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THE EFFECTS OF AROUSAL ON TIME PERCEPTION

by

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THE EFFECTS OF AROUSAL ON TIME PERCEPTION

J. Keith Cardwell, Ed.D.

Western Michigan University, 1993

This study examined the effect of physiological arousal on subjects' time production skills. Time perception is a major element in clinical theories of demandingness and time urgency within the Type A behavior pattern.

Subjects were 94 graduate students, including 67 females and 27 males. They were assigned randomly to three groups: a control group and experimental Groups A and B. All subjects performed 15-, 30-, and 45-second pretest and posttest time production trials. The primary treatment for experimental groups was rapid breathing to increase subjects' heart beat at least 10% above their resting rate. Heart beat was measured by a HR/BVP 110T biofeedback instrument. The testing limit was 140 heart beats per minute. The secondary treatment for experimental Group B was foreknowledge about the experiment which subjects received prior to the timed trials.

A one-way ANOVA of standard, raw data revealed no significant differences between experimental groups due to secondary treatment and none between Group A and the control group due to primary treatment, but there was significance between Group B and the control group. Conversion of raw data to absolute values produced significant differences between Group A and the control group and Group B and the

controls from primary treatment. A probability of .05 was utilized throughout the study. An abnormal distribution of Group A subjects on the normal distribution curve seemed probable.

All groups experienced difficulty in reproducing accurate time intervals in relation to pretrial times. Mean differences compared to pretrial means (baseline) showed moderate-high percentages of time error or distortion, including the control group.

Results suggested that individuals have high variability in time judgment and that arousal, generally free of intense cognitive content/ process, can increase error percentage.

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J. Keith Cardwell

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CHAPTER I

THE PROBLEM AND ITS CONSEQUENCES

Introduction

In the second edition of this text Experimental Psychology, B. J.
Underwood (1966) identified the study of discriminal processes as one
of the oldest areas of experimentation. Examination of situations and
conditions which influence time perception has been a standard part of
discrimination studies. Equally venerable in its tradition is research of
physiological factors (Baddeley, 1966; Du Nouy, 1944; Hoagland, 1933;
J. M. Lockhart, 1967) which tend to alter time perception.

Everyone has probably experienced situations and conditions
which lead to distorted judgment of elapsed time, such as waiting im-
patiently in line or sensing pain (B. J. Underwood, 1966). Generally, re-
search has focused upon single aspects of the perceptual process, often
examining its mechanisms in a benign manner. Current theories of
human behavior (Beck & Weishaar, 1989; Wessler & Wessler, 1980),
including therapeutic interventions, imply that time perception has a
major role in demand behavior and its resultant demand for immediate
satisfaction. Whether verbal or unexpressed, demand/immediacy seem
to appear consistently in depression, rage, fear, and other extreme
emotional states. If most of emotional affect consists of the cognitive
processing of physiological activity (Davidson, 1992; Leeper & Madison,
1962), extreme emotional states probably include the cognitive structure

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of demand/immediacy, suggesting an impacted time perspective accompanying increased arousal. Recent explication of the Type-A behavior pattern (Friedman & Ulmer, 1984; Matthews, 1982; L. Wright, 1988) with its sense of time urgency indicates the presence of demand-immediacy.

Theories of Time Experience

Early Psychiatric Concepts

Early psychiatric perspectives focused upon the causes and effects of time distortion. Schilder (1936) posited that "psychological attitudes express themselves in the way in which we experience time" (p. 531), and that analysis of the psychology of time offers insight into the way the mind works. Persons repress time perception like other perceptions, and the perception of longer or shorter time may be like other perceptions. Psychiatric constructs such as depersonalization, obsessional neuroses, and acute schizophrenia have elements of time distortion. A person suffering depersonalization experiences a sense of emptiness in life which distorts the time perception. Individuals with obsessional neuroses experience time extended. The acute schizophrenic perceives disorientation in time and space as he senses time continually changing.

Schilder (1936) suspected that instinctive drives might change time concepts, including present experiences. Changes in the libidinous situation alters time perception. Personality factors influence the perception and experience of small time units. Schilder suggested

specifically that the parietal lobe and adjacent areas of the temporal lobe in connection with the vestibular apparatus are important sources of perceiving time sequences.

Meerloo (1948) believed that the diencephalon regulates an inner, inherent, autonomous time rhythm which only death extinguishes, and is separate from a cosmic, external rhythm which influences individuals. The inner clock runs unconsciously with the world clock and is vital for the regularity of vegetative functions and many conditioned reflexes. Alteration of the internal clock can cause senile dementia and enceph-alitis lethargic, the latter often producing the loss of awareness of day or night.

Sense of time fluctuates in patients with manic-depression. Persons estimate time as too short during manic episodes and as too long during depression episodes (Meerloo, 1948). Many distressed persons become slaves to regulations and time tables. Their haste and impatience make a defense against guilt. Often, time becomes a symbo-lic element through which the person can release other drives.

Learning Concepts of Time Experience

Another concept is that time awareness is not inherent but the result of learning, and accurate assessment of time is essential to coping (DuBois, 1954). When significant others impose time limitations sym-pathetically and understandingly on a child in order for him to achieve a proper sense of duration in maturity,

> he accepts time as a privilege, not a menace, and takes it at
> its true value and uses it intelligently, an attitude and pro-
> cess that give to an adult a sense of proportion as to the

relative significance of his daily activities and the objectives towards which he is striving. Basically, such a person has learned to wait without undue stress; he can view time objectively and live in terms of "the Reality Principle," a distinguishing mark of the well-integrated and emotionally adjusted adult. (p. 48)

If the infant experiences sympathy from significant others while learning time, he develops a sound sense of duration regardless of early frustrations (DuBois, 1954). If significant others are arbitrary, interfering, and/or critical, failing to cooperate with the growing child's needs in a sympathetic way, a dysfunctional and handicapping time sense results. The adult fails to function in a mature way because of a defective sense of time that is unconsciously equated with a disturbed reaction to authority, motivating failure in social adaption to a culture which accepts a common denominator of time.

