1983

Circadian rhythms: Activity preferences and the ability to adjust schedules

Peggy E. McCallum
The University of Montana

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CIRCADIAN RHYTHMS: ACTIVITY PREFERENCES AND THE ABILITY TO ADJUST SCHEDULES

by

Peggy E. McCallum

B.A., University of Minnesota, 1977

Presented in partial fulfillment of the requirements for the degree of Master of Arts UNIVERSITY OF MONTANA 1983

Approved by:

Chairman, Board of Examiners

Dean, Graduate School

Date
The purpose of this paper was to investigate the frequency of morning and evening people and their circadian rhythms, schedule preferences, and ability to adjust their work or school schedules to coincide with their circadian rhythms.

A self-assessment questionnaire, completed by students and workers, was used to determine the frequency of morning and evening people and their ability to adjust their schedules. A literature search helped determine the ease with which morning and evening people adjusted to schedules that did not coincide with their circadian rhythms.

The results suggested that most people become more morning active as they age, and that students are better able to adjust their schedules than workers. Morning people appeared less able to adjust to night work schedules than evening or intermediate people. The results also suggested that failure to adjust circadian rhythms to coincide with work schedules (as can happen with rapidly rotating shifts) can cause physical and psychological problems.
ACKNOWLEDGEMENTS

I wish to express my gratitude to the students and workers who participated in this study. Thanks also to Dr. David Stroebel, Dr. Dale Nansel, Dr. Dee C. Taylor and Dr. C.G. Smith who allowed me to distribute questionnaires in their classes, and to Ed Roberts, Champion International; Captain Doug Chase, Missoula Police Department; Assistant Chief Chuck Gibson, Missoula County Fire Department; Iona Baertsch, Missoula Nine-One-One Center; Undersheriff Dan Magone, Missoula County Sheriff's Department; and Bill Hull, Law Enforcement Academy Bureau, Bozeman; for their help in distributing the questionnaires.

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All of the illustrations were drawn by Richard D. Periman and the typing was done by Diane Waldo. They especially deserve thanks for their patience with all my revisions.

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CHAPTER 1

INTRODUCTION TO THE PROBLEM

Description of Rhythms

Rhythms are ever-present in nature. There are rhythms of sleep and wakefulness, tides, light and dark, activity and rest, flower opening and closing, temperature and seasons. All living systems have rhythms and these rhythms can be classified as circadian, ultradian or infradian. Ultradian rhythms are those with frequencies greater than 1 in 20 hours, such as the ninety-minute sleep cycles. Infradian rhythms have a frequency lower than 1 in 28 hours, such as the estrus cycle (Halberg and Ahlgren 1979). Circadian rhythms are those with frequencies of 1 in 20-28 hours. In this paper I will concentrate on human circadian rhythms. The term circadian was first used by Halberg in 1959 to denote those rhythms approximating 24 hours. It is derived from the Latin "circa dies," meaning about a day (Halberg, Halberg, Barnum and Bittner 1959). Circadian rhythms of overt behavior can be discovered in responses to stimuli such as: color, light, sound, touch, odor, and memory and learning (Halberg 1976).

Specific Rhythms

The natural environment varies periodically; for example, the daily light-dark cycle, temperature and barometric pressure variations, predator activity and competition for food. Selection favors those organisms which are able to adapt to the periodicity of their particular
environment (Cloudsley-Thompson 1960). In evolutionary history, the earth's rotation is the single factor which has remained constant and that assumed primary importance in the development of circadian rhythms (Bohlen 1979). Today, these rhythms are generally considered to be endogenous, and changes in photoperiod act only as synchronizing cues. Rhythms can be synchronized to obtain maximum benefit in two ways. The organism can be active and alert at times of greatest danger or best feeding, or the organism can rest when activity would bring the greatest threat or poor feeding (Bohlen 1979). The synchronization would, of course, be influenced by a variety of physiological and environmental factors. Circadian rhythms allow the anticipation of recurring stresses, and produce daily physiological changes prior to the stress (Kalmus 1966).

**History**

The evidence suggests that circadian rhythms are genetically based and controlled endogenous rhythms. Their continuing oscillation in the absence of periodic environmental cues (Bohlen 1979) or in the presence of abnormal light-dark schedules (Moore-Ede, Sulzman and Fuller 1982) supports this suggestion. Aschoff (1960) detected convincing evidence that the rhythms were endogenous in the free-running state. Rhythms which are not modified or synchronized by an external stimulus, such as light, and which vary from the 24-hour cycle (by as much as four hours in either direction) are considered to be in the free-running state. He also experimented with six generations of mice living in a continuously light environment. Each generation continued the rhythm
patterns of the parent generation. Research on human infants has shown that rhythms develop at varying rates as the infant develops physically (Helbrugge 1960).

DeMairan is credited with one of the first publications about rhythms in his seventeenth century monograph on the opening and closing of the heliotrope with light as a cue (Block and Page 1978, Bunning 1960, and Moore-Ede et al. 1982). In 1751, Linnaeus designed a time piece similar to a sundial by which he used the times that different flowers opened and closed each day to tell the time without the sun (Moore-Ede et al. 1982). One of the first human circadian rhythms discovered was that of temperature. Marotte and Timbal (1981) credit DeGorter, in 1736, as the first to describe it, while Aschoff (1967) stated that it was first described by Bierse in 1842.

Despite the fact that rhythms were recognized as early as the seventeenth century, scientific interest in human rhythms did not emerge until the 1940s and 1950s. Until recently, scientific and medical investigations revolved around the constancy of human physiology. Today, chronobiologists view the homeostatic mechanism as maintaining the internal environment within narrow limits of variability (Reinberg et al. 1980), not at a constant level. The way the physiologic systems vary in relation to each other can affect the organism's ability to withstand various kinds of stress and its general well-being. Virtually all systems in people vary rhythmically; blood pressure, heart rate, adrenal activity, renal excretion, strength, alertness, and resistance to injury are but a very few examples (Halberg and Ahlgren 1979).
Types of Research

Since about 1940, the interest in, and consequently the literature about, circadian rhythms has increased greatly. There are articles and books describing rhythms in mice, birds, paramecia, fiddler crabs, rats, alfalfa weevils, hamsters, insects, monkeys, cockroaches, humans, and numerous other species. Some authors concentrated on a specific structure such as the brain or pineal gland, while others concentrated on the development of rhythms. There are papers on the effects of drugs, toxins, light-dark variations and other environmental stresses on various rhythms. There are many papers detailing the effects of jet travel, shift work, and sleep patterns. The point in my mentioning this seemingly endless list is to show the impracticability of attempting a comprehensive review of the literature. I will present only a small and very selected sample of the circadian rhythm literature here.

