33.071	.58	n.s.
Error	273	15611.49	57.185		
Total	276	15710.70			

$p < .05$

TABLE XV

SUMMARY TABLE OF ONE-WAY ANOVA FOR SOCIAL STUDIES READINGS TEST SCORES FOR THE EMOTIONAL CYCLE

Source	DF	SS	MS	F	p
E	3	37.26	12.422	.25	n.s.
Error	273	13765.48	50.423		
Total	276	13802.74			

$p < .05$

TABLE XVI

SUMMARY TABLE OF ONE-WAY ANOVA FOR NATURAL SCIENCES READINGS TEST SCORES FOR THE EMOTIONAL CYCLE

Source	DF	SS	MS	F	p
E	3	68.87	22.959	.67	n.s.
Error	273	9399.84	34.432		
Total	276	9468.71			

$p < .05$

TABLE XVII

SUMMARY TABLE OF ONE-WAY ANOVA FOR COMPOSITE TEST SCORES FOR THE EMOTIONAL CYCLE

Source	DF	SS	MS	F	p
E	3	60.84	20.280	.65	n.s.
Error	273	8475.83	31.047		
Total	276	8536.67			

$p < .05$

Intellectual and Physical Cycles

No significant difference was expected between the mean test scores of students who were on a high, low, or critical day of their intellectual cycle and who were on a high, low, or critical day of their physical cycle. Five separate one-way ANOVAs were computed for 374 student test scores. These test scores were those of the students from the population of 17,603 who were at a high, low, or critical day of their intellectual cycle and at a high, low, or critical day of their physical cycle. Since separate one-way ANOVAs were previously evaluated, the main effects were not investigated further. Of the five ANOVAs, only the F value for the social studies readings test indicated significance.

The individual two-way ANOVA summary tables for the intellectual and physical cycles can be found in Tables XVIII through XXII. The results for the English usage test scores are displayed in Table XVIII. The results for the mathematics usage test scores are shown in Table XIX. The results for the social studies readings test scores are indicated in Table XX. The results for the natural sciences readings test scores are exhibited in Table XXI. The composite test score results are presented in Table XXII. Although the interaction between the two cycles on the social studies readings tests was significant, the amount of variance accounted for in the interaction as identified by the eta squared value was only .052 for the sample. The omega squared value resulted in .029 for the population from which the sample was drawn (17,603 students). In other words, while this relationship was real, it was actually quite weak. Investigation of the raw test scores showed that the range of test score variance was a maximum of two points. However, a standard error of measurement of plus-or-minus two points exists in each test of the ACT Assessment (Buros, 1978). Consequently, the interaction effect was negligible. Since the eta squared or omega squared values were less than the minimum acceptable (.10), the null hypothesis was not rejected.

TABLE XVIII

SUMMARY TABLE OF TWO-WAY ANOVA FOR ENGLISH USAGE TEST SCORES FOR THE INTELLECTUAL AND PHYSICAL CYCLES

Source	DF	SS	MS	F	p
I	3	119.61	39.869	1.56	n.s.
P	3	203.57	67.857	2.65	<.05
I X P	9	406.52	45.169	1.76	n.s.
Error	359	9196.39	25.617		
Total	374	9823.03			

Note: Total SS may not add up due to use of harmonic means in the computations.

$p < .05$

TABLE XIX

SUMMARY TABLE OF TWO-WAY ANOVA FOR MATHEMATICS USAGE TEST SCORES FOR THE INTELLECTUAL AND PHYSICAL CYCLES

Source	DF	SS	MS	F	p
I	3	17.99	5.996	.11	n.s.
P	3	200.11	66.702	1.18	n.s.
I X P	9	763.62	84.847	1.50	n.s.
Error	359	20357.50	56.617		
Total	374	21261.73			

Note: Total SS may not add up due to use of harmonic means in the computations.

$p < .05$

TABLE XX

SUMMARY TABLE OF TWO-WAY ANOVA FOR SOCIAL STUDIES READINGS TEST SCORES FOR THE INTELLECTUAL AND PHYSICAL CYCLES

Source	DF	SS	MS	F	p
I	3	91.99	30.663	.60	n.s.
P	3	241.83	80.609	1.58	n.s.
I X P	9	1018.71	113.190	2.22	< .05
Error	359	18312.66	51.010		
Total	374	19536.94			

Note: Total SS may not add up due to use of harmonic means in the computations.