Perhaps humans attempt to temporally escape the present and enter the future where they can conceive of values and discover some meaning in existence (Ketchum, 1951). Possibly, human groups organize temporally and spatially, and extend themselves in time with reference to the future. Human activities have temporal foundations, and construction of stable relationships with others represents for individuals their only victory over time. Group membership provides humans with an understanding of time.

<center>Time Perspective in the Type A Pattern</center>

Research into time effects expanded into cognitive-behavioral assessment processes with the advent of the Type A behavior pattern in 1960-61 (Smith & Anderson, 1986). The Western Collaborative Group

Study began as a prospective epidemiological investigation of the incidence of coronary heart disease in 3,524 men, ages 39-59, employed at 10 California companies (Rosenman et al., 1975). The study's major researchers, Rosenman and Friedman (1977), discovered the Type A pattern as a set of specific behaviors that caused increased levels of autonomic arousal, contributing to the development of heart disease, particularly coronary heart disease and atherosclerosis. Rosenman et al. (1975) identified Type A behavior as "enhanced aggressiveness, ambitiousness, competitive drive and chronic sense of time urgency" (p. 872). Conversely, Type B behavior is a lack of time urgency; no free-floating hostility or chronic aggressiveness; high self-esteem; and usually, aesthetic and intellectual interests (Friedman & Ulmer, 1984).

Of the 1,589 Type A patients in the Western Collaborative Group Study, 34 died from coronary heart disease during the research (Rosenman et al., 1975). Of the 1,565 patients without Type A behavior (Type B subjects), 16 died of coronary heart disease. Average systolic and diastolic blood pressures, serum levels of cholesterol and triglycerides, and beta-/alpha-lipoprotein ratios were significantly higher in patients who later developed coronary heart disease compared to subjects who did not incur the disease. Subjects who were Type A at intake also had significantly higher rates of coronary heart disease than did patients who were Type B.

Rosenman and Friedman (1977) contended that the Type A pattern includes:

> a profound sense of time urgency. All Type A subjects strive almost incessantly to accomplish more and to involve themselves in more events despite necessarily dwindling

reserves of time. They squander their time in the execution of too many projects (or tasks) or participate in too many events. (p. 324).

The authors stated that more than 50% of American urban populations demonstrate Type A behavior.

Validity of the Type A Concept

Although some research has questioned the validity of Type A behavior eliciting physiological reactivity which contributes to coronary heart disease, consistent research continues which indicates that Type A behavior is strongly associated with heart disease. Studies showed no significant association between Type A behavior and 104 patients undergoing cardiac catheterization (Dimsdale et al., 1979); increased blood pressure (Gallacher, Beswick, Jones, & Turkington, 1988); or increased heart rate, blood pressure, epinephrine, or norepinephrine levels (Myrtek & Greenlee, 1984). Pishkin, Braggio, and Lovallo (1987) found that Type A men showed higher levels of somatic activation than did Type B men, even under moderate tasks, but activation was in noncardiac parameters.

Other studies found that Type A behavior correlated positively with increased physiological measures. Type A males in a subject pool of 218 undergraduates had higher pulse rates than did Type B subjects when both groups worked on digit span tasks, and Type A subjects showed greater sympathetic nervous system arousal in response to a psychological threat to self-esteem (Pittner & Houston, 1980). Patients who had undergone angiographic evaluations to determine their incidence of coronary heart disease had a high association with hostility, a

component of Type A behavior (Dembroski, MacDougall, Williams, Haney, & Blumenthal, 1985). Type A women had more tension in their frontalis muscles by electromyocardiograph (EMG) measurement than Type B women while both were in mildly competitive conditions (Drennan, Ford, & Rutledge, 1987).

Individuals showing time-urgent behavior had high urinary norepinephrine levels, and persons perceiving deadline pressures suffered substantial increases in serum cholesterol levels (Glass, Snyder, & Hollis, 1974). Type A subjects demonstrated elevated blood flow to peripheral tissue responding to competitive tasks (Goldband, 1980). Following exercise, Type A men had higher platelet counts in their whole blood than did Type B men along with increased durations of platelet aggregation (Haynes, Feinleib, Levine, Scotch, & Kannel, 1978). Accelerated heart beat was consistent for Type A persons throughout tests for impatience/speed (Jennings & Choi, 1981). Sixty-seven male cardiac patients ages 34-59 had increased disposition of plaque in their coronary arteries, while Type B persons seemed to show little plaque deposit over time (Krantz, Sanmarco, Selvester, & Matthews, 1979). Lovallo, Pincomb, and Wilson (1986) found that subjects with high heart rate reaction were likely to be more responsive to a given level of demand than were low heart rate reactives. High heart rate reactives had greater norepinephrine concentrations, blood pressure, and muscle tension with higher sympathetic response during active coping.

A recent study (Scher, Hartman, Furedy, & Heslegrave, 1986) discovered that Type A males demonstrated greater T-wave amplitude attenuation during mental work than did Type B participants. T-wave

flattening or inversion reveals ventricular repolarization in electromyocar-diograph (EMG) readings, a result of myocardial ischemia, a heart disease. Research by Williams et al. (1980) on physiological responses to mental tasks showed that Type A men had greater muscle vasodilation. In a study of 319 Type A patients and 105 non-Type A, or Type B, patients with coronary heart disease, they found that 71% of Type A patients had at least one significant coronary arterial occlusion of 75% blockage or better (Williams et al., 1980). Only 56% of Type B patients had a significant occlusion.

Critics suggest that the validity of the Type A construct's major measuring devices is questionable due to their tendency of measuring separate, discrete behavioral factors rather than factors that overlap (Linden, 1987). The Structured Interview, a 25-item questionnaire which is a result of the Western Collaborative Group Study, measures the factors impatience, hostility, and competitiveness (Matthews, 1982). The Jenkins Activity Scale is a self-report scale that contains 50 questions. The Jenkins scale measures speed and impatience factors (Haynes, Feinleib, & Kannel, 1980). The Framingham Type A scale came from a longitudinal study of 2,282 men and 2,845 women initially free of any manifestations of coronary heart disease (Haynes, Levine, Scotch, Feinleib, & Kannel, 1978). The Framingham scales are psycho-social measures of emotional reactivity which might make a person more susceptible to anxiety/arousal, and the scales correlate significantly with ambitiousness, tension, daily stress, and anger factors. Some research found a high correlation (r = .52 for male workers; r = .64 for male college students) between the Framingham and Jenkins scales (Haynes

et al., 1980).

