AN ABSTRACT OF THE THESIS OF

ELLA JEAN SMITH for the degree of MASTER OF SCIENCE

in EDUCATION presented on JUNE 7, 1979

TITLE: DIURNAL VARIATIONS OF BODY TEMPERATURE AND REACTION TIME ACCOMPANYING EARLY MORNING AND EVENING AEROBIC ROUTINES

Abstract Approved: Redacted for Privacy

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The primary purpose of this study was to determine the effects of early morning and evening bouts of aerobic exercise upon the diurnal pattern of reaction time and body temperature. An effort was made to classify subjects according to the rhythmic trends identified with 'morning' and 'evening' type persons.

Eight physically active male students of Oregon State University between the ages of 18 and 27 volunteered to serve as subjects. Four 'morning' and four 'evening' efficient types comprised the two test groups. Diurnal orientation was determined using questions designed to detect physiological and psychological orientation to the two extremes of day. Treatments consisted of three different jogging routines of six days each. Exercise bouts were submaximal, lasting 15-30 minutes. The first six day period all subjects ran at their customary time, establishing a baseline for subsequent comparisons. The two following weeks subjects were scheduled for periods of 0630 and 1830 running, in random order. During all three treatment periods, visual and auditory reaction time and temperature were

measured. Testing was accomplished on a rotating schedule of two and three-a-day visits at 0800, 1400 and 2000, or 1100 and 1700 hours. In this manner, the testing procedure was replicated three times, at 48 hour intervals for all individuals, over all treatment periods.

Two way analysis of variance was employed to determine effects of subject type and jogging schedule upon reaction time and temperature. The diurnal patterns that manifested themselves between 0800 and 2000 were analyzed by means of a triple classification ANOVA of trend components. The .05 level of confidence was the basis for rejection or acceptance of each hypothesis tested.

The results of the study indicated that: a) no significant difference of reaction time or temperature existed between evening and morning types, or between jogging regimes or interaction of those two variables; b) no significant differences existed between trends for subject types; however, c) reaction time and temperature variation over the day exhibited a rhythmic trend and; d) significant difference of trend between treatments was found.

Quantitatively neither exercise scheduling nor subject type affect the body's mean response as measured by reaction time and temperature. The curves of morning and evening persons were not significantly different. However, when compared with the control week, trends associated with evening and morning runs reflected phase purturbation indicative that the time of day one exercises can affect the synchrony of psychomotor performance and body temperature.

DIURNAL VARIATIONS OF BODY TEMPERATURE AND REACTION TIME ACCOMPANYING EARLY MORNING AND EVENING AEROBIC ROUTINES

by

Ella Jean Smith

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

Completed June, 1979
Commencement June, 1980

APPROVED:

Redacted for Privacy

Professor of Physical Education
in charge of major

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Redacted for Privacy

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Date thesis was presented June 7, 1979

Typed by CAMPUS PRINTING AND COPY CENTER (Mary Syhlman)

for ELLA JEAN SMITH

ACKNOWLEDGEMENTS

Though but a small token of appreciation in comparison to the debt, special thanks are due the following contributors:

Dr. Thomas N. Tillman, for your indefatigible faith and support through the full course of this project;

Dr. Donald E. Campbell, the educator and exercise physiologist I most admire;

Drs. Ruth Stiehl and Elizabeth Yearick, committee members;

Dr. John P. O'Shea, for your assistance throughout a major portion of the study.

Eight faithful volunteers who persevered a three week disruption of schedule and suffered through cold, dark mornings of 0630 runs.

Finally, I dedicate this effort to Edith Hilton. Happy Mothers' Day, Mom.

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CHAPTER I

INTRODUCTION

Investigators have reported that in the course of a normal day, performance in a variety of tasks varies according to a rhythmic pattern. These 24-hour periodicities have been termed circadian or diurnal rhythms. Vigilance tasks, reaction time, mathematical calculations and an array of cognitive tests have all been utilized experimentally to monitor 'psychic' and sensory motor processes. Two variations upon the human diurnal response pattern have been isolated, confirming the existence of individuals more or less predisposed to morning or evening efficiency,

In addition to psychomotor rhythms, most physiological processes, including those involving the nervous system, speed up or slow down, gain or lose efficiency, depending on the time of day. Normal body temperature displays a fairly constant 24-hour periodicity. Temperature follows the mental performance curve with regularity and has been established as the most useful physiological variable for comparison with performance devisions. Exercise has been shown to affect immediate mental performance changes, by altering level of arousal. Arousal levels may heighten or depress systemic and psychomotor functioning. However, research has not proven the delayed effects of exercise upon psychomotor performance.

Human biorhythms are not easily perturbed by external factors. When adaptation is affected a phase shift or flattening of the curve is seen. Although altered, rhythmic response remains intact.

Significance of the Study

Aerobic exercise in the form of jogging or running is becoming a national pastime. Concurrently, human biorhythmic response is under investigation. Knowledge of body rhythms has been used beneficially to both predict and explain performance of all kinds. Very little research has been done to date that enhances understanding of how exercise may affect or be affected by circadian rhythms. Joggers, athletes and educators can benefit by understanding more about the body's rhythmic responses to exercise.

Purpose of the Study

This study was initiated for the purpose of determining the effects, if any, jogging or running might have upon human performance throughout the day. The problem entailed establishing parameters of diurnal variation in performance as measured by the psychomotor task of reaction time and by the standard of temperature. The observations accumulated during the initial period wherein subjects exercised at their regular times were to be compared with subsequent periods of early morning and evening aerobic exercise. Since the exercise performance comparison involved the two daytime extremes; it was decided to observe morning and evening efficient, diurnal personality types as separate groups.

The central question of whether diurnal psychomotor performance is significantly affected by either early morning or late day regimes of aerobic exercise is more clearly analyzed in the context of three subsidiary questions. First, is a diurnal trend of the criterion measures detectable? Then, does the temperature or reaction time trend differ between diurnal types; or with diurnal type, between the three treatments of normally scheduled, morning and evening exercise? Finally, does trend vary with exercise schedule? To answer the questions stated above the following null hypotheses were formulated and tested at the $p = .05$ level of rejection:

Hypothesis one: No significant differences exist within either the reaction time or temperature variables as related to trend.

Hypothesis two: No significant difference in reaction time or temperature trend exists between diurnal types.

Hypothesis three: No significant difference in reaction time or temperature trend exists between exercise times.

Hypothesis four: No significant difference in reaction time or temperature trend exists between diurnal types by exercise time.

Delimitations and Limitations

Several restrictions were incorporated with the study design in order to diminish variability and to better utilize previous research findings. The study was restricted to male volunteers involved in programs of aerobic conditioning. Subjects were classified as either a morning or an evening diurnal personality type in an appraisal of best fit since a large subject pool would have been required to select pure variants. The testing involved measurement of oral temperature and both auditory and visual reaction time. Three exercise regimes, each imposed for a six day period of time, characterized the study as an observation of acute trend responses.

The limitations of available facilities necessitated testing one subject at a time. The number of tests was thus restricted to keep appointment times to a minimum. Furthermore, testing sessions had to be staggered about the designated hours and spread out over a 48-hour period. Finally, as a result of utilizing the quasi-experimental setting, subject adherence to guidelines for adequate rest and pretest cautions was difficult to monitor and control.

Definition of Terms

Rhythms are regularly fluctuating processes that repeat them selves in cycles. Rhythms, or periodicities that occupy periods of approximately a day (21-28 hours) are termed circadian or diurnal. Although the words diurnal and circadian are used interchangeably, 'diurnal' may be somewhat confusing in that it is also used in conjunction with 'nocturnal' to distinguish between day and night. This study uses 'diurnal' in both senses of the definition. It deals with functions that conform to a 24-hour period, but is fitted to daytime observations.

A diagramatic representative of a rhythm is presented in Figure 1. The time required for a single cycle is a period. Amplitude in this context will refer to the difference between the trough and the peak of the measured variable. Phase describes the time location of some point of a cycle, usually the peak or trough with reference to some external point such as local time or the beginning or end of sleep. When a phase-shift occurs the rhythm retains its form but is somewhat advanced or retarded.

Efficiency is frequently used in reference to system effectiveness. Assuming identical input such as the audible stimulus for reaction time, performance should vary according to the efficiency of mental and sensory processes.

Jogging and running are used interchangeably in this study and indicate a submaximal pace that can be sustained for a minimum of fifteen minutes.

Treatment, in this study, refers to a six-day period of either an imposed 0630 or 1830 jogging bout, or the initial six days of subject adherence to their normal time of jogging. 'Control period' and 'normally scheduled jogging' refer to that first six-day treatment.

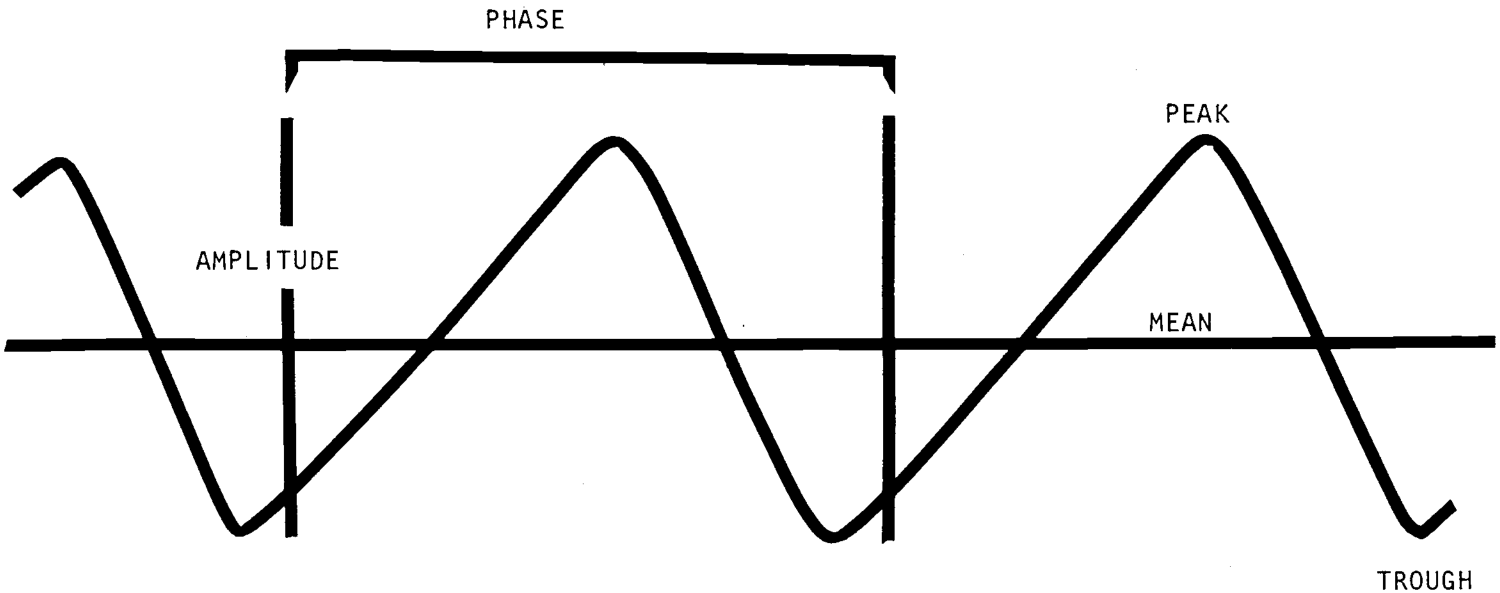


Figure 1. Nomenclature of a biorhythm.

Lark and *owl* trends are recognized as two common individual diurnal response patterns. Larks tend to experience psychological and physiological maximums earlier in the day than do owls.

CHAPTER II

REVIEW OF RELATED LITERATURE

Rhythmic patterns of overt behavior and biological response have long been recognized in many plant and animal life forms. Individuals sensitive to their body's daily rhythms may translate variations in response into subjective observations such as, "I do my best work early in the day...or late at night, etc." Indeed, two distinct and opposite diurnal response patterns have been classified as morning efficient types and evening efficient persons. Human biological, psychic, and motor functions have been monitored to reveal daily, monthly, and even yearly periodicities. Present knowledge is inconclusive relative to the control of rhythmicity. However, researchers are aware of a number of external modifiers that affect individual patterns. This study seeks to determine if physical exertion, specifically an aerobic routine, is capable of altering the circadian rhythms of eight male joggers, grouped according to their psychological and physiological orientation to the daytime extremes, morning and evening. The criterion indicators are reaction time and body temperature. The following review of biorhythmic research is aimed at providing an orientation to important concepts of diurnal cyclic variations in human performance, and presenting methodological approaches supportive of the procedures employed herein.

Circadian Rhythmicity

Biological and psychic variations that coincide closely with the alteration of day and night are termed 'diurnal' or 'circadian'. More definitively, any cycle that repeats itself every 21-28 hours is circadian. The time required for a single cycle is a 'period'. The reciprocal of period is its 'frequency'. As an example, the day/night cycle is completed once every 24 hours, a frequency of 1/24 (34).