$p < .05$

TABLE XXI

SUMMARY TABLE OF TWO-WAY ANOVA FOR NATURAL SCIENCES READINGS TEST SCORES FOR THE INTELLECTUAL AND PHYSICAL CYCLES

Source	DF	SS	MS	F	p
I	3	53.81	17.936	.62	n.s.
P	3	149.65	49.884	1.72	n.s.
I X P	9	298.34	33.149	1.14	n.s.
Error	359	10415.89	29.014		
Total	374	10875.33			

Note: Total SS may not add up due to use of harmonic means in the computations.

$p < .05$

TABLE XXII

SUMMARY TABLE OF TWO-WAY ANOVA FOR COMPOSITE TEST SCORES FOR THE INTELLECTUAL AND PHYSICAL CYCLES

Source	DF	SS	MS	F	p
I	3	34.76	11.586	.41	n.s.
P	3	151.41	50.469	1.77	n.s.
I X P	9	474.53	52.726	1.85	n.s.
Error	359	10209.14	28.438		
Total	374	10798.47			

Note: Total SS may not add up due to use of harmonic means in the computations.

$p < .05$

Intellectual and Emotional Cycles

No significant difference was expected between the mean test scores of students who were on a high, low, or critical day of their intellectual cycle and who were on a high, low, or critical day of their emotional cycle. Five separate one-way ANOVAs were computed for 276 student test scores. These test scores were those of the students from the population of 17,603 who were at a high, low, or critical day of their intellectual cycle and were at a high, low, or critical day of their emotional cycle. Since separate one-way ANOVAs were previously evaluated, the main effects were not investigated further. Of the five ANOVAs, the four F values for the English usage test, the mathematics usage test, the social studies readings test, and the composite score indicated significance. The natural sciences readings test did not indicate significance.

The individual two-way ANOVA summary tables for the intellectual and emotional cycles can be found in Tables XXIII through XXVII. The results for the English usage test scores are displayed in Table XXIII. The results for the mathematics usage test scores are shown in Table XXIV. The results for the social studies readings test scores are indicated in Table XXV. The results for the natural sciences readings test scores are exhibited in Table XXVI. The composite test score results are presented in Table XXVII. Although the interaction between the two cycles on four of the scores was significant, the amount of variance accounted for in the interaction as identified by the eta squared and the omega squared values was low. The eta squared values for the English usage test, the mathematics usage test, the social studies readings test, and the composite score were .072, .070, .061, and .070, respectively. The omega squared values were .042, .040, .029, and .039, respectively. Investigation of the raw test scores showed that the range of test score variance was a maximum of two points. However, a standard error of measurement of plus-or-minus two points exists in each test of the ACT Assessment (Buros, 1978). Consequently, the interaction effect was negligible. Since the eta squared or omega squared values were less than the minimum acceptable (.10), the null hypothesis was not rejected.

TABLE XXIII

SUMMARY TABLE OF TWO-WAY ANOVA FOR ENGLISH USAGE TEST SCORES FOR THE INTELLECTUAL AND EMOTIONAL CYCLES

Source	DF	SS	MS	F	p
I	3	31.31	10.438	.45	n.s.
E	3	112.62	37.539	1.62	n.s.
I X E	9	496.13	55.126	2.39	<.05
Error	261	6029.06	23.100		
Total	276	6872.27			

Note: Total SS may not add up due to use of harmonic means in the computations.

$p < .05$

TABLE XXIV

SUMMARY TABLE OF TWO-WAY ANOVA FOR MATHEMATICS USAGE TEST SCORES FOR THE INTELLECTUAL AND EMOTIONAL CYCLES

Source	DF	SS	MS	F	p
I	3	5.77	1.922	.04	n.s.
E	3	263.83	87.950	1.66	n.s.
I X E	9	1105.73	122.859	2.32	<.05
Error	261	13822.81	52.961		
Total	276	15710.70			

Note: Total SS may not add up due to use of harmonic means in the computations.