Selected Relevant Literature

Development. The development of circadian rhythms in humans is still not well understood, but Hellbrugge (1960) presented three basic facts which underlie their development. First, at birth the human infant does not have a fully mature neuro-hormonal system. Second, a precondition to the development of a circadian rhythm is a fully mature neuro-hormonal system and the functional efficiency of the organs, on which the rhythms can be measured. Third, each day and night rhythm is bound to fully functioning organs of perception through which the synchronizer is mediated. Hellbrugge's investigations began with
twelve healthy pregnant women and their fetuses. He sampled their heart
rates from eight months until birth. The women exhibited the typical
24-hour variation, but the fetal heart rates were nearly constant. His
results showed that different rhythms developed at different rates after
birth. For instance, pulse rate rhythms do not fully develop until 11
to 12 months (Figure 1), although some variation can be observed from

![Graph](image)

Figure 1. Pulse rate variations at different ages. (After Hellbrugge
1960)
the second day. Total excretion rhythms exhibit some day-night variation at two to three weeks, but sodium and potassium rhythms are not observable until the second month. The maturity of the child is essential to the development of circadian rhythms; the pulse rate develops more slowly in premature children. Aschoff (1967) presented similar data from Jundell's 1904 study and concluded that circadian rhythms are innate, not learned. Reinberg et al. (1980) addressed the problem of the relationship of temperature rhythm amplitude, aging, and shift work tolerance. The amplitude of a rhythm is the distance from the midpoint value to the upper or lower limit of variation. Their findings indicated that senior oil refinery operators who were tolerant of shift work had a larger amplitude than no longer tolerant senior operators (Figure 2). They concluded that subjects who remain tolerant to shift work are likely to have a larger temperature amplitude than those who will become intolerant in their forties or fifties.

Figure 2. Temperature amplitude for senior operators tolerant (○) and intolerant (●) to shift work (\(\bar{x} \pm 1\ SE\)) (After Reinberg et al. 1980)

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Time Schedules. For most of man's existence, he has been a daylight creature. Alternation of activity and rest is the most widely recognized rhythm and is accompanied by, and reflected in, alternating physiological functions which reach maxima during activity and minima during sleep. Man's emotional and physiological makeup is such that relatively minor changes can produce large fluctuations in physiological functions (Lobban 1965). Due to the ever-increasing demands for workers to adjust or even reverse their activity schedules, an understanding of the adjustments the body is required to make and the effects of failure to make these adjustments is vitally important. M.C. Lobban has been associated with many studies on adjustments of people on unusual time schedules and light-dark schedules. In 1957, Lewis and Lobban wrote two papers concerning human subjects living on abnormal time schedules. In one paper, they concentrated on the effects of prolonged abnormal time schedules on excretion rhythms. The subjects were divided into two groups; one group (7 subjects) lived on a 21-hour routine and the other group (5 subjects) on a 27-hour routine for cycles of eight experimental days. The results showed that one subject on the 21-hour schedule and two on the 27-hour schedule initially adapted to the routine. Some progressive adaptation occurred but complete adaptation seldom occurred even after six weeks. This confirmed the conclusions reached in a pilot study by Lewis, Lobban and Shaw in 1953 that rapid adaptation of excretory rhythms was uncommon and the intrinsic 24-hour rhythms could persist for long periods (Lewis and Lobban 1957a). In the second paper they concentrated on the dissociation of rhythms. Rhythms are usually associated in a specific pattern or sequence of maxima and minima, and
they dissociate when one fails to follow the pattern or sequence. For example, if rhythm A normally reaches its minimum three hours before rhythm B, they are considered to be dissociated if B reaches its minimum before A. Again, the subjects followed 21- or 27-hour schedules and Lewis and Lobban analyzed the rhythms of temperature and of water, chloride and potassium excretion. Their results indicated that temperature and excretion rhythms are easily dissociated and that temperature is most easily influenced by the environment. Sodium and chloride dissociation is very uncommon, but potassium dissociation from sodium and chloride is fairly common. Potassium is the most resistant to environmental influence. An interesting fact to note is that one subject (D) showed temperatures that were lower during the waking period than the sleeping period. Follow-up testing indicated this was a normal condition for this individual (Lewis and Lobban 1957b). In another study Lobban (1974) found no great difference, in adult and aged subjects, in the amplitudes for spring, summer and autumn for all four urinary constituents (sodium, chloride, water and potassium). However, in children the amplitudes for the four urinary constituents were markedly lower in summer. The children led more irregular lives during the summer and this helped convince Lobban that social cues play an important part in the development and maintenance of circadian rhythms.

Shift Work. Many studies have been performed on shift workers and their problems in adjusting to night shifts or rotating shifts. One common complaint of intolerant shift workers is sleep deprivation. Hume (1980) did a study with simulated time shifts in isolation units that eliminated all external light cues. His results gave clear indications
that sleep was disturbed by the shift and he noted that rapid eye movement sleep significantly increased following a time delay but decreased following a time advance. Adaptation generally occurred within a week of the change. Dahlgren (1981) tested the adjustment of body temperature, of self-rated activation, and of sleep quantity and quality in six permanent night workers and six shift workers on rotating schedules. Dahlgren's results demonstrated that permanent night workers exhibited better adjustment of temperature rhythms to night work than did workers on rotating night shifts (Figure 3). Permanent night workers showed a

![Graph showing body temperature and general activation for permanent night workers and rotating shift workers.](image)

**Figure 3.** Activation and average body temperatures for permanent night workers and rotating shift workers (After Dahlgren 1981)
larger amplitude with peaks during working hours and troughs during sleep. Also, the permanent night workers seem to maintain their rhythm during free days, but in the rotating shift workers there is a reduction of the amplitude associated with free days. In general, the permanent night workers showed better adjustment, but they also had some sleep disturbances, although these were less marked than in the rotating shift workers. The permanent night workers showed some disturbances of their night sleep (as opposed to day sleep) and this was more marked when compared to "normal" night sleep. Akerstedt and Torsvall (1981) undertook another study with shift workers in which they concentrated on reactions to various shifts within the group rather than between groups of day and shift workers. In their study they investigated sleep length and quality for workers on a three-shift system. The results generally showed most sleep complaints and greatest sleep length for those on the afternoon shift with the fewest complaints for those on the night shift. Sleep length was approximately the same for workers on the morning and night shifts (Figure 4). Since increasing age was associated with increasing sleep problems, it appears that a worker does not learn to adjust to shift work and, in fact, there are individual differences which affect adjustment and age may be a major factor.