Though extensive literature concerning cycles in plants, animals and insects exists, until recently human rhythmicity has not been intensively investigated. Aschoff (1) described more than 100 activities in humans which oscillate between maximum and minimum values diurnally. He noted variations in sleep and wakefulness, mental alertness, visceral and glandular activity, pulse and body temperature. In addition, 28- and 30-day, seasonal and even yearly rhythms have been reported (30).

Two categories of biological periodicity are recognized. The 'exogenous' cycle is entirely dependent on external oscillations, such as day and night. If environmental conditions are kept constant, the exogenous rhythm fades, or becomes desynchronized (34). According to some biorhythm theorists, an 'endogenous' rhythm has its own natural period, varying with the organism. The environment may influence the phase frequency of an endogenous rhythm, but periodicity will persist even in the absence of all external cues (7, 29, 34). Sollenberger (34) classifies all circadian rhythms as endogenous. Conroy and Mills (7) are of the opinion that endogeneity exists in varying degrees. These individuals adhere to the theory that rhythmicity is either inherent or integrated as an adaptive response very early in life. Brown (3), on the other hand, found support in his fiddler crab experiments for the theory that rhythms are extrinsically generated by geophysical factors. Though research is inconclusive as to the control of circadian behavior, all studies reviewed confirm the persistence of human biological processes that conform to a pattern only mildly disturbed by environmental influences. These functions are generally classified as endogenous and include the variables of concern in this study, body temperature and mental or psychological performance.

Exercise as a Rhythm Modifier

Researchers (7,21,22) are aware of a number of external modifiers or oscillators that affect individual patterns. On a grand scale, the dominant influences are termed zeitgebers. Included are light, temperature and surrounding regimens. These are external rhythms that because of their constancy, affect the synchronization of endogenous periodicities. Reinberg and Ghata (33) sum up the gross temporal relationship between endogenous rhythms and environmental or exogenous effects when they write that the way of life of an individual can alter the time of day minimal and maximal responses are manifested.

Arousal has frequently been associated with exertion (8, 9, 12, 13). Arousal is defined as a state of responsiveness to sensory stimulation and is also referred to as activation, alertness, vigilance, and sometimes wakefulness (12). Arousal occurs in degrees from high to low, never being totally absent. In fact, sensory keenness fluctuates with rhythmic dependability (13). Exercise can affect changes in arousal level. Researchers (29) correlating pulse, galvanic skin response and other physiological changes with performance of workers report that the effects of physical exercise could be detected in a person's diurnal test performance, brain wave response and general psychological tone. On the other hand, the effect of monotony and relative physical inactivity was reported to cause noticeable brain wave alteration in people in isolation (25).

In an attempt to shed some light on the degree of arousal optimal for enhanced mental functioning, Davy (10) experimented with the effects of three tasks upon success at a mental test. After familiarization with the Brown-Poulton test of mental alertness, he divided the 15 male and 15 female subjects into three groups for the different treatments. One group engaged in an alternative-tapping task, another pedaled a bicycle ergometer and the third group rested. Each treatment lasted two minutes. The results of mental test scores post-treatment were significantly higher after exercise, significantly lower after rest and somewhat lower after tapping. A follow-up study by Davy (10) employed the same format except that five treatments consisting of progressively more strenuous exertion were administered to the subject groups. The findings led Davey to reaffirm the inverted U hypothesis of the activation and performance relationship that a significant improvement in mental performance can be achieved after moderate exercise while maximal exercise and rest both produce deterioration.

Entrainment

Experiments with animals and humans have demonstrated that biological clocks can be reset to conform to environmental or other factors (3, 7, 17, 18, 21, 31). Reconditioning or regearing is termed entrainment. The frequency of cycles will adjust to unusual conditions, but it is not possible to eliminate phases, nor to make a rhythm disappear (34). If the timing of any synchronizer perturbs the endogenous rhythm the effect would be observed in one or a number of the following fashions: 1) a diminution of the differences between maxima and minima; 2) a time lag between them or 3) a phase shift identified by a periodicity that retains its form but is advanced or retarded to some degree (7).

How long does it take for the body's regularity to assume a new pattern in response to environmental alterations? Kleitman's studies (25, 26) of shift workers and imposed 28-hour day schedules noted body temperature rhythms that adapted immediately and others that did not change over the 30 day observation period. When subjects taken from a hospital population were placed on a schedule of daytime sleep and nightime wakefulness, body temperatures on the average did not show a regular rhythm for three weeks. Yet upon return to nightime sleep, body temperatures readjusted to normal after two to three days (29). Transmeridian flights provoked a perturbance of biorhythms that in eight subjects required an average of two weeks to correct (24).

Individual Variability

Kleitman's observations of adaptation to shift work or a 28-hour day schedule, ranging from immediate entrainment to no change at all, illustrate the significance of individual variability. Luce (29) observed that rhythmic phenomena are partially determined by physiological characteristics and are equally bound to be influenced by a person's habits. Two general personality types have, however, been identified according to individual rhythmic tendencies. Reinberg and Ghata (33) grouped morning efficient persons and evening individuals: for purposes here termed 'larks' and 'owls'. Their bases for classification have both psychological and physiological elements. Larks tend to experience physiological and mental maximums earlier in the day than do owls. The body temperature of a lark rises rapidly upon waking, while the nocturnal person's temperature rises gradually through the day. These tendencies were affirmed by Ostberg (32), who studied temperature response with a subject population consisting of 'evening' and 'morning' psychology students. The mean maximal temperatures were separated by five hours, coming at approximately 1200 for the morning group and 1715 for the evening sample.

Body Temperature, Reaction Time and Mental Performance

Body Temperature

One of the most frequently reported cyclic variables has been body temperature. It is simple to measure, displays a fairly constant 24-hour periodicity, and is not easily influenced by perturbing factors. The existance of a diurnal rise and nocturnal fall of body temperature for the nycterohemeral person has been accepted, though precise times of minima and maxima vary among observers (7). Kleitman (25) monitored volunteers confined to bed and found temperature rhythms persisted despite inactivity. The author's resulting conclusion was that the rhythms depended neither upon food intake nor muscular activity.

A widely reported temperature trend is an early morning increase from minimum, a late morning decrease and then a rise beginning early in the afternoon and continuing until an evening maximum is attained (5, 6, 7, 16). Colquhoun (6) monitored 70 young adult males for 24 hours during which the subjects followed a sequence of activities similar to that of the average industrial worker. During waking, oral temperature was recorded hourly. The range of variation in the smoothed curve was 1.19°F with a peak of 98.35° at 2000 and a trough of 97.16° at 0500. Temperatures increased to 60% of maximum by 1000. Between 0700 and 1000 the average hourly increment was .24°, roughly five times the rate of succeeding hours. Luce (29) reports that in testing the vigilance of navy recruits, oral temperature was measured hourly during waking and every two hours during sleep. The average temperature increment for the first three waking hours was 0.56°F and thereafter it changed only 0.4° during the remaining 60% of the day.

Reaction Time and Mental Performance

Hildebrandt (20) makes the claim that temperature over the 24-hour period is representative of diurnal variation in psychic performance and that its rhythm is parallel to that of body temperature. He goes on to say that the typical psychic pattern is one of two peaks, morning and afternoon, and a noon slump. The main trough occurs sometime after midnight. The majority of the authors reviewed agree with Hildebrandt's suggestion that reaction time and psychic performance vary together, although the exact times of peaks and troughs vary with experiments.

Reaction time has found wide and variable usage. Reaction time and EEG readings were employed as indicators of wakefulness in a study reported by Conroy and Mills (7). The two measures varied together. Hildebrandt and Engel (20) used reaction time as representative of a psychological task in a comparison of diurnal variation in psychic and physical performance. Luce (30) made reference to reaction time as an indicator of sensory acuity. Klein et al. (23), attempting to detect rhythmicity in mental performance, used auditory and visual reaction time as criterion measures. Frazier (15) monitored vigilance with reaction time among the four tasks administered. Blake (2) included reaction time in a battery of eight tests of mental performance efficiency. Colquhoun et al. (6), studying mental efficiency, chose three tasks, detection of an auditory signal on a noisy background, speed of adding two-digit numbers and reaction time. Hauty and Smith (19), in a classic study involving time zone displacement designed to monitor phase shift of physiological and psychological performance, included visual reaction time as one of seven psychological assessments.

Typically, reaction time was reported as the mean of a given number of trials. Published reports did not include tables of standard deviation or variance. Instrumentation and test procedure varied with each study, as did time of day and frequency of testing.

Temperature and Mental Performance

Most of the studies involving both body temperature and mental, sensory or motor tasks report covariance of temperature and performance. Kleitman (25) has been a prolific rhythm researcher. In one of his early studies five mental tasks were administered to six subjects (5). After 20 days a well marked rhythm of speed and accuracy had established itself. The minimal performances were early in the morning and late at night, while the maximal scores were reported at midday. Temperature and performance varied in parallel except between 1200 and 1800 when performance declined somewhat and temperatures rose slightly. Sensory-motor and sensory-mental functioning were observed in another experiment with five subjects (25). The observations were made at various times during the day on five to seven occasions. Performance decreased during the morning and early afternoon and improved with evening. Kleitman reported that performance was frequently related to the body temperature curve and that daily curves appeared unaffected by practice. The great majority of studies reviewed affirm Kleitman's appraisal of the temperature/performance agreement (2, 6, 22, 24, 25, 27, 28, 29).

Two interpretations have been offered by Kleitman (25) as an explanation for the temperature/performance relationship. One, assuming temperature change is a manifestation of biochemical interaction, he suggests that mental processes representing chemical reactions may themselves precipitate a temperature elevation. Alternatively, the speed of thinking parallels the metabolic rate in cerebral cortex cells. Temperature elevation is accompanied by more rapid metabolism and consequently mental activity speeds up.

Summary

Rhythmicity of response and function in humans appears to be innate. Though variability between humans exists, morning and evening response patterning for example, the trend of the nyctohemeral individual is characterized by a morning depression of temperature and arousal with a gradual warming/efficiency increase over the day. Covariance of temperature with mental function has been observed repeatedly. Rhythmic patterns are partially regulated by environmental cues and to a limited degree will adapt to alteration of external effects.

CHAPTER III

METHODS AND PROCEDURES

Investigative efforts have identified a number of physical and psychological processes that reflect circadian rhythmicity. Whether or not exercise can modify periodicity has not been established. The purpose of this experiment was to determine if exercise scheduling would affect the rhythmic patterns of temperature and reaction time. The experiment was conducted during the 1976 winter academic session at Oregon State University, Corvallis.

Subjects

Permission to test human subjects was sought and granted by the Oregon State University Committee for the Protection of Human Subjects (Appendix A). In order to reduce the number of variables only male subjects were sought. Individuals accustomed to regular, aerobic running routines of at least four, 15 to 45 minute bouts per week were sought in order to reduce physiological stress due to the training. Fitness classes offered by the Department of Physical Education provided the logical source for subjects.

First, prospective volunteers were interviewed to impart information about the study, ascertain the adaptability of individual schedules to the testing situation and screen for personality types. Questions concerning normal rising and retiring times, food consumption patterns, subjective feeling during the day and routines of work and exercise were utilized to determine the joggers' orientation to the day. The questions, derived from the work of Ostberg, are replicated in Appendix B. Subjects, thus classified, are henceforth, referred to as 'larks' (morning people) and 'owls' (the evening preference).

Eight male university students ranging in age between 18 and 26 were recruited. Subjects signed a written acknowledgement of willingness to participate (Appendix C) with the understanding that they could withdraw from the study at their discretion. A medical approval was required to certify their fitness for participation (Appendix D). A preliminary testing and orientation session was arranged for each subject. Procedural familiarization and reduction of a learning effect with regard to the reaction time tests were the objectives. A list of precautions and a verbal explanation of the reasons why particular practices might influence test results (Appendix E) was disseminated at that time. Specific exercise duration and intensity guidelines were included to insure at least a minimal circulorespriatory overload and still allow for recovery between exercise and testing. Each participant was given a form on which to record times of food consumption, rest and exercise (Appendix F). The form was designed to aid subjects in their adherence to a precise schedule.

Temperature and reaction time were selected as criterion measures. Male college students (n=8) accustomed to regular, vigorous exercise in the form of jogging served as subjects. Subject type was designated as an independent variable to facilitate analysis based upon the foreknowledge that circadian patterns vary between early day and late day individuals. Subjects were grouped with larks numbered one through four and owls as five to eight. Subject type was identified for computational purposes as factor A, larks being a_1 and owls a_2.

The three exercise regimes of normally scheduled, early morning and late day runs were termed treatments, or factors b_0, b_1 and b_2 respectively. The self-determined routine was considered to be the 'control' or b_0 period. This, the first treatment for all subjects, served to establish a baseline for comparison with the two imposed or experimental routines (b_1, morning and b_2 evening jog). The subjects served as their own controls and participated in all three periods of running and testing. Each period consisted of six exercise and test days. A seventh, rest day was interposed between routines, so that each week a new schedule was initiated. Thus, 'period' and 'week' are used interchangeably with 'treatment'. Scheduling of treatments is shown in Table I.

The testing schedule corresponded to the treatment periods. Each day an individual ran he was tested. The test procedure consisted of measuring body temperature, and auditory and visual reaction time at designated times throughout the waking hours. The master schedule for all three weeks of testing follows in Table II.