$p < .05$

TABLE XXV

SUMMARY TABLE OF TWO-WAY ANOVA FOR SOCIAL STUDIES READINGS TEST SCORES FOR THE INTELLECTUAL AND EMOTIONAL CYCLES

Source	DF	SS	MS	F	p
I	3	10.49	3.498	.07	n.s.
E	3	73.85	24.618	.51	n.s.
I X E	9	840.95	93.439	1.94	<.05
Error	261	12548.45	48.078		
Total	276	13802.74			

Note: Total SS may not add up due to use of harmonic means in the computations.

$p < .05$

TABLE XXVI

SUMMARY TABLE OF TWO-WAY ANOVA FOR NATURAL SCIENCES READINGS TEST SCORES FOR THE INTELLECTUAL AND EMOTIONAL CYCLES

Source	DF	SS	MS	F	p
I	3	19.54	6.512	.19	n.s.
E	3	76.42	25.474	.75	n.s.
I X E	9	465.84	51.760	1.52	n.s.
Error	261	8894.24	34.078		
Total	276	9468.71			

Note: Total SS may not add up due to use of harmonic means in the computations.

$p < .05$

TABLE XXVII

SUMMARY TABLE OF TWO-WAY ANOVA FOR COMPOSITE TEST SCORES FOR THE INTELLECTUAL AND EMOTIONAL CYCLES

Source	DF	SS	MS	F	p
I	3	9.76	3.253	.11	n.s.
E	3	93.18	31.060	1.07	n.s.
I X E	9	594.68	66.076	2.27	$<.05$
Error	261	7592.03	29.088		
Total	276	8536.67			

Note: Total SS may not add up due to use of harmonic means in the computations.

$p < .05$

Overall

Overall summaries of the one-way ANOVA results can be found in Table XXVIII. The overall summary of the two-way ANOVA interaction results can be found in Table XXIX. The Eta Squared and Omega Squared Strength-of-Association Test results can be found in Table XXX.

TABLE XXVIII

SUMMARY OF ONE-WAY ANOVA RESULTS

	Significance				
Effect	ENG	MATH	SS	NS	COMP
Intellectual	n.s.	n.s.	n.s.	n.s.	n.s.
Physical	n.s.	n.s.	n.s.	n.s.	n.s.
Emotional	n.s.	n.s.	n.s.	n.s.	n.s.

$p < .05$

TABLE XXIX

SUMMARY OF TWO-WAY ANOVA INTERACTION RESULTS

	Significance				
Effect	ENG	MATH	SS	NS	COMP
I X P	n.s.	n.s.	$<.05$	n.s.	n.s.
I X E	$<.05$	$<.05$	$<.05$	n.s.	$<.05$

$p < .05$

TABLE XXX

ETA SQUARED AND OMEGA SQUARED STRENGTH-OF-ASSOCIATION TEST RESULTS FOR SIGNIFICANT F VALUES FOR INTERACTIONS

Effect	ACT Test	Eta Squared	Omega Squared
I X P	SS	.052	.029
I X E	ENG	.072	.042
I X E	MATH	.070	.040
I X E	SS	.061	.029
I X E	COMP	.070	.039

Minimum acceptable Eta Squared or Omega Squared = .10

It was interesting to note that the pattern of intellectual and physical cycle interaction for each of the component tests was consistent, but that the social studies readings test had a greater variability of mean scores at the four specified cycle locations, thereby indicating a significant relationship. Similarly, the pattern of interaction for each of the tests on the intellectual and emotional cycles was essentially the same. However, the one test, the natural sciences readings test, that did not indicate a significant relationship had a smaller amount of variability of mean scores of students whose biorhythm cycles were at the four specified locations.

It was also interesting to note that when the intellectual and emotional cycles were in combination, the mean test scores were a few points higher than were those when the intellectual and physical cycles were in combination. This discovery, however, does not necessarily indicate that the intellectual and emotional cycles in combination are a predictor of ACT Assessment results. This identified relationship is likely the result of individual student variance in scores.