Rhythm Adjustment. Wever (1977) investigated the effect of low-level, external electric and magnetic fields on endogenous circadian rhythms. He tested subjects in two units; one shielded from electromagnetic fields and the other unshielded. He applied artificial fields in the shielded unit and compared the effects to those found in the unshielded unit. His results indicated that 10-Hz fields shortened
Figure 4.
Means and standard errors for complaints and sleep length for afternoon (A), Morning (M), and night (N) shifts of three-shift (solid), two-shift workers (dotted) and day workers (●) (After Akerstedt and Torsvall 1981)
circadian rhythms of sleep and wakefulness and of rectal temperature in a manner similar to the natural fields. Aschoff, Hoffmann, Pohl and Wever (1975) investigated the re-entrainment (resynchronization) of rhythms after a phase-shift of the entrainer or synchronizer. Apparently, seven days on a reversed activity schedule are not sufficient to shift totally plasma cortisol, calcium and magnesium rhythms. Five subjects in a metabolic research ward completely and rapidly shifted the rhythm of urinary volume, but four of the five failed to reverse body temperature. In another study, the amplitude of the temperature rhythm was still depressed after the eighth day following a westward flight. Aschoff et al. (1975) suggested that the dissociation associated with time shifts is unlikely to be completely harmless. Animal studies which are not directly applicable to man do indicate possible cumulative effects of repeated disruption of circadian rhythms.

Performance. The effect of circadian rhythms on performance and general wellbeing is a topic frequently debated in both medical and industrial journals. The results are not clear cut; some studies indicated little or no effect. Dirken (1966) concluded that self selection among Dutch shift workers made them healthier and reduced the number of complaints. Hawkins (1980) stated his belief that the effects of rhythm disruption were more related to psychological performance than to health, and he also believed there was a considerable amount of selection by shift workers, which reduced the health problems. Meers, Maasen and Verhaegen (1978) studied 31 subjects who were no longer working shifts at an unidentified plant, 37 experienced shift workers and 27 novice shift workers after an initial survey of 104 who were
about to begin shift work. They found that complaints increased significantly, and general health decreased significantly after six months and deteriorated further (significantly) after four years. One-third of the major reasons for leaving the plant involved concern for the workers' subjective assessment of their own health or social relationships, and one-fourth of the workers felt this was the most important reason. Curtis (1972) studied the neuro-endocrine rhythms of shift workers and noted that adrenal rhythms may not shift in night workers. The adrenal rhythms maintain their original phase even through several days of constant or waking bedrest and constant light or dark.

Colquhoun, Blake and Edwards (1969) focused on performance. They determined that ability to detect errors rose as the body temperature rose and there was a pronounced post-lunch dip in this ability. They also noted that, in night workers, the initial adaptation did not take place until about the sixth day, but the greater the phase shift attempted the less complete the adaptation. Ilmarinen, Ilmarinen, Korhonen and Nurminen (1980) tested subjects every four hours for physical strength and recovery. Their findings indicated that coordination and strength are lowest, physical work appears most difficult, and the recovery period is the longest at night. All the subjects were living on a normal daytime schedule and there was no attempt to alter these schedules or to test adjustment. Buck (1980) studied performance rhythms in the Arctic. The tests were done, in all four seasons, on subjects living on a rigid time structure. The subjects were working shifts but had not worked a night shift for at least four days. The test required the subject to keep a pointer
aligned with a target light as it moved randomly between five lamps. The
total response time scores (the total time required to align the pointer
with the target light 100 times) and the accuracy scores (rate of over­
shooting the target) were representative of the other tests for speed
and accuracy. The scores exhibited a circadian rhythm and the amplitude
did not appear to be reduced by the periods of continuous light or dark.
This would seem to indicate that, in humans, social cues are more
important than light-dark variation.

**Activity Preferences.** Nearly everyone knows someone who is
convinced there is only one time of day to do a certain activity but, as
Marsh stated in 1906, there is no one time plan that will fit all in­
dividuals. Marsh researched biographies of 160 authors and discovered
that 34 percent wrote from 6:00 a.m. to 2:00 p.m., but 27 percent wrote
from 2:00 p.m. to midnight. The preference for morning or evening
activity involves more than just the choice of time to perform some
activity; it also involves the ability to perform that activity. Horne,
Brass and Pettitt (1980) developed a self-assessment questionnaire for
identifying morning and evening people. The terms 'morning' and
'evening' people refer to preference but also to physiological ability
to perform. Performance at a simulated production line inspection task
measured in twenty-minute sessions indicated that morning people
deteriorated in performance while evening people improved as the test
progressed (Figure 5). Webb and Bonnet (1978) compared the sleep of
morning and evening people. Temperature readings were taken four times
a day for extreme morning and evening people, as indicated by a self­
assessment questionnaire. The subjects also kept a sleep log and
honesty was stressed over completeness. The logs were kept for two weeks and the evening people attempted to change or shift their average awakening time to the time that the morning people awoke (the average time). Morning people reported better sleep, waking more easily, feeling better physically, and having fewer worries than evening people. The

Figure 5. Time-of-day effects with number of faults correctly detected for morning and evening types (detrended for learning effects) (After Horne et al. 1980)
evening people who attempted to shift their waking time shifted an average of 50 minutes and showed no other significant changes. Horne and Ostberg (1977) evaluated individual differences to determine if introversion-extroversion was related to circadian peak time, to preference for morning or evening activity, and to sleep times. There was a slight tendency for introverts to be morning people and extroverts to be evening people, but this was not statistically significant. The rising time was nearly two hours earlier for morning types than for evening types; the peak temperature time for the evening type occurred only 70 minutes later than the morning type's peak. Horne and Ostberg concluded that the factors involved in morningness and eveningness are quite complex.

Hypothesis

I attempted to test the following hypotheses: 1) There are individuals whose circadian rhythms are not adjusted to the predominant work schedule (8:00 a.m. to 5:00 p.m.) of the western industrial culture; and its corollary, 2) there are other individuals whose rhythms are not adjusted to the evening and night work schedules which are becoming more common. I have attempted to determine to what degree workers and students have been able to adjust their schedules to coincide with their circadian rhythms. I began with the basic assumption that there are, in fact, morning and evening people and that these people can be identified on the basis of a questionnaire. Another assumption was that there are physiological and psychological complaints (or problems) associated with individuals working job schedules which do
not coincide with their circadian rhythms. Maladjustment, then, is measured by determining the frequency of morning people who work night jobs by necessity, and of evening people who work early morning jobs by necessity and studying their problems. A final assumption was that morning people normally would not choose an evening or night schedule unless some other factor influenced the decision. While this might not be true for all morning types, I suggested it is a valid generalization. I also suggested it was probably less true for evening types, since the day schedule usually would not require the same amount of adjustment as a night schedule would for a morning type.