TABLE I. Schedule of jogging treatments with b_o = Control Period B_1 = Morning Jog and B_2 = Evening Jog.

Type	Subject	Week 1	Week 2	Week 3
Lark	1	B_o	B_1	B_2
	2	B_o	B_2	B_1
	3	B_o	B_1	B_2
	4	B_o	B_2	B_1
Owl	5	B_o	B_1	B_2
	6	B_o	B_2	B_1
	7	B_o	B_1	B_2
	8	B_o	B_2	B_1

TABLE II. Schedule of testing for all treatment periods.

Day		HOUR 0800	1100	1400	1700	2000
1	Ss	1,3,5,7	2,4,6,8	1,3,5,7	2,4,6,8	1,3,5,7
2	Ss	2,4,6,8	1,3,5,7	2,4,6,8	1,3,5,7	2,4,6,8
3	Ss	1,3,5,7	2,4,6,8	1,3,5,7	2,4,6,8	1,3,5,7
4	Ss	2,4,6,8	1,3,5,7	2,4,6,8	1,3,5,7	2,4,6,8
5	Ss	1,3,5,7	2,4,6,8	1,3,5,7	2,4,6,8	1,3,5,7
6	Ss	2,4,6,8	1,3,5,7	2,4,6,8	1,3,5,7	2,4,6,8

Criterion Measures and Administrative Procedures

Testing of the subjects was conducted in the Psychomotor Laboratory in the Department of Physical Education, Oregon State University, Corvallis. The criterion measures consisted of temperature, and auditory and visual reaction times. Temperature was taken sublingually at each sitting, using a clinical thermometer scaled for 0.2°F increments. Readings were observed to the nearest one-half gradation, or 0.1°.

The device used to measure reaction times was manufactured by Lafayette Instrument Company. The measurement procedure was initiated by the tester operating a manually activated cueing box. The cueing apparatus initiated either auditory or visual stimuli. A wooden shield made possible the discreet use of the activating switch. Both visual and auditory stimuli were timed to occur between one and five seconds in random fashion after the verbal 'ready' signal was given. Fifteen trials each of audible and visual reaction time were recorded (Appendix G). The first trial was subsequently eliminated and a mean time derived from the remaining observations to establish the criterion score.

Experimental Design

The experiment was designed to consider the factors of variable subject types and three different aerobic exercise schedules. Provision was made to calculate the effects of these independent variables upon diurnal performance curves. The testing facilities dictated that at most, four individuals could be scheduled an hour. Therefore, observations at the hours 0800, 1100, 1400, 1700 and 2000 were collected over a 48 hour period, with subjects alternating between two and three sessions of testing a day. Over the span of six days, three repeated measures were recorded at each of the five designated times. Experimental control was enhanced and replications multiplied by entering all respondents into every treatment, thus strengthening the external validity. Internal validity was enhanced with a counterbalanced testing design employing the Latin-square arrangement for randomization of subjects that controlled the effects of treatment sequencing and made it possible to test both for main effects and for interactions of group differences and time of day. Campbell and Stanley (4) explain in detail the use of this quasi-experimental approach.

Statistical Procedures and Reduction of Data

The experimental model was designed to analyze effects throughout the day ($T=t_1, t_2 \ldots t_5$) of three jogging programs or treatments ($B=b_o, b_1, b_2$) upon the criterion measures of reaction time and temperature with reference to subject diurnal type ($A=a_1, a_2$). See Figure 2. A triple classification, two by three by five analysis of variance (Figure 3) was used to test the hypotheses.

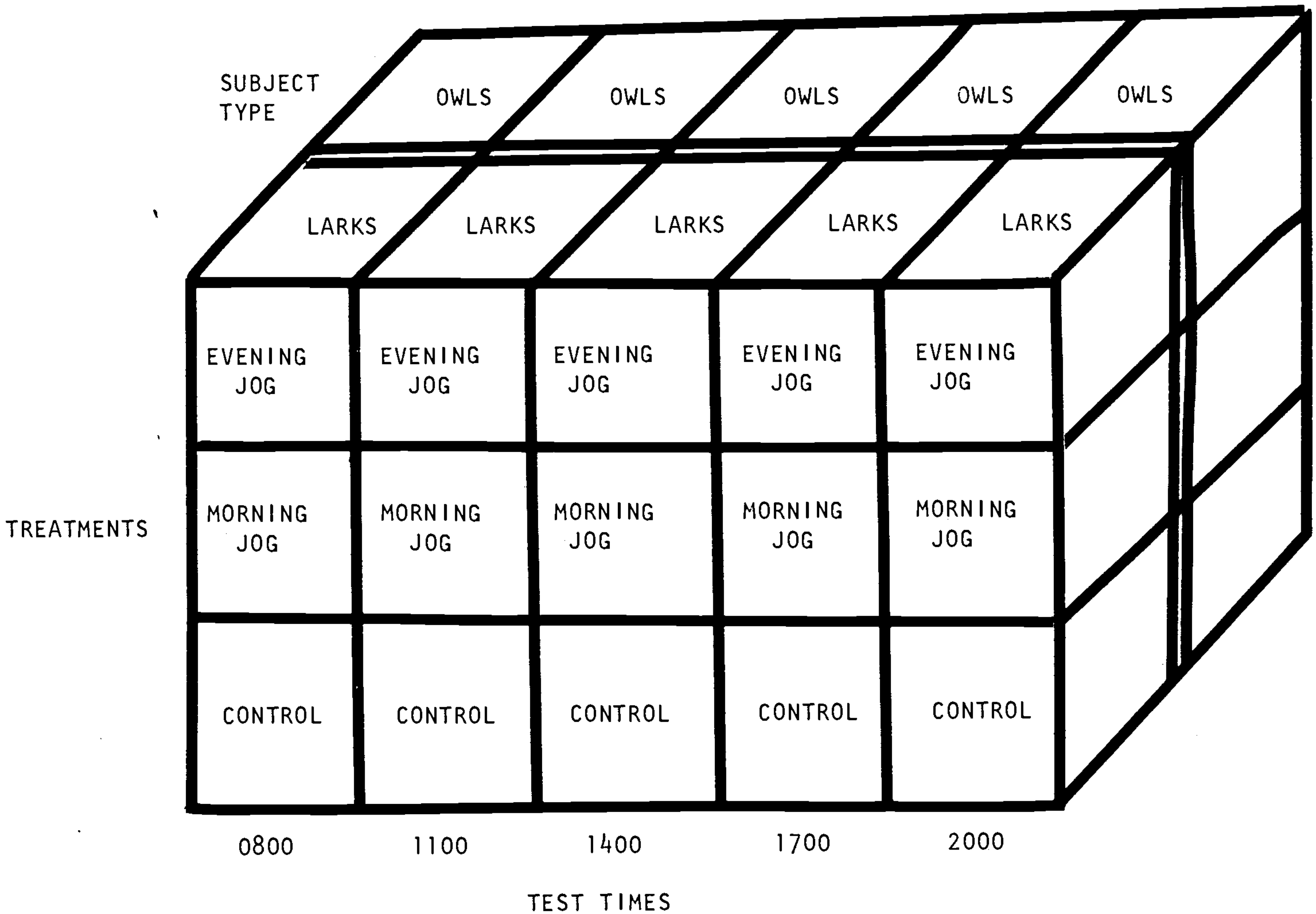


Figure 2. Factor model. Two by three by five triple classification.

A_1			A_2		
B_0	B_1	B_2	B_0	B_1	B_2
T_1	T_1	T_1	T_1	T_1	T_1
T_2	T_2	T_2	T_2	T_2	T_2
T_3	T_3	T_3	T_3	T_3	T_3
T_4	T_4	T_4	T_4	T_4	T_4
T_5	T_5	T_5	T_5	T_5	T_5

Figure 3. Two by three by five triple classification analysis of variance model with A = Subject Type, B = Treatment Period and T = Time of Day.

Analysis of variance for each dependent variable and analysis of trend components were calculated for main effect and interaction with the independent variables. The statistical program allowed for involvement of two factors, each at two or more levels, as well as trial means (Figure 3.). Subject type was the 'A' designate with a_1 representing larks and a_2 owls. The treatment factors, or jogging programs, B, were the control week (b_o), an early morning regime (b_1) and an evening jog (b_2). Scores for the dependent variables of reaction time, visually and audibly cued, and temperature consisted of means derived from the three trials per treatment at each of five testing times. The ANOVA trend profiles allowed for interpretation of the linear, quadratic, cubic and quartic components of the dependent variables over time. Graphically these components are illustrated in figure 4. A detailed description of computational procedure and interpretation of trend is presented by Edwards (14).

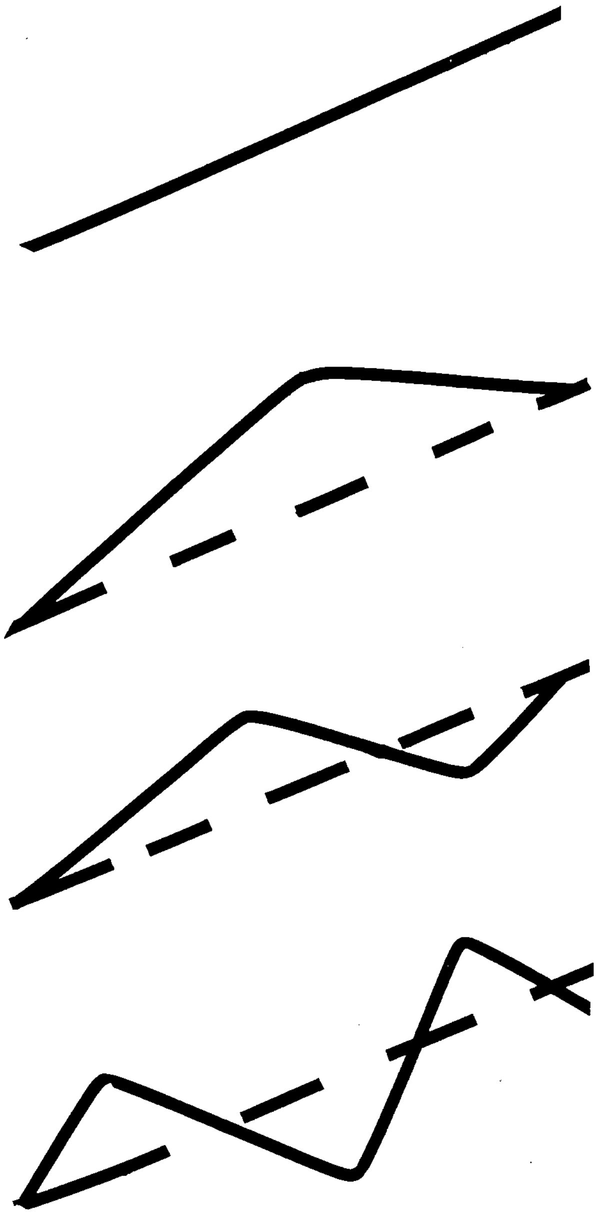
F values were used as the basis for rejection at the p = .05 level for the two-tailed null hypotheses formulated on the basis of the central question of whether diurnal psychomotor performance would be significantly affected by an early morning or late day regime of jogging. The hypotheses tested were:

1. No significant trend differences exist in reaction time or temperature among times of day of testing.

   (T = time of day)

   H_o: $T_1=T_2=T_3=T_4=T_5$

   H_a: $T_1 \neq T_2 \neq T_3 \neq T_4 \neq T_5$



Linear configuration coincides closely with a line of best fit.

Quadratic configuration about the trial means.

Cubic configuration about the trial means.

Quartic configuration about the trial means.

Figure 4. Graphic representation of trend components.

2. No significant difference in reaction time or temperature trend exists between diurnal types (TA).

   H_o: $TA_1 = TA_2$

   H_a: $TA_1 \neq TA_2$

3. No significant difference in reaction time or temperature trend exists among exercise times (TB).

   H_o: $TB_0 = TB_1 = TB_2$

   H_a: $TB_0 \neq TB_1 \neq Tb_2$

4. No significant difference in reaction time or temperature trend exists between diurnal types by exercise time (TAB).

   H_o: $TA_1B_{0-2} = TA_2B_{0-2}$

   H_a: $TA_1B_{0-2} \neq TA_2B_{0-2}$

CHAPTER IV

PRESENTATION AND INTERPRETATION OF DATA

This experiment was designed to observe effects of early morning and evening regimes of exercise upon the pattern of diurnal variation in body temperature and reaction time. Subjects were grouped as morning (lark) or evening (owl) types, according to their affinity toward and alertness during those diurnal extremes. Eight volunteer joggers served as their own controls for a period of six days, exercising at their normal times and undergoing testing at the five designated times of day as described in the previous chapter. The purpose of the control period was to establish subjects' normal diurnal rhythms with respect to the dependent variables of temperature and reaction time. Subjects were then alternately assigned to six-day periods of 0630 and 1830 jogging combined with testing. The fit of larks and owls in this study with reported norms for those two subject types is viewed. A graphic comparison of the introduced jogging routines and the control week follows, in preparation for the statistical evaluation of trends in ANOVA format. The results of temperature observations are reported first, followed by visually and then audibly cued reaction time.