Matthews (1982), a longtime researcher in Type A behavior, recognized that the pattern is not a discrete typology but a continuum of behaviors ranging from extreme Type A to extreme non-Type A, or Type B. Time urgency is a vital component of the Type A pattern (Matthews, 1982; Rosenman & Friedman, 1977). Some (Gastorf, 1980; L. Wright, 1988) believe that time urgency is the primary dysfunctional behavior of the pattern.

Models of the Type A Pattern

Models of the construct have developed with research (Smith & Anderson, 1986). The original concept was a mechanistic interaction approach, where Type A behavior is a characteristic style of responding to certain classes of stimuli and in which it correlates positively with enhanced sympathetic nervous system activity. Hemodynamic stresses, such as increased blood pressure and turbulence, and circulating catecholamines associated with sympathetic arousal produce initial injuries to the lining of coronary arteries, establishing the site for developing atherosclerotic plaques.

The mechanistic interaction approach was basically a stimulus-response approach and, because of its simplicity, did not explain more involved processes of the behavior pattern (Smith & Anderson, 1986). The biologic interactional model suggests that a constitutional factor underlies the pattern, with Type A persons responding to challenges and demands with specific behaviors and physiological activity. The approach suggests that persons need no conscious mediation to act and

that behavior is the result rather than the cause of physiological processes.

Time Urgency and Arousal in Type A Behavior

The biopsychosocial interactional model that evolved from previous models recognized that challenges and demands elicit Type A behavior from predisposed persons and that situations reinforce and maintain the behavior (Smith & Anderson, 1986). This model allows persons not only to respond to situations but to create additional challenges and demands. Smith and Anderson insisted that Type A individuals systematically construct environments that are subjectively and objectively in those classes of stimuli known to elicit overt Type A behaviors and enhanced reactivity. This action produces physiological reactivity, which influences the expression of specific Type A behavior. By seeking conditions that will provide stimuli to excite their autonomic nervous systems, Type A persons increase stressfulness in their environments as well as the frequency, degree, and duration of reactive episodes (Feather & Volkmer, 1988; Smith & Rhodewalt, 1986; L. Wright, 1988). Friedman (cited in Friedman & Ulmer, 1984) hypothesized early in the development of the Type A concept that individuals who exhibit time-urgent, excessively competitive, and/or hostile behavior condition themselves to high and continual discharges of epinephrine and norepinephrine which aroused the autonomic nervous system. They become self-addicted to the hormones, seeking cognitions and actions which stimulate the drugs.

The biopsychosocial interactional concept rejects unidirectional causal models, following a social learning concept (Smith & Anderson,

1986). The Type A pattern seems to suggest an association between the factors of time urgency (speed/impatience) and anxiety/arousal. Type A subjects had greater difficulty responding to slow-response demands of a task than did Type B persons, 47% of Type A subjects demonstrating tense and hyperactive behavior compared to 12% of Type B subjects (Glass et al., 1974). Type A subjects exhibited greater impatience and irritation to slowed-down decision-making.

L. Wright (1988) concluded after extensive observation of heart patients that the three components that contribute to Type A behavior more than other components are: time urgency, chronic activation, and multiphasic thinking. L. Wright defined time urgency as concern over a few seconds, not a large segment of time. Chronic activation is a tendency to remain active and physiologically aroused for most of the day, each day. Multiphasic thinking refers to a tendency to be involved in many activities at one time and to do more than one thing at a time for achievement. Clinical interviews with coronary patients who possessed strong Type A profiles revealed that a high need for achievement, often in competitive activities, to bolster self-worth was a primary factor of the pattern.

Goldband (1980) found that Type A individuals reacted pathophysiologically to reaction time tasks only when they contained time urgency and competitive components. Type A persons made more errors than did Type B individuals when under time pressure but not when they performed the same task under a condition of no time pressure (Bingham & Hailey, 1989). Type A subjects attempted to solve more problems in no-deadline situations, significantly underestimated

time intervals, and became impatient with delay (Burnam, Pennebaker, & Glass, 1975). Type A individuals report little control-for-self in time-pressure conditions (Dyck, Moser, & Janisse, 1987).

Hospitalized postinfarction heart patients who were Type A showed a daily perception of time urgency during their hospital stays but showed little in relation to their length of hospitalization (Smith & Rhodewalt, 1986). Patients with coronary heart disease often have difficulty relaxing, even before the onset of the disease (Jenkins, 1971). Time urgency and the ability to relax are valid precursors and sustainers of heart disease. Hamberger and Hastings (1986) discovered a high correlation between speed/impatience, high expectations, and anxious overconcern, suggesting that Type A persons tend to demand much of themselves while being concerned to a high degree about control issues.

There is a link between time urgency and anger, which is physio-logical (L. Wright, 1988). The body has a neuroendocrine response to both time urgency and anger, which is the fight or flight response. Adrenalin and noradrenalin output increases, raising heart rate and blood flow to voluntary muscles. Heightened anger is secondary to time urgency. Time-urgent persons become easily angry at anyone who wastes their time.

Time-urgent Type A persons might perceive threat from lack of sufficient control over more intense environmental stressors and often feel helpless (Krantz, Glass, & Snyder, 1974) even though other re-searchers suggest that Type A persons seek exciting, time-urgent situa-tions (Feather & Volkmer, 1988; Friedman & Ulmer, 1984; Smith & Rhodewalt, 1986; L. Wright, 1988).

A study (Hansson, Hogan, & Johnson, 1983) of 69 male college students revealed that "driveness," a behavior often connected to time urgency, correlated negatively with empathy and positively with anxiety. Hard-driving behavior and speed of activity have correlated significantly (Dembroski et al., 1985). Data from 242 undergraduates showed significant correlations between state and trait anxiety, irrational beliefs, and dysfunctional attitudes (Lohr & Bonge, 1981).