The primary purpose of the questionnaire was to determine the frequency of morning and evening people in the sample and to determine the frequency of people whose rhythms seemed to be at variance with their work or school schedules. A literature search enabled me to address the problem of the ease with which the rhythms can be adjusted and whether one type adjusts more easily. These seem to be some specific complaints common to shift workers and a literature search helped to indicate the validity of these complaints.
CHAPTER 2

METHODOLOGY

Questionnaire

The questionnaire used in this study was a combination of two earlier questionnaires with some additional modifications. One questionnaire (Horne and Ostberg 1976) was an English language form adapted from an earlier Swedish questionnaire by Ostberg. It consisted of nineteen questions and the final scores were placed on a five-point scale: definitely morning, moderately morning, neither, moderately evening, or definitely evening type. A small random sample (of each type) was selected to record their temperatures regularly during waking hours for three weeks. Statistical studies indicated that this questionnaire was able to determine morning and evening people.

The second questionnaire (Torsvall and Akerstedt 1980) consisted of only seven questions and is the form that seemed best adapted for the present study. The times used in this questionnaire were previously found to differentiate between morning and evening people. Seven questions were chosen from the two questionnaires, mostly from the Torsvall and Akerstedt form, but in several instances the questions were very similar on both forms. The major modifications involved changing the times from 0600 or 2100 to 6:00 a.m. or 9:00 p.m., since this is more commonly used in the United States. Other minor changes were made to "Americanize" the wording. Two questions were added relating to the time preferred to do artistic or analytic tasks.
Two forms of the questionnaire were used: one for students and one for workers; but the only difference was in the demographic information requested. The use of separate forms, rather than to ask the respondents to skip portions that did not pertain to them, seemed preferable. Although this did occur with rotating and non-rotating workers, it was kept to a minimum. Both forms requested age, sex, and occupation or academic major. The workers forms requested information regarding shift rotation while student forms requested the percentage of classes before 10:00 a.m. and if these were taken by choice or necessity. Workers on fixed shifts were also asked if they worked those hours by choice or necessity. Much of this information was not strictly necessary for the present study but it may aid the analysis of the results.

Pilot Study

A pilot study was carried out in which thirty-three members of a medical anthropology class completed the questionnaires. They were encouraged to add any comments about the questions or their answers and, as a result, the time choices on question number 2 (preferred time to go to bed) were made one hour later. The earliest time on the original form was "before 9:00 p.m." and even the most extreme morning type did not choose it. It appeared that the later times increased the questions' ability to separate morning and evening types. The results of the pilot study indicated that the questionnaire would be able to distinguish morning and evening people; the distribution formed a normal or bell-shaped curve. The pilot study was not included in the final results since the changes to the questionnaire would probably have altered the
way some people answered.

**Student Sample**

The self-assessment questionnaire was completed by 367 students during spring quarter 1983 at the University of Montana, Missoula, Montana. Three fairly large classes were selected with the intention of obtaining a broad cross-section of academic majors. These classes were Human Anatomy and Physiology, Drug Abuse, and Introduction to Anthropology. Questionnaires were also completed by students in several physical anthropology classes. The majors were divided into five categories: social science and liberal arts, 150 students; business and computer science, 60 students; fine arts, 7 students; science, 101 students; and miscellaneous, 49 students. The science category included all medical and related majors, such as nursing, pre-med, pharmacy, and physical therapy, as well as math, chemistry, microbiology and physics. The miscellaneous category included forestry, radio-television, and no response. The student sample consisted of 171 males and 192 females (four omitted this information). The mean age was 23.3 years with a range from 14 to 63.

**Worker Sample**

The sample of workers included law enforcement officers, firemen, emergency dispatchers, mill workers, secretaries and a social worker. The 181 law enforcement officers participating were from the Missoula Police Department, the Missoula County Sheriff's Office, and the officers attending the Law Enforcement Academy Bureau (LEAB) training sessions in Bozeman, Montana between March 22 and April 18, 1983.
The participants from the LEAB training sessions included veteran and rookie officers and they represented police, sheriff, and highway patrol officers throughout the state of Montana. The Missoula County emergency dispatchers (911) were also included in this category. There were 19 firemen from the Missoula County Fire Department and 28 respondents in the miscellaneous category which included secretaries (mostly connected with the law enforcement agencies) and a social worker. The 43 mill workers participating were employed by Champion International in Bonner, Montana and most worked in the plywood plant. The sample consisted of 219 males and 52 females with a mean age of 34.6 and a range from 20 to 59. Individuals on fixed shifts comprised almost one-half the sample of working people. There were 120 who indicated they worked fixed shifts and 149 who indicated they worked rotating shifts. There were a few instances in which the respondents omitted the demographic information.

Combined Sample

The total sample consisted of 637 individuals with a mean age of 28.1 with a range from 14 to 63. There were a total of 390 males and 244 females. The discrepancies between the total figures and the sub-totals are due to omitted information.

Scoring

Scoring was based on questions 1, 2, 4, 5 and 7, with one point for extreme morning, two for moderate morning, three for moderate evening and four for extreme evening answers. The minimum total score was five and the maximum was twenty, and based on these and possible combinations of scores I placed people into one of three categories.
Morning people scored five to eight, intermediate people (moderate morning and evening people) scored nine to sixteen, and evening people scored seventeen to twenty. Questions three and six were omitted because comments by some respondents indicated these questions were interpreted in two ways and therefore elicited two different kinds of responses. Questions eight and nine were also omitted from the scoring procedure; these contained much wider time ranges which had not previously been shown to distinguish morning and evening people, but they were used in some of the analyses.

Analysis

Analysis of the data was done by a DECsystem-20 computer. The statistical programs were chosen from McGraw Hill's Statistical Package for the Social Sciences. The primary programs utilized were subprograms FREQUENCIES, CROSSTABS and FACTOR. Subprogram FREQUENCIES produced a one-way frequency distribution table of a discrete variable, in this instance, a frequency distribution of total scores. Subprogram CROSSTABS produced a joint frequency distribution or a distribution of cases based on two or more variables. The chi square statistic was used to determine if the variables were statistically independent. A significance level of .05 or less was considered statistically significant; this means that there is a 5 percent chance that some event occurred by chance alone. These programs were used to look for significant differences in age groupings, sexes, academic major/occupations, and the ability to choose work or school schedules. Subprogram FACTOR performs many types of factor analyses, but in this study, it was used to provide a correlation matrix for questions one
through nine. The correlation matrix provided a measure of association between the questions. Partly on the basis of the matrix, I eliminated questions 3, 6, 8 and 9 from the scoring procedure. The remaining questions exhibited a moderate association (Nie et al. 1975).