Presentation of Data

Subject Type

The first period of normally scheduled exercise was designed to observe normal temperature and reaction time rhythms and the normal, subject type response differences. Previous research (33) indicates that the body temperature of a lark rises rapidly upon waking, while a nocturnal person's temperature rises gradually through the day. Ostberg (32) reports equal mean group temperatures over all times. However, mean maximal temperatures came at approximately 1200 for larks and 1715 for owls, a separation of five hours. Control temperatures of larks and owls for this study, as shown in Figure 5, did not resemble the pattern expected. The warming occuring between 0800 and 1400 was 63% of the difference between minimum and maximum for larks and 81% for owls. The lowest temperatures were observed at 0800 and the highest at 2000 for both groups. Average temperatures over all control times were 96.9 for larks and 97.8 for owls.

Type specific response was more stereotypical for reaction time than for temperature. Observing the grouped, control period visual reaction time of Figure 6, rapid improvement to a 1400 maximal is seen of larks and more gradual quickening to a 2000 high is shown by owls. Subject type audible reaction trends are at least marginally typical of those groups. Figure 7 illustrates that the greatest speed increment for larks was between 0800 and 1100 in what amounted to 73% of the difference between the maximal and minimal reaction time. Owls too, gained most of their improvement early in the day,

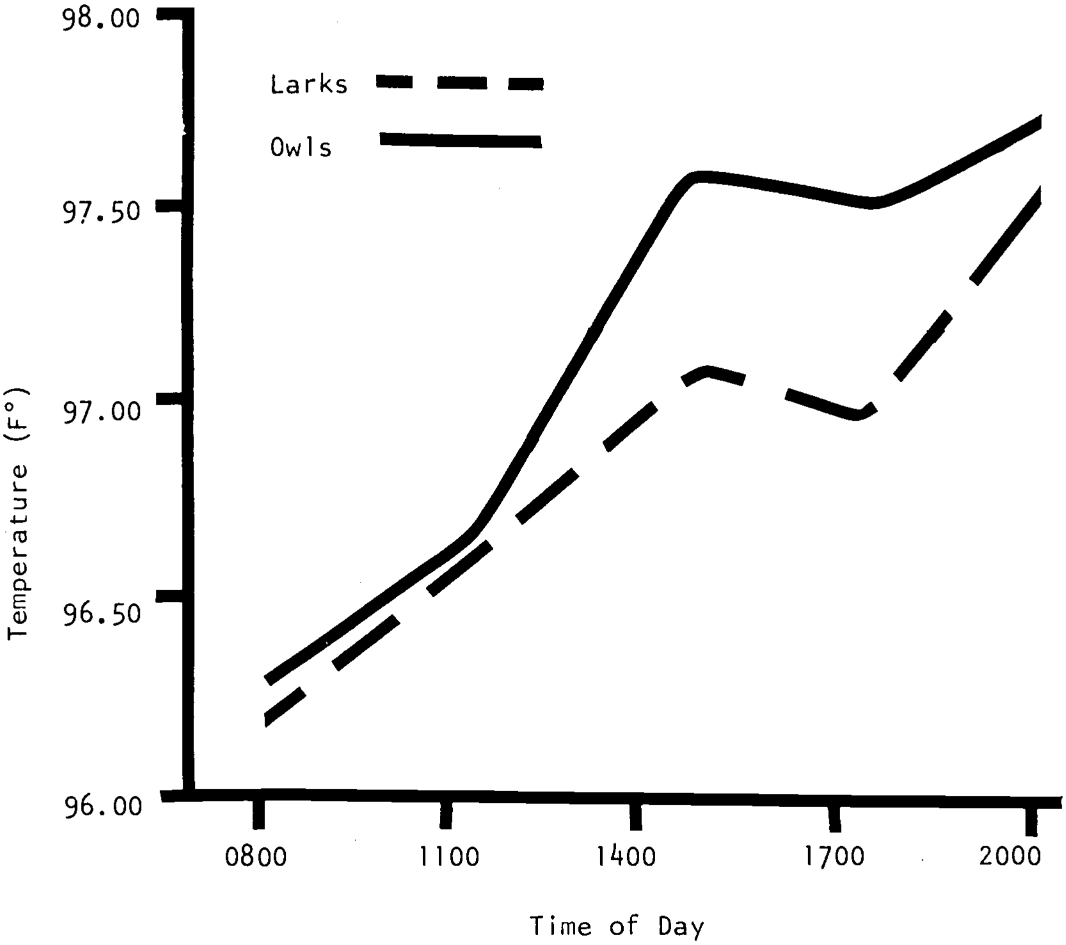


Figure 5. Control period temperatures over the day. Larks and Owls.

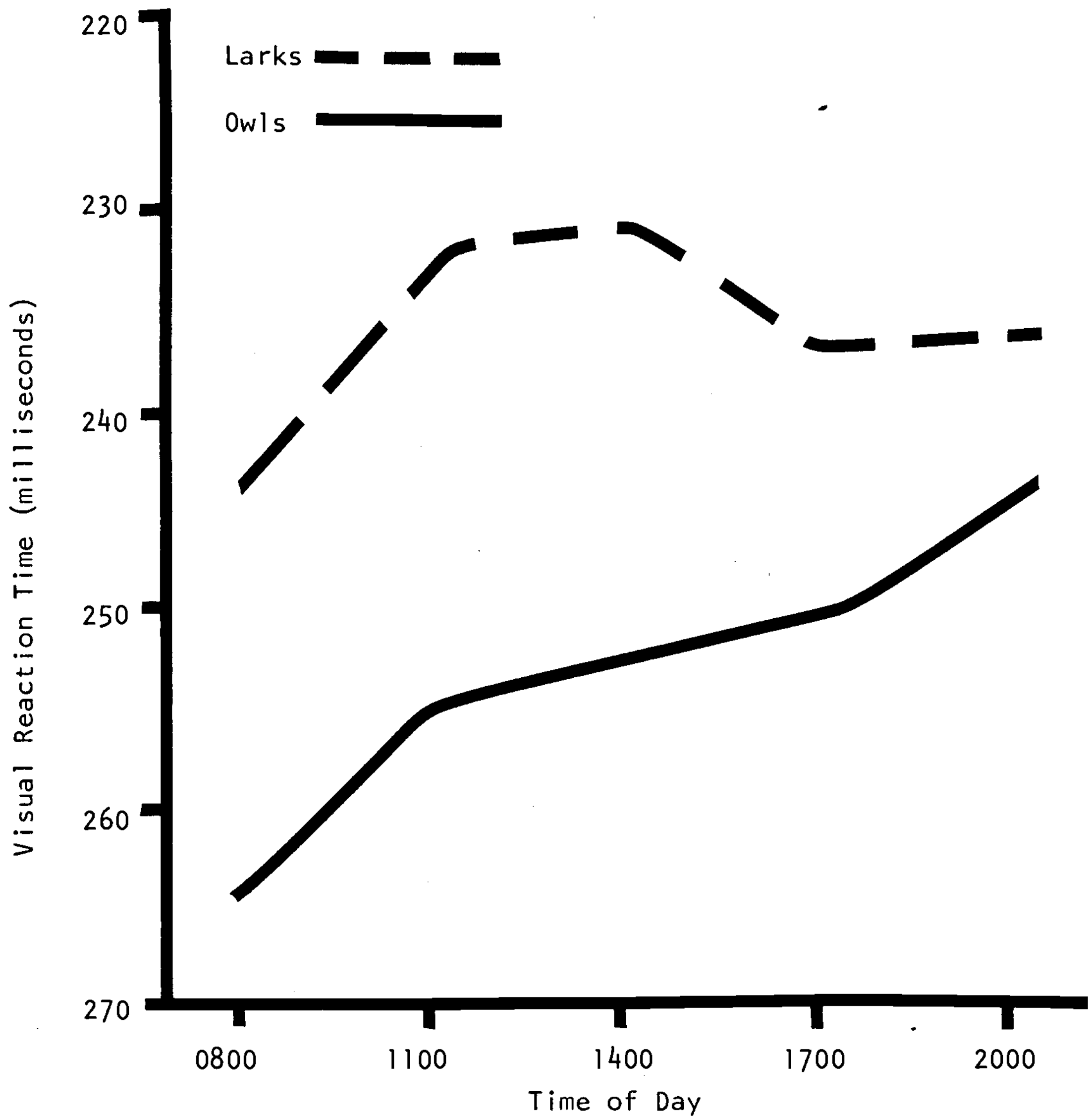


Figure 6. Control period, visual reaction times over the day for Larks and Owls.

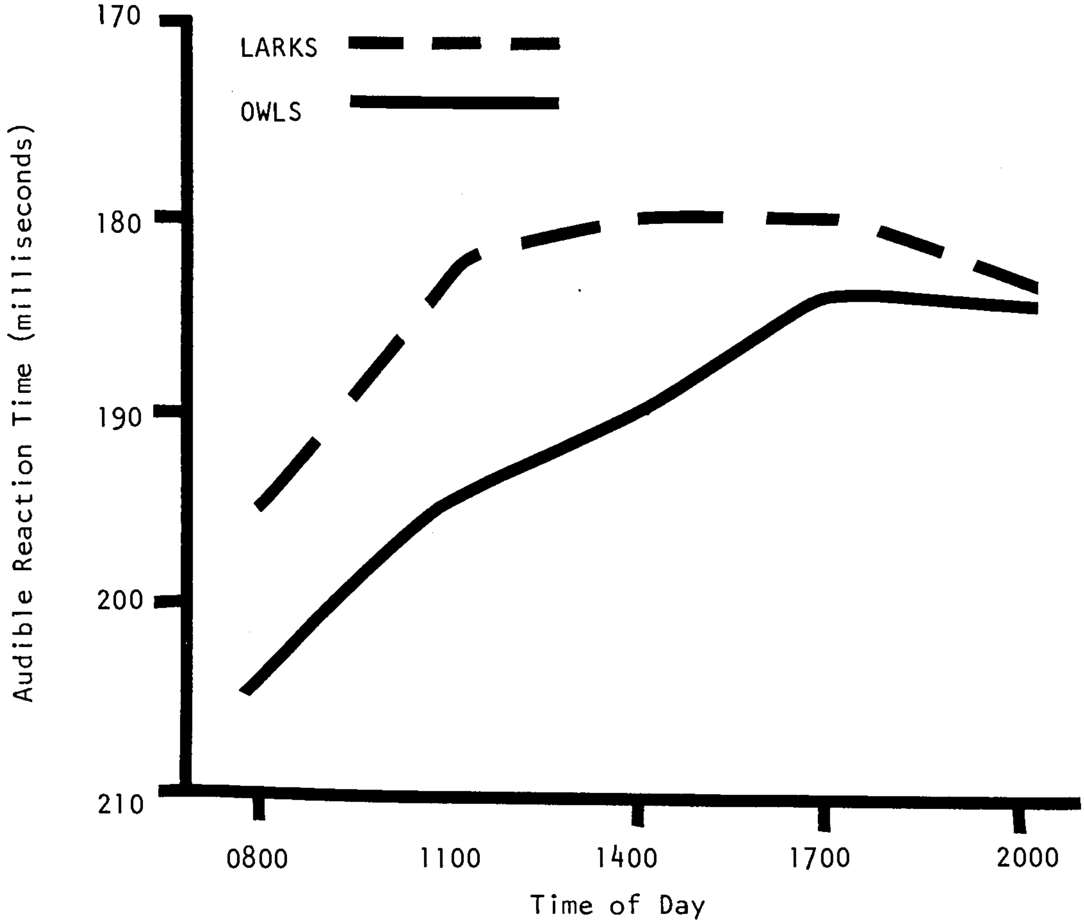


Figure 7. Control period, audible reaction times over the day for Larks and Owls.

but at a more gradual rate (50%, 20% and 30%). Peak speed for both groups was attained by 1700.

Cumulative main effect means are presented in Appendix H. Tables for ANOVA of main effect means appear in Appendix I. Grouped according to subject type, these means were not significantly different for temperature or either reaction time.

Trend

A standard pattern of temperature and mental performance for the waking hours, taken from a review by Colquhoun (5), is that of rapid warming and efficiency improvement between 0800 and 1100, with the trend continuing upward more gradually over the next nine hours to an evening maximum at 2000. Some studies (6, 7, 16) report a late morning or early afternoon decrease and recovery, described as a dip.

Temperature Trend

The trends of non-grouped temperatures for the imposed morning and evening jogging schedules (B_1 and B_2) and their relationship to the norms generated in the control period (B_o) are reproduced graphically in Figure 8. The phase amplitudes of morning and evening jog treatments are diminished 0.8° to 1.0°, respectively, from the control value of 1.6°. The mean temperature for both the imposed schedules was 4.0° higher than during the control period. Rhythm response to the morning jog was one of increased early day values and depressed evening temperatures, whereas, the evening run produced more or less linear increments to a maximal at 2000.