Type A subjects have demonstrated time urgency behavior by arriving earlier than Type B subjects to participate in experiments (Gastorf, 1980; Yarnold & Meuser, 1984); returning questionnaires significantly earlier than Type B persons (Yarnold & Meuser, 1984); significantly underestimating a one-minute time interval (while Type B participants overestimated it) (Yarnold & Grimm, 1982); and being significantly involved in numbers of traffic accidents and violations compared to normal driving behavior (Perry, 1986).

Evidence indicates that impatience/time urgency can begin in early childhood. The mothers of 126 subjects who were interviewed when their children were ages 3-4 and young adults gave data indicating that early childhood temperament accounts for approximately 13% of the variance in the young adults' impatience (Steinberg, 1985). Goldman (1985) found reflective children to have a more highly developed time concept compared to impulsive children, the latter estimating time intervals longer than accurate and showing poorer skills at delay of gratification.

Physical Results of Time Urgency

Subjects with speed/impatience behavior reported 86% more physical symptoms than persons without this behavior (Woods & Burns, 1984). Symptoms of significance were chest pain, respiratory symptoms, and sleep disorders. Spence, Helmreich, and Pred (1987) found that impatient and irritable men and women reported a greater number of physical complaints.

Research has shown that anxiety correlates positively with time urgency (Burke, 1985) and negative cognitions (Smith, Houston, & Zurawski, 1985), and correlates negatively with cognitive therapy (Jenni & Wollersheim, 1979). However, the latter researchers found that Type A behavior and anxiety are not synonymous. Type A individuals rarely showed signs of acute or chronic anxiety.

Hypothesis and Limitations

This research hypothesized that subjects who experience increased physiological arousal will significantly distort time perception by underestimating or overestimating specific time intervals compared to earlier time estimations at a nonarousal resting rate. The dependent variable was the change-score differences between pretest and posttest time interval productions. Independent variables were aroused/ unaroused states and subjects blind/knowledgeable to experimental procedure.

A usual limitation of experimental design is its weak external validity, which limits generalization of results to the population and other

environments (Ary, Jacob, & Razavieh, 1986; Hopkins, Glass, & Hopkins, 1987, McBurney, 1983). External validity must have strong similarities between the subject sample and population for generalization, requiring the experimenter to have a thorough knowledge of the characteristics of the sample and the general population (Ary et al., 1986). Subjects who come from a specific pool, such as college students, tend to limit generalization of results to persons with similar socioeconomic status. Additionally, significant statistical interaction between experimental groups restricts confidence in external validity (Hopkins et al., 1987).

Other variables which tend to confound external validity are the effects of a laboratory environment upon subjects in comparison to their external environments (McBurney, 1983). A laboratory might affect a subject differently than other environments, including other laboratories or experimental conditions. Experimenter effect can be part of laboratory experience for subjects when they respond to the biases and/or expectations of the experimenter (Dember & Jenkins, 1970). Experimenter effect occurs usually without the awareness of either subjects or experimenter, and can affect data surreptitiously. Experimental assistants who conduct research blind to the hypothesis and the purpose of data collection generally obtain results free of experimenter effect, but often, as in this experiment, assistants are unavailable or the costs for their services are prohibitive.

Progressive error is another variable that can confound data. Progressive error is any change in behavior which is a consequence of continued experience or successive trials with a specific task (B. J.

Underwood, 1966), and is known also as learning or practice effect. If two or more stimulus variables change concurrently, results are not attributable to a single stimulus variable, blurring the validity of any cause-effect relationship. One method of diminishing progressive error is to limit the amount of behavior change, or dependent variable. One intention of this experiment's design was its attempt to avoid confounding variables. Although the design included pre- and posttest tasks, subjects did not receive feedback regarding the accuracy of their performances, which should have limited any practice effect. To achieve parsimony, tasks required the time production method, which B. J. Underwood (1966) identified as "a variant of absolute judgment" (p. 50).

The possibility exists that confidentiality of the experiment's design and/or hypothesis could be in jeopardy when subjects come from an environment with high social access such as a university department or college. Although subjects received debriefing which included an emphasis on the need for confidentiality to promote the research's success, some subjects might have shared their experiences with incoming subjects.

The general design was a three-group pretest (baseline), posttest; experimental (two), control group (one) design with three separate time trials (15 seconds, 30 seconds, and 45 seconds). Data were analyzed with a one-way analysis of variance and comparison of the change-score means to the pretest (baseline) means to obtain percentages of time distortion. The latter is a nonstatistical method. Null hypotheses were tested at the .05 level of significance.

Definitions

Change score: A difference between the pretest and posttest time productions of a task.

Time production: The interval which a person creates mechanically after another individual has given him or her a number representing a specific time period.

Time reproduction: The interval which a person creates mechanically in an attempt to replicate a prior experienced time interval.

Time estimation: The verbal assessment which a person gives of a prior experienced time interval.

Primary treatment: Rapid breathing by subjects.

Secondary treatment: Knowledge of the research design prior to experimentation.

Qualified data: The results of any task which an experimental subject did before and/or during rapid breathing and in which the reading of heart rate at the end of the posttest trial was 10% or greater than the reading of heart rate at the close of the pretest trial.

CHAPTER II

SURVEY OF TIME CONCEPTS AND RESEARCH

Time's Role in Life

Time and space are two basic dimensions of human ordering behavior (Ainlay, 1988). Temporality is determining the subjective placement of events within the flow of time--past, present, and future. To be aware of one's self, an individual must be able to perceive or understand his position in the present between his recollections of a past beginning and a future approaching death.

Weber (1933) believed:

An adequate understanding of the nature of time is not only important from the standpoint of general scientific theory, but it is also fundamental to the understanding of every problem of conscious experience. The temporal problem is involved in psychological processes ranging in complexity from the most involved memory processes down to the simplest sensory experiences. (p. 233)

Philosophical views of time generally acknowledge the existence of subjective time but some deny the existence of objective time. Others claim that temporal illusions are gross deviations in subjective time from objective representations.