Limitations

Limitations inherent in this study include lack of physiological validation of the morning-evening categories. I took no blood or renal excretion samples, nor recorded temperatures, except in two instances and they were not for validation purposes. When establishing the morning-evening categories, possible combinations were considered; it is possible that some (intermediate people, moderate morning or evening people) may actually belong in the morning or evening category. The samples were not completely random--there was some selection of samples. In most instances, the students were from large lecture classes in which a cross-section of ages and majors might be expected.
CHAPTER 3

FINDINGS

Frequencies

The frequency of morning people was higher in the sample of workers than in the sample of students: 19% of the workers and 10.6% of the students. However, the frequency of evening people was slightly higher in the student sample. Evening people comprised 16.3% of the student sample and 14.7% of the worker sample (Figures 6 and 7). These

Figure 6. Frequency of morning, evening and intermediate people by sample group.

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groups were further analyzed by age and sex. The samples were divided into three age categories; 14-30, 31-45 and 46-65 years. I established

![Bar chart showing frequency of morning, evening, and intermediate workers by age groups.](image)

Figure 7. Frequency of morning, evening and intermediate workers by age groups. Chi square = 12.12173 with 4 degrees of freedom.

these categories, in part, because of the age distributions in the student and worker samples and, in part, because of the report (Reinberg et al. 1980) that some workers became intolerant to shift work in their forties or fifties. The percentage of morning people in the combined sample increased from 13.9% in the 14-30 year group to 17.6% in the
31-45 year group, and to 36.8% in the 46-65 year group; while the evening people decreased from 18.5%, to 13.6%, and to 5.3% in these same age groups in the sample of workers. The differences in the number of morning and evening people in the age groups were significant ($p = .0343$) and in the worker sample ($p = .0165$). The significance of the combined sample ($p = .0005$) indicated that there were only five chances in 10,000 that these differences were due to chance alone (Figure 8). No

![Figure 8](chart.png)

**Figure 8.** Frequency of morning, evening and intermediate people in combined sample by age. Chi square = 20.06850 with 4 degrees of freedom.

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significant differences between the sexes were found in any of the sub­
groups. In the combined sample, 13.1% of the females and 14.9% of the
males were in the morning group and 18.0% of the females and 13.8% of
the males were in the evening group. There were no significant
differences between morning-evening people and academic major or
occupation, but I observed some interesting differences. Only 5% of the
business/computer majors were morning people, while 10.7% of the social
science/liberal arts majors and 13.9% of the science (and related)
majors were morning people. Science majors had the smallest percentage
of evening people with 8.9%, while social science/liberal arts majors
and business/computer majors had 18.7% and 18.3% respectively. Mill
workers in the sample were 30.2% morning people and 7% evening people;
however, the law enforcement category contained only 16% morning people
but 15.5% evening people. Nearly half of the mill workers who responded
worked the day shift.

Shifts

People who worked rotating shifts comprised 55.4% of the sample
of workers, with the balance of the sample comprised of people on fixed
shifts. Workers on the day shift constituted 66.4% of the fixed shift
workers. The sample of workers included 55.4% who indicated they worked
their shift by necessity rather than choice. Only 3.8% of the workers
in the morning category worked the evening or swing shift by choice,
while 11.5% worked this shift by necessity. None of the morning people
worked the night (graveyard) shift by choice, but 3.8% worked it by
necessity. Responses that gave any indication of some choice in shift
selection were recorded as choice. I made no attempt to discover if the necessity response was due to financial or family factors, job availability or other reasons. Among evening people, 35.7% of the workers worked the day shift by necessity and 14.3% worked the day shift by choice. The differences between ability to choose and the shift worked were not significant. In the student sample, 72.2% of the morning people were able to choose the percentage of classes they took before 10:00 a.m., but only 45.8% of the evening people were able to choose. None of the evening people chose to take more than 60% of their classes before 10:00 a.m., but 34.6% of the morning people did choose to take more than 60% before 10:00 a.m. The differences in the student sample were not significant.

Performance

Differences in the choice to perform tasks at specific times were examined in questions eight and nine. These questions asked what time would be easiest to perform artistic or analytic activities, respectively. The differences between morning-evening people and the time period chosen were significant at the .0000 level of less than 1 in 10,000 that this was by chance. Morning people in the combined sample chose earlier times to perform both artistic and analytic tasks, but 10.9% more chose the earliest period (6:00-11:00 a.m.) to perform analytic activities (Figures 9 and 10). These activity periods were also significantly different (p = .0000) from the preferred time to get up and go to bed as shown in Figures 11, 12 and 13. There were significant differences (p = .0000) between question five, alertness
Figure 9. Differences between morning-evening people and the time preferred to perform artistic tasks (Q8) in the combined sample. Chi square = 135.92110 with 6 degrees of freedom.

Figure 10. Differences between morning-evening people and the preferred time to perform analytic tasks (Q9) in the combined sample. Chi square = 115.05860 with 6 degrees of freedom.
Figure 11. Differences between early-late times chosen to get up (Q1) and the preferred time to perform artistic activities (Q8) in the combined sample. Chi square = 82.84279 with 9 degrees of freedom.

Figure 12. Differences between early-late times chosen to get up (Q1) and the preferred time to perform analytic tasks (Q9) in the combined sample. Chi square = 100.64665 with 9 degrees of freedom.
during the first half hour after waking, and questions eight and nine in the combined sample. Figure 14 illustrates the differences between questions five and nine.

![Graph showing differences between early-late times chosen to go to bed (Q2) and preferred time to perform analytic tasks (Q9) in the combined sample. Chi square = 98.71581 with 9 degrees of freedom.](image)

**Figure 13.** Differences between early-late times chosen to go to bed (Q2) and preferred time to perform analytic tasks (Q9) in the combined sample. Chi square = 98.71581 with 9 degrees of freedom.
Figure 14. Differences between very alert-not alert during the first half hour after waking (Q5) and preferred time to perform artistic tasks (Q8) in combined sample. Chi square = 49.53495 with 9 degrees of freedom.
CHAPTER 4

DISCUSSION

Frequencies

Morning people are those who choose to be active early in the day, at least in part because they feel they are better able to perform mental and physical tasks early in the day. Morning people feel they are at their best early, while evening people feel they are at their best late in the day. Intermediate people feel best during the middle part of the day, between the morning and evening people. They may have a slight preference for morning or evening activity but not to the extent of morning and evening people. Personal preference is not the single determining factor. Previous studies (Webb and Bonnet 1978, Horne and Ostberg 1977, Lobban 1965) indicated that there were physiological factors as well.