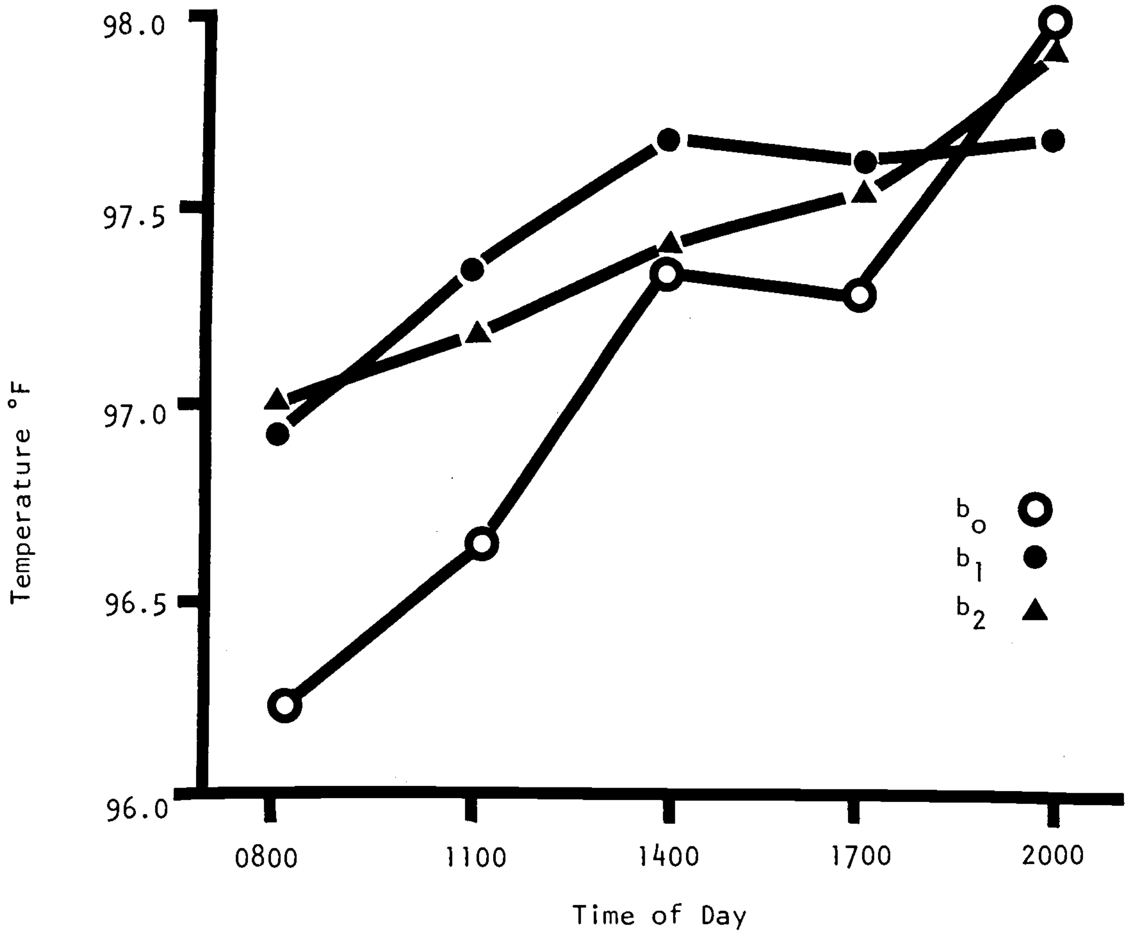


Figure 8. Temperatures by treatment and time of day for all subjects.

Table III. Two by three by five triple classification ANOVA of temperature trend.

Source	M.S.(10^4)	D.F.	F-Ratio[a,b]
Within	3159.815	96	
Time - Time of Day	45744.586	4	40.220
Linear	172985.611	1	121.574
Quadratic	3036.014	1	N.S.
Cubic	1322.270	1	N.S.
Quartic	5634.448	1	5.963
TA - Time by Subject Type	584.120	4	N.S.
Linear	1385.601	1	N.S.
Quadratic	24.107	1	N.S.
Cubic	366.713	1	N.S.
Quartic	560.060	1	N.S.
TB - Time by Treatment	3337.225	8	2.934
Linear	8924.497	2	6.272
Quadratic	3228.079	2	N.S.
Cubic	0.741	2	N.S.
Quartic	1195.582	2	N.S.
TAB - Time By Type by Treatment	1179.953	8	N.S.
Linear	1868.934	2	N.S.
Quadratic	1438.787	2	N.S.
Cubic	689.629	2	N.S.
Quartic	722.459	2	N.S.
Error (W)	1137.361	72	
Linear	1422.885	18	
Quadratic	1071.696	18	
Cubic	1108.904	18	
Quartic	944.959	18	

[a] $P \leq .05$

[b] $P \geq .05$, F-Ratio not significant

The two by three by five, triple classification ANOVA confirmed the occurrence of patterned rhythmical response to a significant degree. The analysis of trend components is presented in Table III. Significant variability of temperature, over the day (T), F = 40.22, is reflected in a highly linear (L) F value of 121.57 and somewhat quartic (Q) trend profile, F = 5.96. The curve illustrates a gradual warming over the day interrupted temporarily by a mid-afternoon depression (Figure 9). Significance was also computed for trend differences attributed to treatments (TB) with an F = 2.93 most pronounced in the linear aspect, F = 6.27. Subject type (TA) and type by treatment (TAB) were not significant sources of variability between temperature trends.

Visual Reaction Time Trend

A comparison of the three visual reaction time treatment periods for all subjects is graphed in Figure 10. The morning jog routine was followed by increased rapidity of response that prevailed until 1400 and then dropped. The evening run period was characterized by slight, erratic reaction improvement between 0800 and 1400 and pronounced improvement between 1400 and 2000.

The triple classification trend analysis of Table IV indicates that visual reaction time scores exhibit a significantly linear pattern over the day with F of Trend = 5.99 and F of Linearity = 25.06. Figure 11 presents the curve. Difference between trends attributable to treatment effect was found (F of Trend for Treatment = 2.54 and F of Linearity = 5.40). The analysis did not reveal significance difference between trend specific to subject type or subject type by treatment.

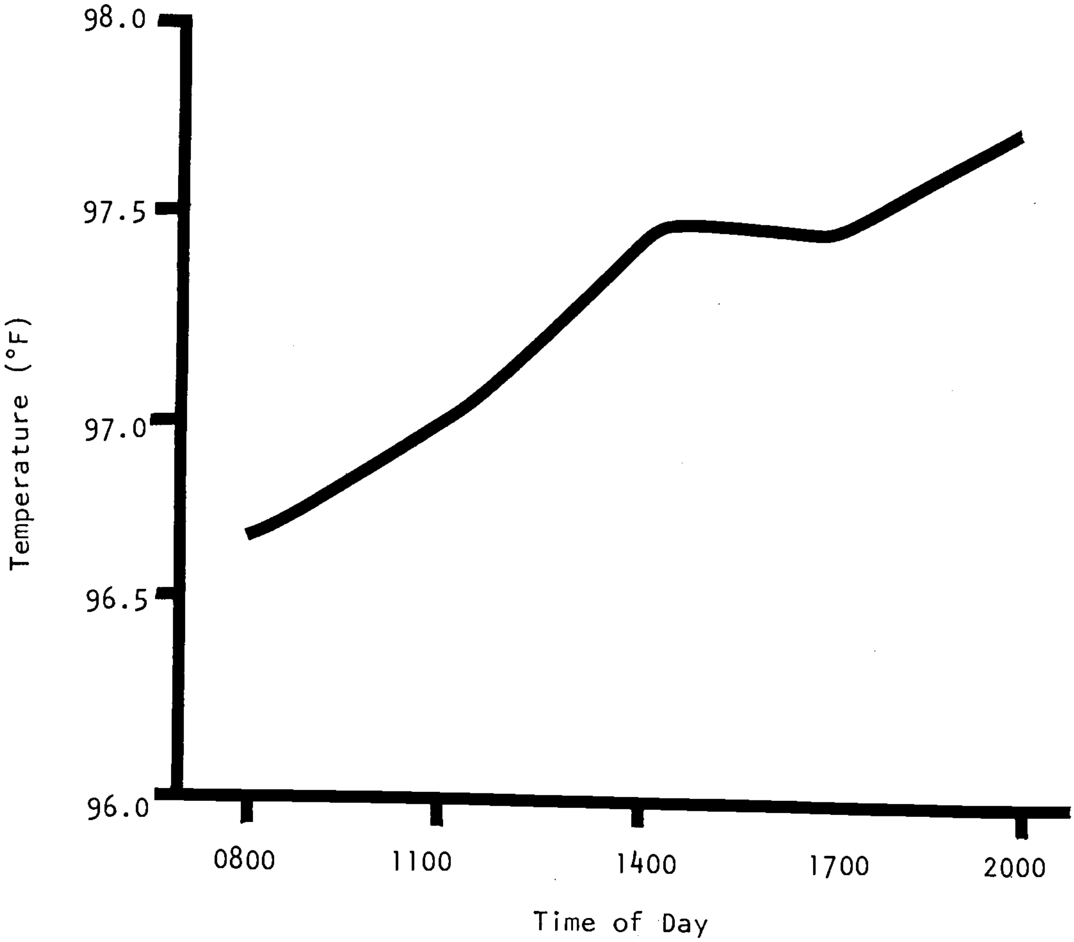


Figure 9. Mean temperature trend over all treatments for all subjects.

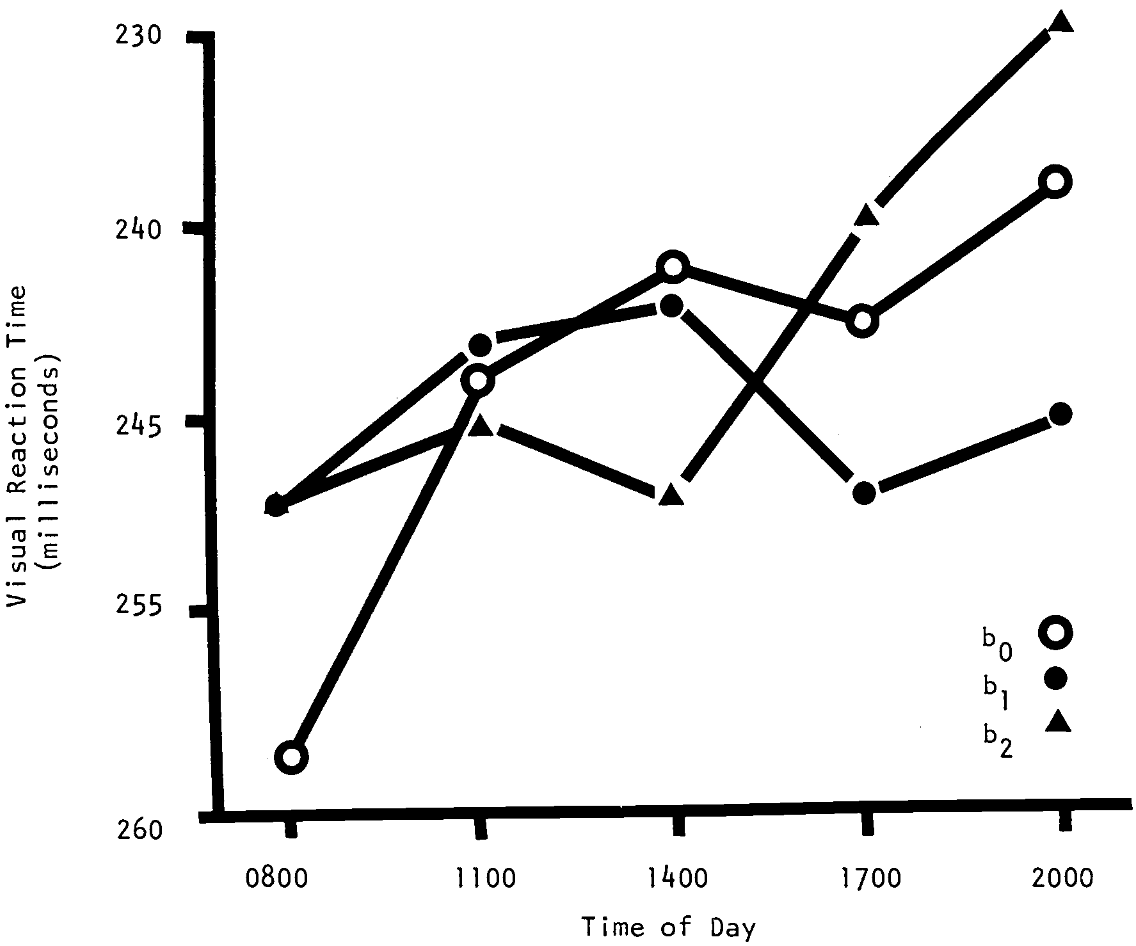


Figure 10. Visual reaction times by treatment and time of day for all subjects.

Table IV. Two by three by five triple classification ANOVA of visual reaction time trend.