Dapkus (1985) surveyed male and female white middle-class adults to assess their naturalistic, descriptive concepts of their experiences of time. Results yielded three major categories of temporal experience: (1) change and continuity, (2) limits and choices, and (3) tempo. Change and continuity refer to persons and things changing

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constantly while maintaining continuity in time. Limits and choices occur when persons choose to spend time on certain activities while time limits them. Tempo is the speed or pattern of movement in time. Integration of first-order pairs produced three second-order categories: (1) change and continuity/limits and choices (CL), (2) change and continuity/tempo (CY), and (3) limits and choices/tempo (LT). CL includes experiences which relate to doing and becoming. CY represents the rate or pattern of change. LT refers to the rate or pattern of activity. Dapkus (1985) concluded that time urgency is probably present in limits and choices (doing in time) and tempo (pacing).

Evidence for an Internal Clock

<u>Hoagland's Discoveries</u>

Hoagland (1933, 1943) presented the first evidence for existence of a chemical, or physiological, clock. The multimodel frequency distribution curves of temperature features in many biological processes implied the existence of a limited number of catalytic substances involved in the control of rates of a wide variety of physiological mechanisms. These mechanisms included the emission of repetitive discharges of impulses from nerve centers. Hoagland suspected that if time judgment relies upon an underlying chemical master reaction in brain cells, modification of the internal body temperature should alter judgment of time intervals. "It is not unreasonable to suppose that chemical changes locally produced in the brain by excited groups of neurons would increase the velocity of our hypothetical clock, making time appear to pass

more rapidly when we are active" (Hoagland, 1933, p. 277).

Fraisse (1984) disclaimed the existence of a biological clock.

> The perception of duration, <u>stricto sensu</u>, is situated at a level above 100 ms and within the limits of the psychological present as described by W. James [1980]. It includes a unity among perspective events as is revealed, for example, by the perception of rhythmic patterns. On the other hand, the perception of rhythm disintegrates if the stimuli are spaced too far apart; there are then nothing more than more or less regular successions. The duration of the presentifiable can hardly extend beyond five seconds. (p. 30)

Fraisse (1984) conceded that a person can create an internal clock by counting but denied a physiological clock or time counter when voluntary measurement is impossible to use. Research (Allan & Kristofferson, 1974) demonstrated the contrary--that subjects were able to maintain discrimination levels without deterioration as intervals increased between two signals. Persons were able to discriminate a constant difference in duration independently of duration values over wide ranges of duration values. Bakan and Kleba (1957) had subjects make five estimates ranging from 15 to 240 seconds for each of two daily sessions with a week separating two test days. Results indicated that reliability in individual time estimates decreased between the first and second test days, which support Fraisse's (1984) contention.

Further Evidence of Biological Activity

During World War I, scientists discovered that the rate of cicatrization of wounds varied as a function of the patient's age and dimensions of the wound (Du Nouy, 1944), which is a form of physiological time. The speed of cicatrization is 5 times greater at age 10 than at age 60. A wound of four square inches takes about 20 days to heal for a

10-year-old person, 30 days to heal for a 20-year-old person, and 100 days for a person age 60. Work with cold-blooded animals showed that the healing process increases were increases in temperature. For individuals age 60, 5 hours of physiological and psychical existence are equivalent to 1 hour of existence for a child age 10, leaving parents and children in different temporal worlds.

Hoagland (1933) recognized that time passes more rapidly for aging persons because continuous, irreversible changes occur throughout life to the lungs, kidneys, intestines, and other mechanisms of homeostasis. Being a closed system operating within narrow parameters, homeostasis is extremely vulnerable to change, which slows physiological time while physical (astronomical) time remains constant.

Results suggested that estimates of short time intervals vary with internal body temperature, although time judgments for a person might vary from day to day. Hoagland (1933) believed that time variation is a result, also, of factors exclusive of temperature, such as sensorimotor activity, which influence the chemical clock. Also, the clock probably determines cyclic diurnal rhythms and metajudgments of time.

Hoagland (1943) hypothesized that persons with hypernormal internal temperatures would arrive early for appointments and that persons with hyponormal temperatures would arrive late. Research showed that ants and bees shaped to seek food at specific times came earlier for food when environmental temperature was higher than usual and arrived later when the temperature was below the standard level. Thyroid extract, which increases biological oxidation and temperature, causes persons to overestimate time. Quinine, which impedes oxidation,

causes persons to underestimate time. Other research (Newman, 1972) produced results showing that increased body temperature (mean increase = 0.537 degrees Fahrenheit) did not alter accuracy of time production for 52 subjects.

Experimental research (Baddeley, 1966; J. M. Lockhart, 1967) confirms that alterations of environmental temperature from normal conditions (about 80 degrees Fahrenheit) distorts the accuracy of time judgment. Zelkind (1973) tested 24 female undergraduates by the methods of direct estimation, comparison estimation, reproduction, and production. He discovered that perceived duration is correlated with the intensity of the stimulus. As intensity increased, estimations of duration increased. Zelkind considered intensity as a stimulus raising metabolism, which affects the rate of the internal clock. The reticular activating system, which is sensitive to arousal, might control the clock. The system receives neural signals from the major sensory centers and projects to the thalamic, hypothalamic, and cortical areas, positioning the system to influence activities of these structures.

Neural Processes and the Internal Clock

Recent data (Keele & Ivry, 1990) implicate the cerebellum as a major center of the internal clock. Traditional concepts hold that the cerebellum is part of the motor system, usually associated with functions such as fine coordination and balance. If this process exists, the cerebellum might provide a specific temporal computation that is task independent. A study of 30 persons with cerebellar damage alone or with damaged related structures showed marked disruptions in the

timing of motor and nonmotor tasks. Nineteen subjects had cerebellar atrophy or olivo-ponto-cerebello atrophy with bilateral damage. Eleven had unilateral lesions as the results of strokes ($\underline{n}$ = 6) or tumor ($\underline{n}$ = 5). These subjects showed a significant deficit in perception of time intervals in comparison to groups of the elderly, Parkinson patients, and patients suffering anterior cortical lesions and peripheral nerve damage.