Students tended to prefer later times to get up and to go to bed, although 26 percent of the workers indicated they would prefer to go to bed after midnight while only 24 percent of the students chose this time. Despite the preference for a later schedule, the students tended to see themselves more as morning people than did the workers. Only 15 percent of the students indicated they were extreme evening people (question 7); however, the total scores revealed that 16.3 percent were actually extreme evening people (referred to as evening people). While 24 percent of the workers indicated they were extreme evening people, the total scores showed only 14.7 percent were evening people. Some of the
differences between the two samples may have been due to the more relaxed atmosphere of the campus and to age differences in the samples (effects of aging will be discussed later) as well as strong social influences. The students and workers may interpret "late" differently.

Adjustment of Schedules

A majority of students (58.9 percent) indicated they were able to choose their schedules, but only 36.2 percent of the workers were able to do so. In the student sample, 20.3 percent of the evening people estimated they took 21-40 percent of their classes before 10:00 a.m. by necessity and 6.9 percent of the evening students estimated they took more than 40 percent of their classes before 10:00 a.m. by necessity. No evening person estimated he took more than 60 percent early classes by choice.

In the sample of workers, 55.4 percent worked a rotating shift and there is a likelihood that most of these people did so by necessity rather than by choice. Those individuals who worked a fixed shift were divided into morning and evening people and 57.7 percent of the morning people worked a day shift by choice, but only 14.3 percent of the evening people chose to work a day shift. No morning people worked a night shift by choice, but 3.8 percent worked an evening shift by choice; and 11.5 percent worked an evening shift and 3.8 percent worked a night shift by necessity. To put this into perspective, 14.3 percent of the evening people worked an evening shift and 14.3 percent worked a night shift by necessity.

Generally, students were able to make at least some adjustments to their schedules; workers were much less able to make adjustments.
Intermediate people in both sample groups also indicated that they took classes or worked certain schedules by necessity, but an implicit assumption of this study was that intermediate people were better able to adjust than extreme morning or evening people. Therefore, the intermediate group will not be discussed here.

Shift Work and Temperature

Shift work requires many adjustments, the most obvious being the adjustment of sleep/wake patterns. Kleitman (1963) reported a cycle of alertness in subjects in a 1922 study in which the subjects attempted to follow a normal routine except for sleep. There was a period of two to three hours very early in the morning during which the need to sleep was described as almost overpowering. Later in the morning the feeling of sleepiness diminished and the subjects could function normally. Even without sleep, the subjects achieved what is frequently referred to as "second wind," but was actually a result of their circadian cycle. Body temperature was associated with the ability to fall asleep and remain asleep throughout the night (Moore-Ede et al. 1982) and with performance (Colquhoun, Blake and Edwards 1969); and Aschoff et al. (1975) reported that some subjects failed to adjust their temperature rhythms after eight days. In this study, 30 percent of the workers on rotating shifts rotate on a weekly basis or more frequently. These workers would require rapid adjustment of their circadian rhythms or they would constantly be fighting their rhythms. This could increase their health complaints and lower their productivity. Reinberg et al. (1978) suggested rapid shift adjustment was associated with low amplitude rhythms, but Reinberg et al. (1980) indicated that older individuals who remained tolerant of shift
work had larger temperature amplitudes than those who are no longer tolerant.

Two individuals volunteered to record their temperatures for approximately two weeks to demonstrate the differences in peak temperatures between morning and evening people based on the questionnaire results. Subject A recorded her temperature every two hours from 7:00 a.m. to 11:00 p.m.; subject B recorded temperatures at two different times and on two different schedules, approximately 7:00 a.m. to 2:00 a.m. and 9:00 a.m. to 2:00 a.m. Subject B, who recorded temperatures in 1981 and 1983, had three hours between peak times even though there was only two hours' difference between rising times. Subject B rose and went to bed two to three hours later on weekends in 1981. The only controls placed on this procedure were avoidance of food or drink for one-half hour prior to recording the temperatures and avoidance of strenuous exercise during this period. The hourly temperatures were averaged and the means plotted in Figures 15 and 16. These temperatures indicate that the differences in peak temperatures between morning and evening people were not simply related to waking times. Subject A, who was categorized as a morning person by the questionnaire, had a peak temperature more than three hours earlier than subject B, an evening person.

Body temperature has also been associated with mental performance; higher temperatures were associated with better performance. Bernstein (1977) found no indication that these fluctuations of performance were related to ability or motivation differences. Kleitman (1963) reported that the more difficult the task, the greater the effect
Figure 15. Daily mean temperatures, variation of a morning person (subject A) and an evening (subject B) person.
Figure 16. Daily mean temperature variations of an evening person on different time schedules.
of temperature. When shifts rotate rapidly (as they did for 30 percent of the rotating workers in this study) and the workers are unable to adjust their temperature rhythms, they may find they feel and perform best when their work schedules indicate they should be sleeping.

Age

Hellbrugge (1960) and Aschoff (1967) presented evidence that circadian rhythms begin to develop from birth and, since some individuals become intolerant to shift work in middle age, it appears that the process continues throughout life. In the worker sample, 18.3 percent of the people in the 14-30 age group were evening people, but only 5.3 percent of the people in the 46-65 age group were evening people. The trend for people to become less evening active became very evident when I looked at the evening people only. More than half the evening people (51.3 percent) in the worker sample were aged 14-30, 43.6 percent were aged 31-45, but only 5.1 percent were aged 46-65. Some of the complaints associated with shift work could be associated with aging rather than shift work, but Reinberg et al. (1978) suggested that only a small proportion of healthy adults are able to sustain shift work. He indicated that most shift workers begin to suffer from fatigue and sleep disturbances from one to four months after starting shift work. Findings in the present study supported the suggestion by Torsvall and Akerstedt (1980) that older individuals were more morning active; there were significant differences between morning and evening activity in the various age groups (Figure 7).
Health and Physical Complaints

Most individuals on rapidly changing schedules do not become adapted, and this fact can lead to increased work errors, delays and increased stress on the shift worker. Meers et al. (1978) indicated that health complaints by shift workers included: apathy, fatigue, gastric disturbances, palpitations, and nervousness. Insomnia or sleep disturbances were included in workers' complaints. One of the physiological systems closely linked to sleep/wake cycles is the adrenal system, especially the steroid hormones called glucocorticoids. Glucocorticoid secretions follow a circadian cycle, and the variation is sufficiently large to be compatible with a diagnosis of adrenal insufficiency at one time and, approximately twelve hours later, hyperfunction (Halberg et al. 1972). While a severe upset can lead to death, milder symptoms include: apathy, anorexia, fasting hypoglycemia, and reduced resistance to physiological stress with reduced glucocorticoid secretion and increased blood glucose, weakness, and hypertension with increased glucocorticoid secretion (Spence and Mason 1983). One factor underlying shift workers' complaints may be the inability to adjust to fixed or rotating shifts. The resulting emotional stress and sleep disturbances may interfere with the normal glucocorticoid circadian rhythms.