In summary, the first three research questions resulted in non-significant F values. Consequently, the first three null hypotheses were not rejected. The position on each of the three biorhythm cycles in isolation, then, had no effect on the mean scores received on the ACT Assessment. The intellectual and physical cycles in combination resulted in a significant F value on the social studies readings test. Though real, this relationship proved to be negligible due to the amount of standard error of measurement associated with the ACT Assessment. This low relationship would serve no practical value in predicting social studies readings test scores in the ACT Assessment. The intellectual and emotional cycles in combination resulted in significant F values on the English usage test, the mathematics usage test, the social studies readings test, and the composite score of the ACT Assessment. Once again, these relationships were extremely weak and would be of no practical value in predicting future performance on ACT Assessment component tests.

CHAPTER V

SUMMARY AND CONCLUSIONS

This chapter will summarize the study, state the conclusions reached, and recommend the direction further Biorhythm Theory studies should take. The chapter is divided into the following sections:

1. Summary,
2. Conclusions,
3. Recommendations for Further Studies.

Summary

The purpose of this study was to determine what relationship existed between the 33-day intellectual cycle of the Biorhythm Theory and performance on mental testing. To accomplish this investigation, a thorough review of the literature related to the Biorhythm Theory and tests of mental measurements was accomplished. The review revealed conflicting information regarding the validity of the Biorhythm Theory.

The data used in the study were obtained from the ACT Magnetic Tape Student Record for the October 1980 through June 1981 testing period provided by the Oklahoma State University Registrar's Office. The tape contained information on 17,603 students from across the United States who requested ACT Assessment scores be sent to Oklahoma State University. Only date of birth, date of test, and five test scores were extracted from the tape for each student. Biorhythm calculations were made to determine the students' position on each of the biorhythmic cycles. Only student test scores were used for those who were at a high (8), low (24), or critical (0 or 16) day of their intellectual cycle and were at a high (5 or 7), low (17 or 21), or critical day (0 or 11 or 14) on either or both of the other two cycles.

The data were analyzed at the Oklahoma State University Computer Center with the subprogram ANOVA of the Statistical Analysis System (SAS). Effects were tested for four locations on the intellectual, physical, and emotional cycles individually and for interaction of the biorhythm cycles. The statistical tests of one-way analysis of variance (ANOVA) and two-way ANOVA were used to determine significance at the .05 level. The ANOVAs were computed using harmonic (weighted) means to ccompensate for unequal group size. Significant relationships were then tested for strength of association through the Eta Squared and Omega Squared Strength-of-Association Tests. The minimum acceptable eta squared and omega squared value was .10.

Conclusions

The study resulted in the following findings:

1. No relationship was found between the location on any of the three biorhythmic cycles and ACT Assessment scores.

2. A significant, but quite weak, relationship existed for the social studies readings test scores as a result of an interaction between the intellectual and physical cycles. This finding, however, would be of no practical value in predicting ACT Assessment results.

3. A significant, but quite weak, relationship existed for the English usage test, mathematics usage test, social studies readings test, and composite scores as a result of an interaction between the intellectual and

emotional cycles. This finding, however, would be of no practical value in predicting ACT Assessment results.

4. Overall, the high, low, or critical days of the three biorhythmic cycles are not related to scores received on the ACT Assessment component tests. In other words, knowledge of an individual's position on each of the biorhythm cycles does not appear to be an effective predictor of high school students' scores on the ACT Assessment of mental performance.

Recommendations for Further Studies

Although this study did not yield data which would lend support to the Biorhythm Theory, further investigation of the theory is recommended. This recommendation for further research is based on the often contradictory findings discovered during the review of literature.

Based on the experience of this study, two recommendations are made which should improve the validity of future studies. These recommendations are:

1. Any future biorhythm research design should include a measure of the strength of association of any relationships discovered. Without such indication of the relationship, it is difficult to make reasonable inferences about the meaning of the research results.

2. Attempts could be made to base biorhythm cycle calculations on subject's minute, hour, and day of birth, rather than simply on the day. This is important since a small deviation in time of birth might result in an error when calculating biorhythm cycles.