Source	M.S.	D.F.	F-Ratio[a,b]
Within	6667.637	96	
T - Time of Day	29625.203	4	5.991
Linear	103693.871	1	25.056
Quadratic	1968.719	1	N.S.
Cubic	12581.962	1	N.S.
Quartic	256.262	1	N.S.
TA - Time by Subject Type	4761.530	4	N.S.
Linear	5587.543	1	N.S.
Quadratic	3885.928	1	N.S.
Cubic	9553.845	1	N.S.
Quartic	18.804	1	N.S.
TB - Time by Treatment	12545.948	8	2.537
Linear	22355.603	2	5.402
Quadratic	17644.766	2	N.S.
Cubic	4776.542	2	N.S.
Quartic	5386.880	2	N.S.
TAB - Time by Type by Treatment	5768.625	8	N.S.
Linear	29753.445	2	4.773
Quadratic	2938.950	2	N.S.
Cubic	804.280	2	N.S.
Quartic	577.826	2	N.S.
Error (W)	4944.856	72	
Linear	4138.440	18	
Quadratic	5802.324	18	
Cubic	5149.590	18	
Quartic	4689.071	18	

[a] $P \leq .05$

[b] $P > .05$, F-Ratio not significant

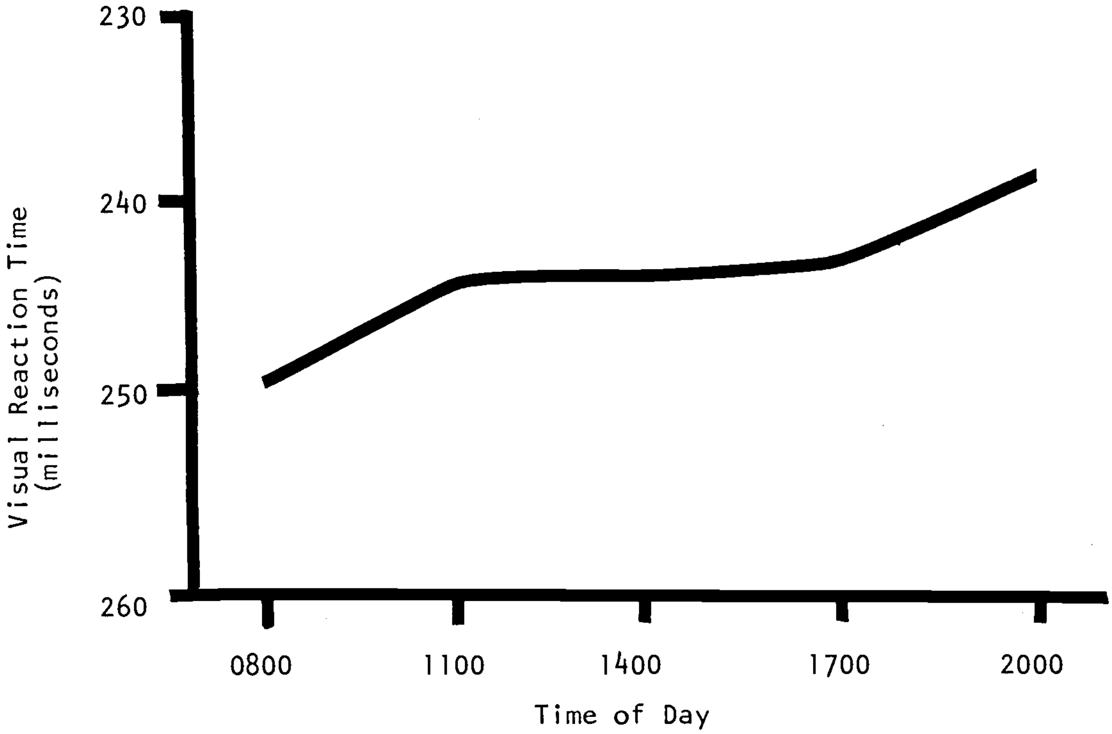


Figure 11. Mean visual reaction time trend over all treatments for all subjects.

Auditory Reaction Time Trend

The most obvious trend difference between the treatment periods, as shown by auditory reaction time (Figure 12), is the heightened speed for the morning and evening runs. Neither visual reaction time nor temperature reflect a similiar improvement. The 0800 reaction time was elevated after an early morning jog. Speed of reaction then slowed to 1100 before improving again to a 1700 high. Response to the evening jog elicited a curve with a desynchronized appearance characterized by drastic alternations between improved and diminished response.

The analysis over time (Table V) revealed significant trend tendencies, F of Trend = 6.24. The curve was highly linear (F = 16.00) and, to a lesser degree, quartic in form (F = 6.65), shown as an erratic, but upward tending line in Figure 13. Again, reaction times between treatments were significantly different (F of Trend for Treatment = 3.21) particularly in the linear aspect (F = 5.92). Audible reaction time, as with visual reaction time and temperature, showed no significant subject type effect, either in the TA or TAB analyses.

Interpretation of the Data

This study was initiated for the purpose of determining what effects, if any, jogging schedules might have upon circadian patterns of human performance. A two by three by five triple classification, quasi-experimental statistical design and an analysis of variance capable of examining the trends of repeated trials over the day

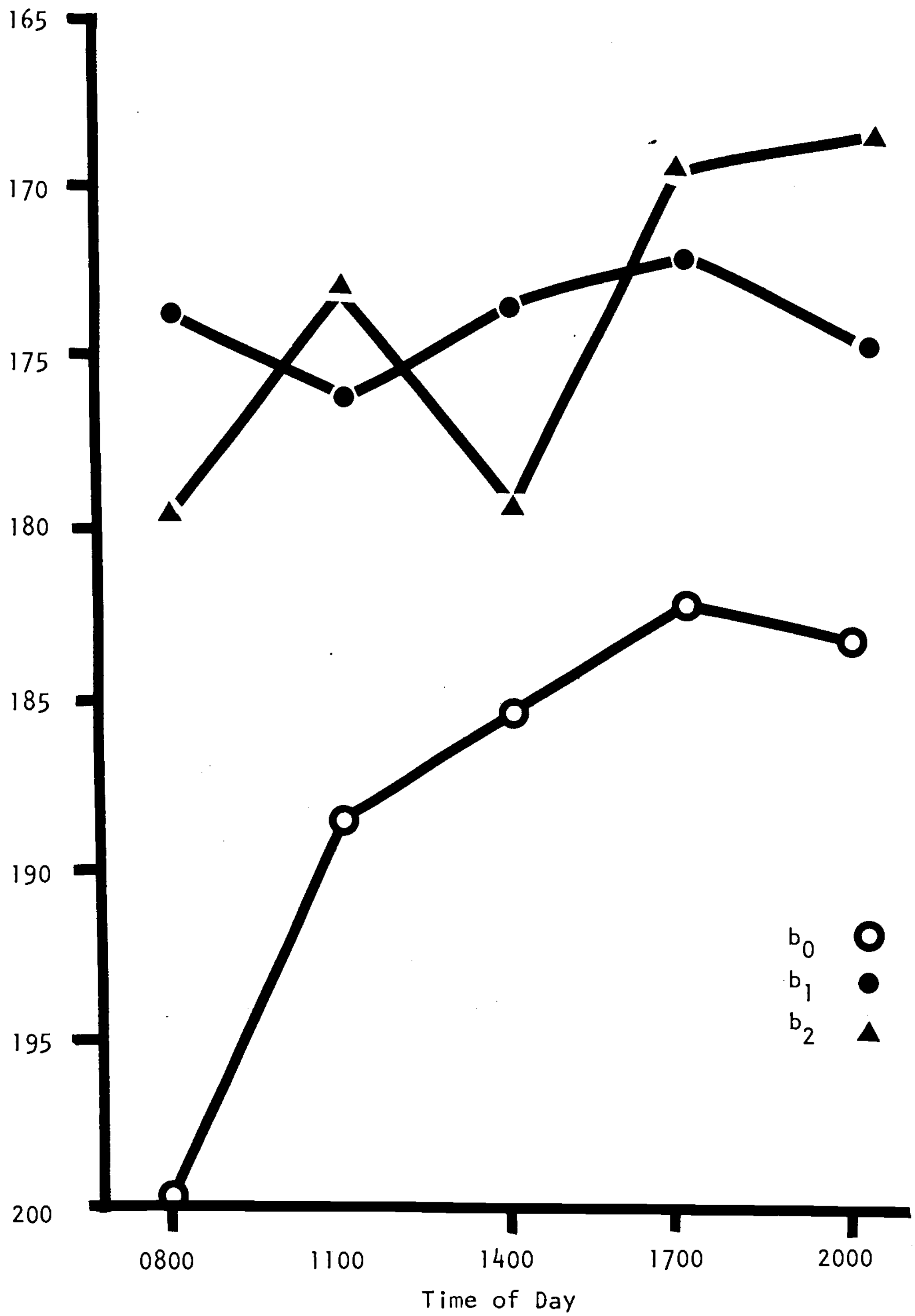


Figure 12. Auditory reaction times by treatment and time of day for all subjects.

Table V. Two by three by five triple classification ANOVA of auditory reaction time trend.

Source	M.S.	D.F.	F-Ratio[a,b]
Within	6572.302	96	
T - Time of Day	81194.628	4	6.242
Linear	100258.200	1	16.005
Quadratic	7380.375	1	N.S.
Cubic	34.239	1	N.S.
Quartic	17105.738	1	6.645
TA - Time by Subject Type	3360.388	4	N.S.
Linear	6769.401	1	N.S.
Quadratic	5019.089	1	N.S.
Cubic	1463.673	1	N.S.
Quartic	189.390	1	N.S.
TB - Time by Treatment	16059.463	8	3.213
Linear	37059.430	2	5.916
Quadratic	15179.199	2	N.S.
Cubic	3924.686	2	N.S.
Quartic	8074.537	2	N.S.
TAB - Time by Type by Treatment	551.303	8	N.S.
Linear	1573.050	2	N.S.
Quadratic	41.797	2	N.S.
Cubic	142.101	2	N.S.
Quartic	448.263	2	N.S.
Error (W)	4977.705	72	
Linear	6264.256	18	
Quadratic	7451.545	18	
Cubic	3700.938	18	
Quartic	2574.080	18	

[a] $P \leq .05$

[b] $P > .05$, F-Ratio not significant

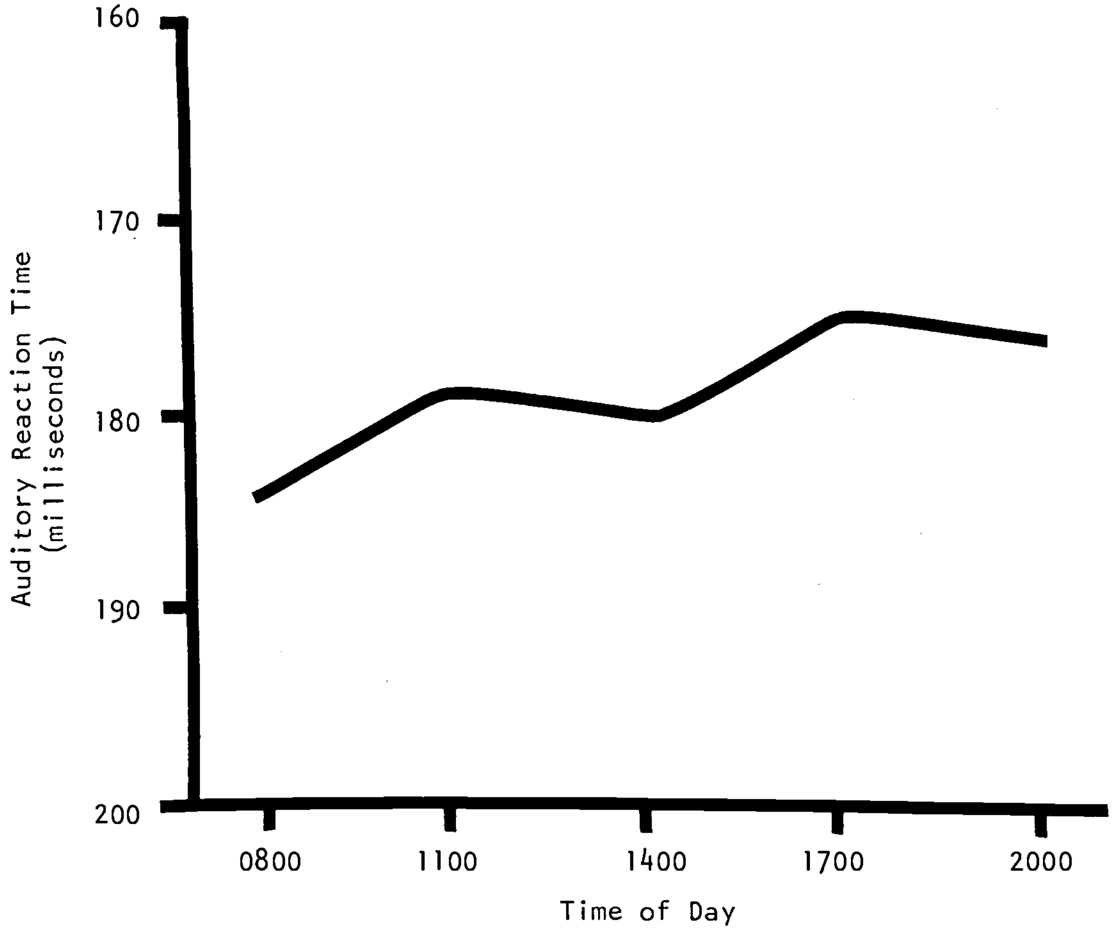


Figure 13. Mean auditory reaction time trend over all treatments for all subjects.

was utilized to determine the validity of the four hypothetical statements considered. The hypotheses are as follows:

1. No significant difference of reaction time or temperature exists among the five test times of day (T = time of day).

   H_o: $T_1=T_2=T_3=T_4=T_5$

   H_a: $T_1 \neq T_2 \neq T_3 \neq T_4 \neq T_5$

2. No significant difference in reaction time or temperature trend exists between diurnal types (TA)

   H_o: $TA_1=TA_2$

   H_a: $TA_1 \neq TA_2$

3. No significant difference in reaction time or temperature trend exists between exercise times (TB).

   H_o: $TB_0=TB_1=TB_2$

   H_a: $TB_0 \neq TB_1 \neq TB_2$

4. No significant difference in reaction time or temperature trend exists between diurnal types by exercise time (TAB).

   H_o: $TA_1B_{0-2}=TA_2B_{0-2}$

   H_a: $TA_1B_{0-2} \neq TA_2B_{0-2}$

<u>Subject Type</u>

Subject typing was accomplished by means of questions, adapted from Ostberg's study (32), pertaining to waking, sleeping, eating, studying and exercising routines. Not every individual responds as either a true lark or an owl would. Instead, a continuum of responses between the two extremes is normally found. Unlike Ostberg's subjects who were carefully screened to represent classic examples of larks and owls, due to a small pool of volunteers, the subjects of this study were grouped according to 'best fit'. The temperature curves of owl/lark designates observed here did not conform to expectations based on former research. However, reaction time, particularly visually cued, did fit the predicted forms.