Adjustment

Reinberg et al. (1980) reported that one could assess good adjustment to shift work by the use of certain clinical criteria, the absence of persistent fatigue, the absence of sleep disorders, and the absence of gastritis and peptic ulcer. Torsvall and Akerstedt (1980)
stated that morning people complained less about sleep disturbances while they worked a morning shift than did evening people when they worked a morning shift. The reverse was generally true when they both worked night shifts. Horne and Ostberg (1977) reported that results of a 1973 study by Ostberg indicated that evening people adapted more quickly to shift work. Reinberg et al. (1980) suggested that some individuals will lose some of their ability to adjust as they age. The present study indicated that at least some individuals become more morning active as they age. The questionnaire indicated that 33 percent of those who worked rotating shifts rotated at least every two weeks. This can result in an almost constant dissociation of circadian rhythms. Those who worked schedules rotating monthly or less frequently (67 percent) would be better able to adjust between rotations. The permanent shift workers had the best opportunity to adjust, but minor schedule shifts upset this adjustment somewhat. The phrase "Monday morning blues" can be heard in almost any office and refers to the effects of minor (sometimes not so minor) schedule shifts during the weekend. Night workers, who comprised 10.4 percent of the permanent workers, can suffer more severe upsets than day workers if they attempt to maintain normal family and social relationships (with those on day schedules). Weekends frequently result in a two-day schedule change for the worker and, for some night workers, it frequently keeps them in a state of continual minor dissociation of rhythms.
CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The findings of this study appear to support the hypotheses that: 1) there are people who are not adjusted to the predominant work schedule of the western industrialized world, and 2) there are other people who are not adjusted to the evening and night work schedules which are becoming more common. There were approximately 14 percent morning people and 16 percent evening people in the combined sample. Morning people and evening people have distinct differences in peak temperature times (as exemplified by the temperature curves of subjects A and B), and high temperature is related to higher efficiency and general performance. Morning people are at a disadvantage when required to perform tasks late in the day after their temperatures have peaked. The reverse is true for evening people who are at a disadvantage in the morning when their temperatures are still low. The differences between morning-evening people and the time of day chosen for certain tasks indicated that most people in this study are at least intuitively aware of this fact. Most morning people prefer to begin their tasks very soon after waking. On the other hand, many evening people appear to be slow starters and prefer to delay their tasks for four to eight hours after waking. Students appear to be able to adjust their schedules. However, the workers' ability to adjust their work schedules to take advantage of their peak abilities was quite low. Slightly more than one-half of the
workers indicated that they worked rotating schedules, which means that
two-thirds of the time they are working shifts for which their circadian
rhythms are not adjusted. Some adjustment of rhythms is possible, but
rotating shifts and weekends during which workers alter their schedules
make this difficult. A night shift worker who attempts to maintain
social relationships on the weekend will delay his adjustment to the
night schedule and the same is true of an evening person working an early
morning shift. Since the workers and students were not asked about their
health complaints, there is no way to determine the degree of adjustment
of those participating in the study.

There are significant differences between the rhythms of people
in the various age groups; people tend to become more morning active as
they age. There also appears to be a decrease in the ability to
tolerate shift work during middle age. Only a very few people are able
to tolerate shift work for their entire working life.

Conclusions

I concluded that there are identifiable groups of people whose
circadian rhythms make adjustment to certain work schedules difficult.
Morning and evening people can be identified by questionnaires based on
preferences and by testing physiological variables such as temperature.
Morning people appear to be less able to adjust to night work schedules
than evening or intermediate people. Morning people are better able to
work a very early schedule, such as 6:00 a.m. to 2:00 p.m. or 7:00 a.m.
to 3:00 p.m. Conversely, evening people are better suited for a late
afternoon shift, such as 11:00 a.m. to 7:00 p.m. or noon to 8:00 p.m.
Few people are well adapted for late night work, but most evening people
can adjust and they experience fewer adjustment problems than morning people. Intermediate people are best adjusted to a normal 8:00 a.m. to 5:00 p.m. schedule, but they are able to adjust to a morning or evening schedule with apparent ease. Rotating shifts cause physical and emotional problems (in varying degrees) for most workers, but evening people usually adjust more rapidly than morning people.

Moore-Ede et al. (1982) reported a study by Dawber in 1980 about the effects of lifestyle. The study concluded that the most difficult shifts to adjust to were those that rotated weekly. This conclusion was supported by Aschoff et al. (1975) who reported that some subjects required more than eight days to adjust their temperature rhythms. Since aging appears to reduce the ability to adjust, allowing senior employees to work the shift that best suits their circadian rhythms might ease some of the problems associated with workers who become intolerant to shift work. In general, the longer the period between rotations, the better the worker is able to adjust to a shift that does not coincide with his circadian rhythms.

Recommendations

Further study should be done to determine if questionnaires or other simple tests can be devised to predict who can tolerate shift work and when tolerant individuals will become intolerant. Since temperature is closely associated with performance, such testing might include temperature rhythms as well as other rhythms such as endocrine rhythms. Comparison of various rhythms of rotating shift workers with those of permanent shift workers and with people who are able to adjust their
schedules to coincide with their rhythms could provide clues as to when and why certain people become intolerant to shift work. Further, discovery of ways to avoid some of the effects of shift work might be helpful; this would be helpful for those involved in important negotiations or in dangerous situations. If shift workers became acquainted with their own rhythms, they could avoid some of their complaints, for instance, by limiting the alteration of weekend schedules. Aschoff et al. (1975) suggested that while single rhythm shifts are not harmful, this may not be true of repeated rhythm shifts such as those workers on rotating shifts must make. Laboratory studies have shown that repeated rhythm shifts can shorten the life span of certain flies by approximately 20 percent. Long-term studies are necessary to determine if repeated rhythm shifts have severe and permanent effects on man. Further investigation should be made into the use of charting the rhythms of healthy individuals to be used later as a help in diagnosing illness. The dissociation of rhythms can be an indicator of very subtle changes in the body which can forecast disease.
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## APPENDIX I

**CORRELATION MATRIX OF QUESTIONS USED FOR SCORING**

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Instructions
1. Please answer questions in numerical order.
2. Each question should be answered independently of all others.
3. Place an X beside only one answer.
4. This questionnaire will be strictly confidential—your name is not necessary.