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APPENDIX A

THE NATURE OF CYCLES

The word "cycle" comes from a Greek word meaning "circle." By extension of meaning, the word has come to refer to any sequence of events that come around again to the same condition. Day, night, and day again is a cycle. Winter, spring, summer, fall, and winter again is a cycle. Boom, depression, and boom again is a cycle. In physics, cycles occur in sound waves and in electromagnetic vibrations, such as light waves, radio waves, X-rays. In astronomy, cycles are created by motions and vibrations of various heavenly bodies. In geology, repetitive patterns are found in earthquakes, volcanic eruptions, and the advance and recession of glaciers. In biology, rhythmic fluctuations occur in the abundance of various species of animal life and in the functioning of the animal's various physiological processes. These are but a few examples of cycles. In fact more than 500 different phenomena in 36 different areas of knowledge have been found to fluctuate in rhythmic cycles (Dewey, 1967).

A factor common to all of the above examples involves time. Because cycles unfold in time, they can generally be charted on graph paper, with time being represented on the horizontal axis from left to right. The intensity of the behavior itself, at any given instant of time, is plotted against the vertical axis.

A wave, when charted, goes from a high to a low and back to a high again, or vice versa. The highs are commonly called highs, tops, peaks, or crests. The lows are known as lows, bottoms, valleys, or troughs. The line from the low to the high is known as the upward leg; from the high to the low is known as the downward leg.

In cycle study, the successive values of the data are often expressed as values above or below some middle line. The height above the axis of the highest point on the curve is known as the amplitude. It represents the strength of the cycle. The amplitude is sometimes called the positive amplitude to distinguish it from the distance below the axis, or lowest point. The lowest point distance is called the negative amplitude. The place where the curve, going up, crosses the axis is called the upward crossing. The point where it crosses the axis, going down, is called the downward crossing. The length of the cycle is the distance from a point on a wave to the same point on the next wave. For example, the distance from one crest to the next crest, or one trough to the next trough is the length of the cycle. In very short cycles, the length usually is measured in physical distance (usually meters). In longer cycles, (those longer than a second) the distance is usually measured in time: seconds, minutes, hours, days, weeks, months, or years (Dewey, 1968).

When the waves of a cycle repeat with perfect regularity, we have what is called a "periodicity." The behavior is said to be periodic. In other words, periodic cycles have waves of equal length. When the cycle is merely rhythmic, however, the length of the cycle will vary from wave to wave. From one crest to the next, the cycle may be seven months, and then nine months to the next crest. Such a cycle has an average length of 8 months. In such instances, we use the word "period" to describe its behavior (Dewey, 1967). The period is the average or typical length of all the waves in the cycle.

Life abounds with rhythmic cycles. The cause of some of these cycles is known. The cause of other rhythmic cycles is mere chance; but some rhythmic cycles of unknown cause can be shown to be non-chance. Let us turn now to the evidence that leads us to believe that some of these rhythmic cycles of unknown cause are not of chance origin.

Individual rhythms are often significant in their own right because the pattern is so ordered that it is not likely to be the result of chance. There are many additional criteria by which significance of pattern in the behavior of any one phenomenon can be determined. These criteria are:

1. Cycle Dominance,
2. Regularity of Timing,
3. Number of Repetitions,
4. Constancy of Period,
5. Re-establishment of Phase,
6. Persistence Through Changed Conditions,
7. Persistence After Discovery.

Cycle Dominance

"Cyclic dominance is the degree to which the ups and downs of a time series are the result of the cycle in contrast to the variations that are caused by other factors" (Dewey, 1967, p. 164). A time series is an arrangement of data that measures the successive changes in phenomena over a period of time.

Regularity of Timing

Regularity of timing comes into play since the more the behavior of the phenomenon adheres to some true periodicity or pattern, the less likely it is to be the result of chance. When observable regularity is present, it is an additional criterion of significance to indicate non-chance behavior (Dewey, 1967).

Number of Repetitions

The number of repetitions is also important in determining significance of cycles. It is obvious that the greater the number of waves in a cyclic recurrence, the greater the odds that the regularity is not the result of chance.