Evidence (Keele & Ivry, 1990) indicates that lateral regions of the cerebellum determine computation of time while medial areas implement the timing system. Persons with lateral cerebellar organicity demonstrated consistent, significant distortion of the clock component. Those with medial damage showed consistent, significant difficulties in motor processing of computations. In humans, medial regions do not seem to be critical for timing but damage to lateral areas severely jeopardizes the timing mechanism. Data revealed that cerebellar regions involved in respondent, or classical, conditioning are similar to regions associated with timing operations. Lesions in limited lateral cerebellar areas might abolish conditional behavior.

Fraisse (1984) found that large groups of subjects with brain lesions showed a lower level of accuracy of time than a control group of subjects without lesions. Time perception tests had subjects manipulate temporal concepts estimating time periods, sequencing events, and judging and producing short and long intervals singly and in pairs. Subjects with frontal lesions showed a marked inaccuracy in perception.

Using galvanic skin response as a measure in respondent conditioning trials, R. A. Lockhart (1966) found that subjects who performed within a distracting environment estimated intertrial intervals while being

unaware of a conditioning process occurring. Results suggested that autonomic conditioning is a temporal function and time has a stimulus function. Jasper and Shagass (1941) found that an involuntary time mechanism probably operated in conditioning processes while subjects performed delayed, trace, and cyclic respondent conditioning tasks. Researchers measured cortical activity, particularly occipital alpha rhythm, with an electroencephalogram (EEG) while subjects made time estimations. Time intervals associated with conditioned responses were independent of conscious time estimations of the same time intervals.

Alpha waves appear implicated in the process of a biological clock. Werboff (1962) measured 48 male undergraduates with an eight-channel EEG while they made time judgments with eyes open/closed and with/without light distraction. Subjects with more than 50% alpha waves in a resting, eyes-closed condition made significantly longer time estimations in eyes-open conditions than subjects with less than 50% alpha-wave readings in the resting condition. The data "indicate that some inherent mechanism of cerebral activity mediated by the EEG may serve as an intervening process or is correlated with cerebral metabolism and control of temporal experience" (p. 159).

Internal Clock's Adjustment to Stimuli

An internal clock might provide mammals with the ability to re-adjust behavior to meet environmental demands. Rats ran two identical physical paths in a discrimination box, but one path delayed the animals for 1 minute and the other path delayed them for 6 minutes (Sams & Tolman, 1925). After they learned to take the path with the shorter

delay, researchers reversed the waiting periods. The animals readjusted quickly to the new route with the shorter delay area. In a reinforcement contingency experiment (Shurtleff, Raslear, & Simmons, 1990), rats showed clear patterns of activity changes corresponding to the time of day. Time of day influenced lever pressing for reward regardless of reward contingencies, the intervals between presses increasing proportionately at night. Research with humans (Rammsayer & Netter, 1989) showed no significant differences between time judgments of intervals in milliseconds performed during mornings and afternoons, although circadian effects appeared in similar research measuring time judgments in seconds.

A person's tempo, or preference of voluntary movement, is a consistent component of motor functioning that manifests itself in repetitive motor responses (Smoll, 1975). Physical movement is consistent over time (Rimoldi, 1951). Fast persons are consistently fast and slow persons are consistently slow, both tending to learn a particular behavior following a specific temporal pattern which they maintain. This pattern is the most economical for the individual, and an externally-imposed pattern generally produces detrimental consequences. A person seems to develop a specific personal tempo for a particular group of behaviors. Newman (1972) discovered contrary evidence when he had 52 males walk at three different intervals on a treadmill and produce time intervals. Accelerated movement did not relate to accelerated rates of time judgment and decelerated movement did not positively correlate with decelerated rates of subjective time.

Maturation of Time Concepts

Speed of Development

Development of time concepts is maturational (Bradley, 1947; Oakden & Sturt, 1922; Pistor, 1940; Springer, 1952). Children learn time concepts slowly, beginning at age 4 and arriving at adult level about ages 13-14 (Oakden & Sturt, 1922). There seems to be a rapid development of time knowledge around age 11, although Bradley (1947) found the process to be gradual and even at this age. Initially, children appear to learn the meaning of the most ordinary words involving time (Oakden & Sturt, 1922), learning parts of the day before days of the week and learning weeks before years. Personal interests, such as birthdays and holidays, stimulate children to learn dates. Usually, the day of the month is difficult due to numbering and the lack of distinguishing activities for different days. Particularly difficult is understanding chronology and the place of historical epochs. However, results (Pistor, 1940) indicate that training in history and chronology have no effects on the acquisition of time concepts for children between the mental ages of 10 and 13.

Bradley (1947) found that children at age 5 have a meager understanding of conventional time but development of time concepts advances rapidly the next 2 years. First, a child learns the distinctions between present, past, and future, and then learns time periods of a day. The capacity to use time-words correctly seems to develop slowly, continuing past ages 10-11. Conversely, Springer (1952) examined 89 children ages 4-6, who provided information regarding clock time, time

periods, and time-related events. The young children identified the time of activities which occurred regularly in their daily schedules, and were able to relate clock time by hour, half hour, and quarter hour. Also, they set a clock to the half hour and explained the purpose of both clock hands and how they operate.

Smythe and Goldstone (1957) tested 180 children ages 6-14 in estimation of one second. Effectiveness of time information depended upon the child's maturational level and knowledge of time learned through experience. All age groups overestimated the one-second interval, but children ages 6-7 did not improve the accuracy of their estimations after receiving specific time information, while children ages 8-14 improved their accuracy. Results indicated that children's estimates of short durations improve with age until the age of 14 when they are comparable to an adult in estimation accuracy.

Development of Duration and Succession

Testing 54 boys and 54 girls in nursery school and first and third grades, Levin, Israeli, and Darom (1978) found that the acquisition of concepts of duration and succession are two separate developmental achievements. Succession relies upon the perceptual elements of an event, such as beginning and end, and does not reduce to a more basic structure. Duration depends upon consideration of other concepts, especially succession, and is more difficult for children to understand than succession. Estimation of time duration occurs when a person uses memory to either associate a moment in the past with a moment in the present or to link two past events (Fraisse, 1984). Perception of

duration involves the psychological present. The psychological present represents the duration of an experiential process and not to a given period of time. Fraisse (1984) maintained that the process has an upper limit which does not exceed 5 seconds and an average value of 2-3 seconds. Within these limits as the perception of duration, a cognitive quantity which has not reached storage in memory.