Age _____  Sex _____  Major ___________________________  GPA (optional) _____

Approximately what percentage of your classes have been before 10:00 a.m. (all quarters) ______; was this by choice or necessity? _______________________________

1. When would you choose to get up (provided you have to put in a full 8-hour day at work or school) if you were totally free to plan your own day? _______________________________

2. When would you choose to go to bed if you were entirely free to plan your day (provided you have to put in a full 8-hour day at work or school)? _______________________________

3. If you always had to go to bed at midnight, what do you think it would be like to fall asleep then? ______

4. If you always had to get up at 6:00 a.m., what do you think it would be like? ______

5. During the first half hour after waking, how alert do you feel? ______

6. At what time in the evening do you feel tired and in need of sleep? ______

7. To what extent are you a morning or evening active individual? ______

8. If you had a totally free day, at what time would it be easiest for you to perform artistic activities (drama, music, dance practice, painting, woodcarving, writing, etc.)? ______

9. If you had a totally free day, at what time would it be easiest for you to perform analytic tasks (balance checkbook, think through a math problem, take a computer science class, etc.)? ______
APPENDIX I (Continued)  ACTIVITY PREFERENCES
(Circadian Rhythms)

Instructions
1. Please answer questions in numerical order.
2. Each question should be answered independently of all others.
3. Place an X beside only one answer.
4. This questionnaire will be strictly confidential—your name is not necessary.

Age ______ Sex ______ Occupation ________________________________

Do you work a fixed or rotating shift? ________________________________

How often does it rotate? _________________________________________

As you rotate, do you go to work earlier or later? _____________________

If on a fixed shift, what hours do you normally work? __________________

How long have you worked this shift? ________________________________

Do you work these fixed hours by choice or necessity? ________________

1. When would you choose to get up (provided you have to put in a full 8-hour day at work or school) if you were totally free to plan your own day? ________ Before 6:30 a.m. (1) ________ 6:30-7:29 a.m. (2) ________ 7:30-8:29 a.m. (3) ________ 8:30 a.m. or later (4)

2. When would you choose to go to bed if you were entirely free to plan your day (provided you have to put in a full 8-hour day at work or school)? ________ Before 10:00 p.m. (1) ________ 10:00-10:59 p.m. (2) ________ 11:00-11:59 p.m. (3) ________ Midnight or later (4)

3. If you always had to go to bed at midnight, what do you think it would be like to fall asleep then? ________ Very difficult—lie awake for a long time (4) ________ Rather difficult—lie awake for some time (3) ________ Rather easy—lie awake for a short time (2) ________ Easy—fall asleep almost at once (1)

4. If you always had to get up at 6:00 a.m., what do you think it would be like? ________ Very difficult & unpleasant (4) ________ Rather difficult & unpleasant (3) ________ A little unpleasant but no great problem (2) ________ Easy—no problem at all (1)

5. During the first half hour after waking, how alert do you feel? ________ Not at all alert (4) ________ Slightly alert (3) ________ Fairly alert (2) ________ Very alert (1)

6. At what time in the evening do you feel tired and in need of sleep? ________ Before 9:00 p.m. (1) ________ 9:00-9:59 p.m. (2) ________ 10:00-10:59 p.m. (3) ________ 11:00 p.m. or later (4)

7. To what extent are you a morning or evening active individual? ________ Pronounced morning active (1) ________ (alert morning, tired evening) ________ To some extent morning active (2) ________ (tired morning, alert evening) ________ To some extent evening active (3) ________ Pronounced evening active (4)

8. If you had a totally free day, at what time would it be easiest for you to perform artistic activities (drama, music, dance practice, painting, woodcarving, writing, etc.)? ________ 6:00-11:00 a.m. (1) ________ 11:00 a.m.-4:00 p.m. (2) ________ 4:00-9:00 p.m. (3) ________ 9:00 p.m.-2:00 a.m. (4)

9. If you had a totally free day, at what time would it be easiest for you to perform analytic tasks (balance checkbook, think through a math problem, take a computer science class, etc.)? ________ 6:00-11:00 a.m. (1) ________ 11:00 a.m.-4:00 p.m. (2) ________ 5:00-9:00 p.m. (3) ________ 9:00 p.m.-2:00 a.m. (4)
TABLE I. NUMBER OF RESPONSES BY QUESTION AND SCORE

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<th>(2) Moderate Morning</th>
<th>(3) Moderate Evening</th>
<th>(4) Extreme Evening</th>
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### TABLE II. NUMBER OF MORNING, EVENING, AND INTERMEDIATE PEOPLE BY AGE GROUP

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<th>46-65</th>
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Chi square = 10.39397 with 4 degrees of freedom. Minimum expected cell frequency = .519 Significance = .0343

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Chi square = 12.12173 with 4 degrees of freedom. Significance = .0165

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Chi square = 20.06850 with 4 degrees of freedom. Significance = .0005
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Chi square = 51.87344 with 9 degrees of freedom. Minimum expected cell frequency = 3.747  
Significance = 0.0000  
Missing observations = 3

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Chi square = 38.78159 with 9 degrees of freedom. Significance = 0.0000  
Missing observations = 4

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Chi square = 82.84279 with 9 degrees of freedom. Significance = 0.0000  
Missing observations = 7

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Chi square = 56.36995 with 9 degrees of freedom. Minimum expected cell frequency = 2.529 Significance = 0.0000 Missing observations = 3

| **Workers** |    |    |    |    |
| 1          | 26 | 16 | 8  | 5  |
| 2          | 30 | 43 | 15 | 3  |
| 3          | 8  | 24 | 18 | 0  |
| 4          | 3  | 31 | 30 | 10 |

Chi square = 55.51568 with 9 degrees of freedom. Minimum expected cell frequency = 3.333 Significance = 0.0000 Missing observations = 1

| **Combined** |    |    |    |    |
| 1          | 44 | 29 | 10 | 6  |
| 2          | 74 | 86 | 30 | 7  |
| 3          | 29 | 83 | 39 | 8  |
| 4          | 15 | 80 | 69 | 24 |

Chi square = 100.64665 with 9 degrees of freedom. Significance = 0.0000 Missing observations = 4
### APPENDIX III

**FREQUENCY OF SCORES**

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