Even though criterion trend responses were variable the analysis of main effect means clearly indicates that subject type evoked no quantitative differences in temperature or reaction time. Neither did analyses of trend reflect significant effect as a result of subject type.

Temperature Trend Analyses

Body temperature is the most commonly used indicator of circadian rhythms. Kleitman (25) stated that body temperature parallels alertness and efficiency reliably enough to justify elimination of time consuming performance tests which only interfere with or disrupt the subjects' routines. Temperatures reported by rhythms researchers range 1.2 to 2.4°F between average minimals of 96.7°F and maximals of 98.6°F. The temperatures in this study, particularly those during the control week, are low according to standards. Diminished temperatures during the control period are partially explainable. The earliest observations did not take into account that the clinical thermometers might require as long as 12 minutes to stabilize, when the directions accompanying the instruments suggested sub-lingual placement of three minutes was adequate. However, later temperatures were carefully checked for stabilization and are still moderately low, an indication that oral thermometers may not be as sensitive as other devices for determining temperature. Other than mean temperature discrepancies, the control period trend for all subjects was in good agreement with prior observations. The diminution of amplitude observed in conjunction with the early morning and evening treatment runs is a common trend of a body attempting to adjust to a changed relationship between its internal clock and external modifiers (25). The flattened curve that characterized rhythmic variation upon the introduction of the two treatments indicates that adaptation was in process and so it is not clear what forms the curves might eventually take. Researchers have reported immediate entrainment, entrainment that required up to three weeks and cases in which adaptation never occurred.

The trend analysis results found significant differences in temperature occurred over the day. In other words, presence of a rhythm was substantiated. Rhythm was also found to be significantly affected by treatment. The trends of larks and owls did not differ from each other, nor did subject type trends by treatment vary significantly. The null version of hypotheses one and three were thus rejected in favor of the alternatives H_a1: $T_1 \neq T_2 \neq T_3 \neq T_4 \neq T_5$ and H_a3: $TB_1 \neq TB_2 \neq TB_3$. On the other hand the data supported the null hypotheses, H_o2: $TA_1 = TA_2$ and H_o4: $TA_1B_{0-2} = TA_2B_{0-2}$.

Visual Reaction Time Trend Analyses

The imposed early and late jogging schedules had varying effects upon rhythmicity. The morning run flattened the curve and brought on an early, 1400, maximal. The evening run appears to have effected a phase displacement as well as disproportionately elevating the 2000 value (Figure 8).

The trend analysis revealed significant variability between times and treatment effects over the day, supporting the alternative hypotheses one and three, H_a1: $T_1 \neq T_2 \neq T_3 \neq T_4 \neq T_5$ and H_a3: $TB_o \neq TB_1 \neq TB_2$. Time of day variability affirmed the presence of rhythmicity and the modification effect of exercise time upon periodicity. Significance within trends comparing subject types and types by treatments was not found. Thus, the null hypotheses held for statements two and four, H_o2: $TA_1 = TA_2$ and H_o4: $TA_1B_{0-2} = TA_2B_{0-2}$.

Auditory Reaction Time Trend Analyses

The treatment effect of an early morning run appears to have advanced the phase, insofar as the maximal was attained three hours earlier than it occurred during the control treatment. The evening jog curve comes close to resembling desynchronization, but it is reasonable to suspect that the exertion of the previous evening advanced the phase, so that at the time of waking the following morning the rhythm had not yet reached its early morning minimal. Consequently, rising brought about premature arousal. At 1100 when early day rates of efficiency improvement began to slow, reaction time readjusted to what would have been normal values. This readjustment appeared as a notable decrease in performance.

Statistically, the presence of linear trends with a quartic 'dip' expressed was affirmed. Treatment effect upon the trends was also apparent and thus, H_a1: $T_1 \neq T_2 \neq T_3 \neq T_4 \neq T_5$ and H_a3: $TB_0 \neq TB_1 \neq TB_2$ were not rejected. The null versions of hypotheses two and four were accepted, H_o2: $TA_1 = TA_2$ and H_o4: $TA_1B_{0-2} = TA_2B_{0-2}$, reinforcing the conclusion that diurnal type was not a critical factor in treatment effect.

Summary

All criterion measures exhibited rhythmicity and in each case this periodicity was apparently affected by bouts of early morning and evening exercise. It is interesting to note that with an evening jog the effect of phase displacement appears to carry over into the following 24 hour period. Early morning runs flattened the curves by elevating the 0800 to 1400 values and diminishing the evening responses. The maximal responses in two out of three criterion measures, temperature and visual reaction time, were recorded six hours earlier for the morning jog treatment than during the control period. The evening jog-associated maximals coincided closely with control period maximals. Temperature was the least perturbed by exercise schedule alterations and auditory reaction time most responsive to changes in routine.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The rates of many psychological and physiological processes vary predictably throughout the day in rhythmic, cyclic fluctuation. Mental efficiency is known to oscillate between minima and maxima over a 24-hour period we describe as the diurnal cycle. The great majority of body rhythms are internally cued or endogenous, meaning that they exhibit a periodicity not greatly affected by external stimuli. However, modifiers, e.g., physical exertion, do alter the rhythms in some instances.

The question was posed, "Will the indicators of mental efficiency, reaction time and temperature, be altered over the day as a result of varying schedules of aerobic exercise?" In order to distinguish between the effects of exercise in general and exercise strategically timed, the experimental design allowed for comparison of two assigned jogging times, morning and evening, and a control regime of self selected time. Subjects' orientation in terms of innate or habituated efficiency was entered into the experimental and statistical consideration as a possible factor in response to the treatments.

Eight male university students ranging in age between 18 and 26 were recruited. The subjects' diurnal types were determined and two groups of four 'larks' and four 'owls' were arranged into a random pattern that involved three experimental treatment periods. The testing procedure consisted of measuring three responses, body temperature, visual reaction time and auditory reaction time. Reaction time was selected to track mental efficiency. Temperature was included as a standard covariant of performance. Observations were recorded for all subjects on fifteen occasions throughout the week for a total of three repetitions per subject at the hours of 0800, 1100, 1400, 1700 and 2000.

A two by three by five double classification statistical model allowed for analysis of variance between main effect means. An analysis of variance within trend means examined linear, quadratic, cubic and quartic components to detect diurnal trend differences resulting from the effects of treatment and subject type. The .05 level of confidence was retained throughout for all hypothesis testing.

Conclusions

Based on a statistical analysis of variance between main effect means and within trend means and in reference to certain descriptive data, the following conclusions have been drawn from the findings of this study.

1. The ANOVA of main effect means indicated that significant differences between subject type treatments and diurnal type by treatment were not present. 'Owls' and 'larks' average reaction times and temperatures did not vary nor did any one treatment diminish or enhance the dependent variable scores more than another.

2. The most frequently observed cyclic pattern was that of rapid criterion increments early in the day, a midday leveling or slight depression and a gradual afternoon recovery to a 2000 hour maximum. In this manner temperature and reaction time varied together for all treatments.

3. When the five trials or times of day were analyzed for trend a periodic rhythm was consistently exhibited by the performance indicators.

4. Neither the trends of subject types nor treatments by type reflected significant differences in pattern responses. Subject type had no effect upon results.

5. The most significant statistical determination was of the tendency of trends to vary as a result of treatment. The early morning jog was associated with slower reaction times, lower temperatures over the day and a more perturbed cyclic profile than did exercise in the evening.

Recommendations

Until recently little biorhythmic research was conducted on human subjects. Physical exertion is virtually unexplored as a potential modifier of circadian periodicity.

1. This study treats rhythm alteration over the short term. It looks at acute or immediate effects. The logical follow-up would be to establish baseline values and treatment values over a time span adequate to allow the body time for adaptation after the routine change.

2. A replication of this study using female subjects should be attempted before the conclusions herein can be used to advance any generalizations regarding the effects of morning or evening jogging upon the measured responses.

3. The effects of exercise scheduling were difficult to isolate in university students constantly on the go. A clinical setting for a similiar experiment would provide a valuable comparison in the study of physical exercise as it affects circadian periodicities.

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APPENDICES

APPENDIX A

OREGON STATE UNIVERSITY

Committee for Protection of Human Subjects

Chairman's Summary of Review

Title: Diurnal Variations of Body Temperature and Reaction Time Accompanying Early Morning and Evening Aerobic Routines.

Program Director: John P. O'SHea

Recommendation:

✓ Approval

_____ Provisional Approval

_____ Disapproval

_____ No Action

Remarks: For the sake of clarity and for emphasis, there should be, under "Procedures and Methods" a comment on the role of the physician. On page four, after the first sentence of the second paragraph (ending in "exercise in the form of jogging") one should insert a statement such as: - Even so, the subjects will participate in the study only after an appropriate medical examination.

Date: February 13, 1976 Signature DONALD L. MacDONALD
(Original was signed)

If the recommendation of the committee is for provisional approval or disapproval, the program director should resubmit the application with the necessary corrections within one month.

APPENDIX B

DIURNAL TYPE DESCRIMINATION SURVEY[a]

Answer the following questions as if they pertain to your normal, or average routine.

1. What time do you wake on school days? Weekends or free days?

2. Do you rise immediately upon waking or spend some time getting up?

3. Do you feel alert upon rising or groggy?

4. What time do you prefer to retire for the evening?

5. What time in the evening do you begin to experience drowsiness?

6. Outline your eating pattern over the day including time of consumption, type and quantity of food.

7. Which meal is your largest?

8. Do you drink coffee? If so, when and what quantity do you consume?

9. Can you predict what times of the day you feel best (most energetic, efficient)? The worst (sluggish, inefficient)?

10. When do you prefer to study?

[a]Questions derived from the work of Ostberg (34).

APPENDIX C

ACKNOWLEDGEMENT OF WILLINGNESS TO PARTICIPATE

The undersigned acknowledges that he will volunteer to take part in the "effects of jogging on diurnal mental performance variations" study being conducted at Oregon State University and that he is informed as to the procedures involved and also the attendant risks and benefits of such participation. Further, the undersigned is free to withdraw consent and to discontinue participation in the project at any time.

Signed ______________________________

Date ____________________ Age ______

CONSENT AND RELEASE FOR PERSONS UNDER TWENTY-ONE YEARS OF AGE

My son ________________________________, who is under the age of twenty-one (21) has my permission to participate in the "effects of jogging on diurnal mental performance variations" study. Further, I release and discharge Oregon State University, its officers, agents, staff, faculty, technicians, physicians and others connected therewith, for all claims or damages whatsoever that I or my representative have or may have against it or any of them be reason of any cause rising out of or incident to such participation.

Signature of Parent ________________

Address of Parent __________________

____

Date ____________________

The procedures of the study will involve division of the experiment into three periods, representing two treatments, early morning jogging and evening jogging and a third, control period of non-time-structured jogging. The duration for each treatment will be one week.

Treatments will require the subject to jog at his own pace for a minimum of 20 minutes and a maximum of 45 minutes. The schedule of jogging will vary each week. The first week the subject will adhere to his own regular routine. The last two-thirds of the study will call for a week of 0630 jogging and one of 1830 jogging. Evaluation will take the form of measures acquired at six-hour intervals beginning at 0730 hours and ending at 2230 on an alternate day schedule spanning six days. These measures will include body temperature and reaction time to both auditory and visual stimuli. Jogging according to a schedule of gradual work increments involves minimal risk to those who regularly engage in the practice and who claim a normal degree of health. Since subjects have established the habit of jogging prior to inclusion in this study, no risks are foreseen that might arise out of participation in the project. The benefits to the subjects lie in the knowledge they will gain of their own diurnal variations as influenced by exercise patterns.