Coordination between duration and succession occurred for children in the first grade (Levin et al., 1978). Some preschoolers showed awareness of this relationship, indicating a temporal frame of references rather than a spatial one as Piaget claimed. Richie and Bickhard (1988) obtained results refuting the Piagetian concept that children ages 3-6 cannot perceive the logical concept of time without reference to nontemporal stimuli, such as succession, speed, and distance. Thirty-six girls and 36 boys ages 3-6 solved time comparison tasks without nontemporal sources involved, suggesting that they perceived duration in some other way. Levin (1977) discovered that children ($\underline{N}$ = 144) in nursery, first, and third grades perceived duration better in still-time situations than in situations involving speed, distance, and other variables. The researcher found that distance was a more confounding variable in comprehending duration than speed.

Social Status and Health Effect Development

Investigation of time orientation and social class (Leshan, 1952) produced significant differences between children. Middle and low socioeconomic-status (SES) children ages 8-10 told stories regarding their lives. Middle SES children told stories covering longer periods of

times from initiation of action to final action than low SES children. For low SES children, stories contained rapid sequences of tension and relief, a future tending to be indefinite and diffuse, and uncertain rewards and punishments associated with low motivation. They had poor tolerance for delayed consequences of behavior. Middle SES children related stories of longer tension-relief behavior, showing plans for the future and acting upon the plans.

Levine, Spivack, Fuschillo, and Tavernier (1959) found that both motor and cognitive inhibition skills affect delay tolerance, which tends to relate to general intelligence. Forty-seven emotionally-disturbed males ages 11-19 with a full scale IQ range of 83-134 on the Wechsler-Bellevue IQ Test performed tasks of time conception, time estimation, cognitive inhibition, and motor inhibition. Time conception had a strong correlation ($\underline{X}$ = 7.86, $\underline{p}$ = .01) with IQ, persons with greater extension of future time having higher IQs than subjects with less future time extension. Time estimation and time conception were unrelated.

Results from time performances of hyperactive children conflict. A study (Capella, Gentile, & Juliano, 1977) of 75 normal children ages 8-12 and 25 children the same ages but classified hyperactive with no evidence of organicity showed that hyperactive children made significantly larger errors estimating intervals of 7, 15, and 30 seconds. The hyperactive children made progressively more mistakes the larger the time interval. After examining 135 children ages 7-16, Senior, Towne, and Huessy (1979) found that hyperactive children did not make significantly larger errors than normal children. All subjects underestimated a 30-second interval.

Time orientation was more difficult for learning disabled children than for nonhandicapped children (Dodd, Smith, & Burd, 1985). Results of a study of 1,079 children in Grades 1-6 revealed that problems of time orientation for learning disabled students were similar across all ages.

Effect of Age on Time Perception

Older persons experience changes in time perception when their senses diminish (Ainlay, 1988). Behavior that relies heavily upon tactile information can change a person's relationship to objects and the amount of time required to interact with and manipulate them. Persons losing their sight commonly set a high priority on present events in an attempt to retain recollections of the past and avoid an uncertain future. With the decline of the biological organism, persons doubt their skills to act upon time and space, placing a low priority on making changes in their physical environments. Many do not rely upon or anticipate future events, appearing incompetent.

Time Perception and Mental Health

Psychiatric research into time effects has shown the results of time distortion by schizophrenic individuals (Dobson, 1954; Lhamon & Goldstone, 1956; D. J. Wright, Goldstone, Boardman, & Lhamon, 1958). Disoriented schizophrenic males showed the greatest mean errors in estimating 38-second intervals but the least number of errors in estimating a 72-second interval among groups including normal, neurotic, and time-disoriented subjects (Dobson, 1954). Time-disoriented

schizophrenic subjects were unable to identify more than two time items (day of the month, month, and/or year).

In a study (Lhamon & Goldstone, 1956) comparing schizophrenic patients to college students, patients overestimated a 1-second interval to a greater degree than students, and showed more variability after feedback than students. The authors suggested that extroverted subjects, especially the students, estimated the 1-second interval at the high end of estimation. More introverted subjects might have made shorter estimations.

Psychiatric patients demonstrated significant difficulties anticipating future events and great self-satisfaction as temporal orientation moved away from past events compared to nonpsychiatric individuals (Braley & Freed, 1971). Schizophrenics overestimated time intervals (Tysk, 1983, 1990). Forty-nine schizophrenic patients overestimated a 20-second interval which they attempted to produce (Tysk, 1990). A subject pool of 60 normals, 50 schizophrenics, and 8 schizotypals (the two latter groups receiving neuroleptic drugs) estimated intervals of 7.5, 17.5, and 27.5 seconds and produced intervals of 10, 20, and 30 seconds. Schizophrenics significantly overestimated short and long intervals in comparison to normals. Drugs might have influenced their behavior, but schizotypals did not overestimate the intervals.

Effects of External Stimulus Variables

Different Tasks and Time Variables

Persons' observable behavior (Gulliksen, 1927) and external

stimuli (Harton, 1938) during time judgment affect accuracy. Individuals perceived time to pass more rapidly during difficult tasks than during easy tasks (Harton, 1938). Altering the movement of a clock's hands affected the time judgment of 88 college students (Rotter, 1969) without significantly influencing their interests in tasks. Craik and Sarbin (1963) varied the movement of a clock's hands while 29 males, ages 33-55, performed 14 paper and pencil tasks. Alterations of the clock rate affected time judgment and personal tempo, indicating the significance of knowledge of clock time in making verbal estimations of time intervals.