Constancy of Period

Constancy of period is exactly as the name implies. If a cycle in a series of figures persists over many repetitions with no change of period, then there is additional evidence that the cycle is not of chance origin.

Re-establishment of Phase

"Phase" is a term that refers to a particular state or stage in a recurring cycle of changes. When the waves of a rhythm are in step with what they were before, they are said to be "in phase" with previous behavior. When they are not in step, they are "out of phase." If, after distortion, the cycle in a series reasserts itself in phase with its previous timing, the cycle is much more likely to be non-chance than if it does not.

Persistence Through Changed Conditions

When a rhythmic cycle persists in spite of changed environmental conditions we have additional evidence that the cycle is of a significant nature.

Persistence After Discovery

If the cycle continues to come true after discovery, we have powerful evidence that the pattern is not the result of change. Since cycle study is so new, many cycles have not had much chance to continue after discovery. This fact makes the criterion of persistence after discovery hard to apply.

Each of the preceding seven criteria can be used by itself in determining the probability that certain cycles are or are not the result of chance. It is obvious that the more that apply to any given cycle, the greater the likelihood that the cycle is not the result of chance. An indication that any particular cycle is not a result of chance does not explain what the cause is, but only that there is some cause for it. Determining the significance of cycles is relatively easy. It is the discovery of the explanation or cause(s) of its occurrence that is often laborious and time-consuming. The Biorhythm Theory was developed as an explanation for certain observed phenomenon that appeared to have occurred not as a result of chance. The validity of this theory, however, is still in question over 90 years after its inception.

APPENDIX B

MANUAL COMPUTATION OF BIORHYTHM CYCLES

The basis for studying biorhythms has been mathematic calculations. This remains true today. When the Biorhythm Theory was first developed, the process of computing the location of the rhythms for any specific day was confusing and time-consuming. Swoboda developed a slide rule that he used to figure critical days, but he did not publicize this device. Fliess, on the other hand, with his knowledge of mathematics, developed numerous tables to facilitate the calculations of biorhythms, but his work only confused those who read it (Thommen, 1973).

Thommen (1973) related that Judt, a mathematician and a doctor of engineering, was interested in studying performance of sports figures in the late 1920's. To compute the rhythm position of an athlete quickly, he designed some calculation tables. These tables established a relationship between the day and year of birth and the day of a particular sports event.

Shortly after Judt had developed his tables, Frueh, a Swiss engineer and mathematician, studied the available materials on biorhythms. To help him with his own research, he improved upon the calculation tables developed by Judt. He later developed a calculator to facilitate the calculation of the rhythms. Frueh also developed a vertical design chart that corresponded with the arrangement of his calculator. This type chart is still used today. The tables developed by Judt and Frueh were the basis for all methods used today.

A sine-curve chart was developed during the 1950's which greatly facilitated the drawing of biorhythm charts. These charts have made it easy for anyone to chart and understand their own rhythms. A brief explanation of how the biorhythms cycles can be computed for any particular day will be presented next.

The calculation of an individual's biorhythm at any given time first requires that the date being investigated be specific. The subject's age in days from the date of birth, up to and including the date of interest, must next be determined. In the calculation, consideration should be given to regular leap years and centurial leap years.

Assume a person's birth date was May 1, 1967. Also assume we desire to determine his biorhythm condition for May 2, 1977. His tenth year ended on April 30, 1977 and he began a new year on May 1, 1977. On May 2, he had been alive for 365 days x 10 years + 3 days for leap years + 2 days in May of the 11th year, for a total of 3,655 days. These 3,655 days represent his total days of life up to and including May 2, 1977. Next, we must divide this number by the length of the cycles to be investigated and determine the remainders. We divide the 3,655 by 23 and get a remainder. This remainder is the location on the physical cycle the which individual was at on May 2, 1977. We do the same procedures for the remaining two cycles. The individual was on the 21st day of his physical cycle (3655/23 = 158 with a remainder of 21); the 15th day of his emotional cycle (3655/28 = 130 with a remainder of 15); and the 25th day of his intellectual cycle (3655/33 = 110 with a remainder of 25) (Berry and DeLoach, 1978).

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