Further questions are welcome and will receive the prompt attention of investigators.

APPENDIX D

The volunteer, ______________________________, has been interviewed/examined and found to have no condition that would counter-indicate his participation in a study involving daily jogging at submaximal intensities, for durations of up to 45 minutes.

____
Signature: Examining Physician

____
Date

APPENDIX E

PRECAUTIONS AND CONDITIONS OF STUDY, "Effects of jogging...."[a]

1. Please abstain from alcohol and/or drug consumption during the interval of the study...in the interest of science.

2. Sleep periods should be six-eight (6-8) hours in length.

3. It is appropriate that the jogging bouts be preceded by a warm-up period and followed by an interval of gradual recovery.

4. Drink a cup of juice or at least a half cup of water prior to an early morning run.

5. If any of the following symptoms are evidenced during or after exercise, jogging should be terminated until a physician is consulted:
   a) dizziness
   b) faintness
   c) difficulty in breathing
   d) chest pains
   e) deterioration of coordination

6. Listed below are a number of activities that can modify reaction and temperature responses, as well as the conditioning effect of jogging:
   a) ingestion of large meals less than two hours pre-test or pre-exercise
   b) ingestion of coffee or other xanthine-containing beverages before testing or exercise
   c) drinking iced or very hot drinks pre-test or pre-exercise
   d) tobacco smoking at all times

7. In conjunction with exercise the following are counter indicated <u>in addition to the items mentioned above</u>:
   a) ingestion of large meals one hour after exercise
   b) ingestion of xanthine-containing beverages after exercise
   c) iced or very hot drinks or alchoholic beverages pre or post exercise
   d) wearing heavy clothing during high level sustained effort
   e) cold or very hot showers immediately after training
   f) dry or wet "hot" rooms or towls
   g) passing quickly from a warm locker room into cold winter weather while still perspiring

8. Duration of aerobic exercise should be a minimum of 20 minutes, but not exceed 45 minutes on test days.

9. Exercise should be of sufficient intensity to stimulate sweating, yet sustainable at a constant rate over the length of the bout.

---

[a]DeVries, H. A. <u>Physiology of Exercise</u>. Dubuque, Iowa. Wm. C. Brown, 1966.

APPENDIX F

FOOD CONSUMPTION/SLEEP LOG

Subject ______________________ Week #__________

Date	Sleep Interval	Naps	Meals	Snacks	Activity: Type/Interval
Wed.					
Thurs.					
Fri.					
Sat.					
Sun.					
Mon.					
Tues.					

APPENDIX G

DATA RECORDING FORM

SUBJECT ______________________ WEEK # ______________ GROUP ____________

Day / Time	Trial	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	RTv RTa															
	RTv RTa															
	RTv RTa															
	RTv RTa															
	RTv RTa															
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APPENDIX H

CUMULATIVE MEANS FOR MAIN EFFECTS

TEMPERATURE (°F)

MAIN EFFECT MEANS

SUBJECT TYPE $(A_{1,2})$[a]	97.2	97.4			
TEMPERATURE $(B_{0,1,2})$[b]	97.0	97.4	97.4		
TIME OF DAY (T_{1-5})[c]	96.7	97.0	97.5	97.5	97.8

SUBJECT TYPE BY TREATMENT

TYPE	B_o	B_1	B_2
A_1	96.9	97.3	97.3
A_2	97.2	97.6	97.5

TIME BY TYPE AND TIME BY TREATMENT

TIME	A_1	A_2	B_0	B_1	B_2
0800	96.5	96.9	96.2	96.9	97.0
1100	96.9	97.2	96.6	97.3	97.2
1400	97.4	97.6	97.3	97.7	97.4
1700	97.3	97.6	97.3	97.6	97.5
2000	97.7	97.9	97.8	97.7	98.0

TIME BY TREATMENT BY TYPE

	A_1			A_2		
TIME	B_0	B_1	B_2	B_0	B_1	B_2
0800	97.1	96.6	96.8	96.3	97.6	97.2
1100	96.6	97.1	97.0	96.7	97.6	97.4
1400	97.1	97.6	97.0	97.6	97.8	97.4
1700	97.0	97.5	97.4	97.6	97.7	97.7
2000	97.7	97.6	97.9	97.9	97.9	98.1

[a] A_1 = Larks, A_2 = Owl

[b] B_0 = Control, B_1 = Morning Jog, B_2 = Evening Jog

[c] T_{1-5} = 0800, 1100, 1400, 1700, and 2000 hours

VISUAL REACTION TIME (Milliseconds)

MAIN EFFECT MEANS

SUBJECT TYPE ($A_{1,2}$)[a/]	238	250			
TREATMENT ($B_{0,1,2}$)[b/]	244	244	243		
TIME OF DAY (T_{1-5})[c/]	249	244	244	243	239

SUBJECT TYPE BY TREATMENT

TYPE	B_0	B_1	B_2
A_1	235	242	237
A_2	253	247	249

TIME BY TYPE AND TIME BY TREATMENT

TIME	A_1	A_2	B_0	B_1	B_2
0800	244	255	255	247	247
1100	236	252	244	243	245
1400	237	251	241	242	247
1700	238	247	243	246	239
2000	235	244	239	244	235

TIME BY TREATMENT AND TIME BY TYPE

	A_1			A_2		
TIME	B_0	B_1	B_2	B_0	B_1	B_2
0800	244	247	240	265	246	253
1100	232	240	236	256	246	254
1400	235	240	242	252	245	253
1700	236	244	235	250	249	243
2000	235	239	240	243	250	240

AUDIBLE REACTION TIME (Milliseconds)

MAIN EFFECT MEANS

SUBJECT TYPE $(A_{1,2})$[a/]	178	180			
TREATMENT $(B_{0,1,2})$[b/]	188	175	174		
TIME OF DAY (T_{1-5})[c/]	184	179	180	175	176

SUBJECT TYPE BY TREATMENT

TYPE	B_0	B_1	B_2
A_1	185	176	173
A_2	192	174	175

TIME BY TYPE AND TIME BY TREATMENT

TIME	A_1	A_2	B_0	B_1	B_2
0800	183	186	200	174	180
1100	177	182	189	176	173
1400	178	182	186	175	179
1700	175	176	182	174	170
2000	177	176	184	177	168

TIME BY TREATMENT AND TIME BY TYPE

	A_1			A_2		
TIME	B_0	B_1	B_2	B_0	B_1	B_2
0800	195	176	178	204	172	180
1100	184	176	172	194	177	175
1400	181	176	177	190	174	182
1700	180	175	169	184	177	170
2000	183	179	168	185	175	168

APPENDIX I

ANOVA of Main Effects for All Three Dependent Variables.

Source	d.f.	$MS (x10^3)$	F-Ratio[a]
		TEMPERATURE °F	
Total	119	42681.575	
Between	23	88942.828	
Subj. Type (A)	1	264033.445	NS[b]
Treatment (B)	2	189450.894	NS
A x B	2	3186.093	NS
Error	18	77576.535	
		VISUAL REACTION TIME	
Source	d.f.	MS	F-Ratio
Total	119	62.653	
Between	23	296.332	
Subj. Type (A)	1	405.537	NS
Treatment (B)	2	4.708	NS
A x B	2	41.924	NS
Error	18	350.936	
		AUDITORY REACTION TIME	
Source	d.f.	MS	F-Ratio
Total	119	43.480	
Between	23	197.530	
Subj. Type (A)	1	15.052	NS
Treatment (B)	2	243.849	NS
A x B	2	21.841	NS
Error	18	222.042	

[a] $p \leq .05$ for $F \geq 4.41$ with 1, 18 df, and $F \geq 3.55$ with 2, 18 df.

[b] $p > .05$, F not significant.

APPENDIX J

TABLED MEANS OVER THREE TRIALS FOR SUBJECT TYPE AND TREATMENT AT THE FIVE OBSERVED TIMES OF DAY.

BODY TEMPERATURE

Subject type/treatment Combination		Times	Mean	Standard deviation	Vari-ance	N[a]
	Control	1	96.14	0.80	0.63	(12)
		2	96.48	1.32	1.75	(12)
		3	97.11	0.79	0.63	(12)
		4	97.12	1.04	1.09	(12)
		5	97.73	0.53	0.29	(12)
LARKS	Morning Jog	1	96.55	0.96	0.91	(12)
		2	97.08	0.96	0.22	(12)
		3	97.57	0.62	0.38	(12)
		4	97.50	0.32	0.57	(12)
		5	97.61	2.14	1.46	(12)
	Evening Jog	1	97.78	1.07	1.15	(12)
		2	96.95	0.95	0.91	(12)
		3	97.41	0.51	0.26	(12)
		4	97.39	0.95	0.91	(12)
		5	97.85	0.76	0.58	(12)
	Control	1	96.26	1.14	1.32	(12)
		2	96.66	0.78	0.60	(12)
		3	97.58	0.56	0.32	(12)
		4	97.57	0.75	0.56	(12)
		5	97.86	0.45	0.20	(12)
OWLS	Morning Jog	1	97.28	0.73	0.53	(12)
		2	97.58	0.88	0.77	(12)
		3	97.80	0.48	0.23	(12)
		4	97.68	0.57	0.32	(12)
		5	97.78	0.50	0.25	(12)
	Evening Jog	1	97.18	0.49	0.24	(12)
		2	97.38	0.35	0.12	(12)
		3	97.36	0.59	0.35	(12)
		4	97.69	0.58	0.33	(12)
		5	98.08	0.33	0.11	(12)

[a]N = Number of subjects, four (larks or owls) by three trials.

TABLED MEANS OVER THREE TRIALS FOR SUBJECT TYPE AND TREATMENT AT THE FIVE OBSERVED TIMES OF DAY.

AUDIBLE REACTION TIME

Subject Type/Treatment Combination		Times	Mean	Standard deviation	Variance	N[a]
	Control	1	.1954	.0272	.0007	(12)
		2	.1836	.0268	.0007	(12)
		3	.1809	.0160	.0003	(12)
		4	.1802	.0204	.0004	(12)
		5	.1830	.0234	.0005	(12)
LARKS	Morning Jog	1	.1763	.0187	.0003	(12)
		2	.1759	.0171	.0003	(12)
		3	.1759	.0215	.0005	(12)
		4	.1751	.0152	.0002	(12)
		5	.1790	.0024	.0005	(12)
	Evening Jog	1	.1784	.0143	.0002	(12)
		2	.1716	.0105	.0001	(12)
		3	.1770	.0158	.0003	(12)
		4	.1693	.0154	.0002	(12)
		5	.1682	.0172	.0003	(12)
	Control	1	.2042	.0458	.0021	(12)
		2	.1941	.0316	.0010	(12)
		3	.1904	.0281	.0008	(12)
		4	.1842	.0291	.0008	(12)
		5	.1846	.0269	.0007	(12)
OWLS	Morning Jog	1	.1739	.0200	.0004	(12)
		2	.1767	.0238	.0006	(12)
		3	.1742	.0222	.0005	(12)
		4	.1720	.0209	.0004	(12)
		5	.1745	.0159	.0008	(12)
	Evening Jog	1	.1806	.0240	.0004	(12)
		2	.1747	.0191	.0004	(12)
		3	.1818	.0195	.0004	(12)
		4	.1704	.0199	.0004	(12)
		5	.1684	.0185	.0003	(12)

[a]N = Number of subjects, four (larks or owls) by three trials.

TABLED MEANS OVER THREE TRIALS FOR SUBJECT TYPE AND TREATMENT AT THE FIVE OBSERVED TIMES OF DAY.

VISUAL REACTION TIME

Subject Type/Treatment Combination		Times	Mean	Standard deviation	Variance	N[a]
	Control	1	.2437	.0295	.0009	(12)
		2	.2391	.0270	.0008	(12)
		3	.2299	.0216	.0005	(12)
		4	.2362	.0244	.0006	(12)
		5	.2353	.0299	.0009	(12)
LARKS	Morning Jog	1	.2473	.0274	.0008	(12)
		2	.2403	.0321	.0010	(12)
		3	.2395	.0292	.0009	(12)
		4	.2424	.0268	.0007	(12)
		5	.2399	.0285	.0008	(12)
	Evening Jog	1	.2365	.0259	.0007	(12)
		2	.2362	.0196	.0004	(12)
		3	.2415	.0301	.0009	(12)
		4	.2351	.0261	.0007	(12)
		5	.2298	.0306	.0009	(12)
	Control	1	.2654	.0384	.0015	(12)
		2	.2555	.0370	.0014	(12)
		3	.2525	.0304	.0009	(12)
		4	.2500	.0330	.0011	(12)
		5	.2433	.0320	.0010	(12)
OWLS	Morning Jog	1	.2457	.0231	.0005	(12)
		2	.2457	.0246	.0006	(12)
		3	.2450	.0244	.0006	(12)
		4	.2487	.0275	.0008	(12)
		5	.2495	.0253	.0006	(12)
	Evening Jog	1	.2529	.0247	.0006	(12)
		2	.2544	.0227	.0005	(12)
		3	.2528	.0234	.0005	(12)
		4	.2427	.0209	.0004	(12)
		5	.2398	.0226	.0005	(12)

[a]N = Number of subjects, four (larks or owls) by three trials.