Swift and McGeoch (1925) had 123 male and 104 female undergraduates estimate "empty" and "filled" intervals of 30 seconds and 1, 2, and 5 minutes. Subjects experienced empty time, in which they only sat during intervals, and filled time, when they copied nonsense syllables or listened to readings during intervals. Both women and men overestimated all intervals, filled and empty. Other research (Roelofs & Zeeman, 1949) found that filling an interval leads to overestimation of a succeeding empty interval if the filled interval hampers awareness of beginning and ending parameters and to underestimation if it supports the process of awareness. Content of visual perception during a filled interval affected time judgments. Subjects overestimated intervals filled with a small object, many objects, or intricately constructed objects and underestimated intervals filled with large objects, one or few objects, or simply constructed objects. In another study (Marshall & Wilsoncroft, 1989), persons underestimated the duration required to do a color-word incongruities task in comparison to doing nothing.

Position of an interval can affect time judgment (Postman, 1944). Regardless of type of task or length of interval, subjects tended to overestimate the middle interval more than the first and last intervals.

Noise as an external stimulus affects time judgment (Delay & Mathey, 1985; Rai, 1975; G. Underwood & Swain, 1973). In a study of 36 undergraduates (G. Underwood & Swain, 1973), subjects listened to four different readings while hearing high and low intensity noise. Subjects estimated readings with high intensity noise to be longer than passages with low intensity noise. Delay and Mathey (1985) discovered that individuals' arousal levels increased as the level of ambient noise increased, time estimations becoming progressively shorter until the level reached 90dB, when time estimations became significantly much longer.

Rai (1975) tested industrial workers who had worked either in quiet or noisy environments for slightly more than 1 year or 10-12 years. All subjects estimated verbally a 60-second stimulus. Overestimation of the interval increased for subjects who had worked more years under noisy conditions. Rai suggested that noise causes a greater use of energy which prompts development of an accelerated rate of metabolism resulting in a faster internal clock.

Studies of light (Delay & Richardson, 1981; Meredith & Wilson-croft, 1989) as an influence upon time judgment have produced conflicting results. Delay and Richardson (1981) found that illumination significantly affected time estimation, with the shortest intervals estimated under low illumination, estimations of slightly longer durations made in high illumination, and the longest estimations made with subjects in the dark. When another sample of subjects reproduced four intervals under

three levels of ambient illumination (Meredith & Wilsoncroft, 1989), data indicated that the ambient levels of light had no significant effect upon perception of time intervals. Schiff and Thayer (1968) obtained similar results when 120 undergraduates experienced pleasant, unpleasant, or neutral olfactory stimuli prior to reproducing or verbally estimating time intervals. Results showed no significant effect upon the accuracy of judgments from the olfactory stimuli.

Distortion From Anchoring

Postman and Miller (1944) found that anchoring distorts time judgment. Anchoring refers to a cognitive process involving comparisons on a mental time scale of multiple stimulus intervals. The anchor is an additional stimulus which occurs concurrently with other stimulus intervals. Anchoring is a shift in the distribution of frequencies with which a person fits a given stimulus into the categories of his scale. Introduction of an anchor produces a more or less pronounced shift in the direction of the anchor. The closer a stimulus is to the anchor, the greater the shift of scale affects its relative position.

Data (Postman & Miller, 1944) showed that anchoring affects temporal judgments as it does subjective scales based on other stimulus materials. Anchoring occurred without instructions to afford an anchor top priority in rating. Apparently, anchoring uses two mechanisms which are generally independent of one another. One is a shift of the subjective scale toward the anchor. The other is a subjective grouping of the objective durations. Both shift and grouping are partial losses of discriminatory skills.

Chronic schizophrenics tended to respond to anchors more readily than acute schizophrenics (D. J. Wright et al., 1958). Schizophrenics in remission overcompensated for this effect while normal subjects resisted it.

Ahmadi (1984) obtained results revealing that waiting expectancy seemed to act as an anchor, producing assimilation effects with judgments tending to converge toward a cue. Boltz (1991) found that different attentional perspectives of the same event can yield different relative duration judgments. Time estimation was accurate when an event fulfilled expectations of the event, but time estimation was inaccurate when events did not temporally confirm expectations. An event occurring later than expected caused overestimation.

Influence of Cognitive Content

<u>Expectation and Focus</u>

Expectation seems to make an interval appear long only when expectation exists, but overestimation of the interval disappears quickly once the expectation becomes reality (Fraisse, 1984). A person senses that a duration is shorter when his estimation concerns the duration of a task in which he is active but his estimation is longer when he simply attends to passing time. This condition appears similar to conditions of empty and filled time.

Examination of attention and interest (Wixen, 1986) yielded results suggesting that attention, interest, and ability to perceive affect accuracy of time judgment. Forty male subjects, ages 17-37, estimated

the time of a 3-minute tone while emitting various voluntary behavior. Behavior included staring at the wall, reading, and sitting with eyes closed. Time estimations related to their interest in and attention to testing. Berman (1939) produced findings that indicated that 87% of satiated subjects in two experiments significantly underestimated the time required to reach satiation, while 52% of nonsatiated subjects overestimated the time required for them to reach a criterion of learning.

Early in time study, Sturt (1923) discovered that mental content experienced during time estimation influenced judgment. Time which contained many thoughts seemed longer than time which had less cognitive activity. One weakness of the study was the subjective difficulty in measuring magnitude and content of cognition. Beattie (1987) had subjects identify thoughts relating to activities in which they were involved and activities which included other persons or things. The subjects significantly underestimated time spent thinking about self activities compared to time used thinking of others or things.

Feedback on the accuracy of time judgment (Emley, Schuster, & Lucchesi, 1968; Montare, 1985) significantly increased the accuracy of further judgment and interference (Fortin & Rousseau, 1987) from a memory search task occurring simultaneously with time judgment significantly decreased accuracy. The use of silent counting as a strategy substantially increased accuracy (Guay & Salmoni, 1987), a technique that researchers often request subjects to forego.

Personal Standards and Time Judgment

A person's learning and social history can affect time judgment.

Sixty-five subjects replied to a test battery which included scales of dogmatism, future orientation, and verbal skills (Zurcher, Willis, Ikard, & Dohme, 1967). Subjects estimated the passage of 85 seconds. Participants who scored high on dogmatism or future orientation either over-stimated or underestimated the interval. Dogmatism and future orientation showed a significant positive correlation (r = .39; p < .01). Verbal intelligence had a low negative correlation (r = -.07) with dogmatism and a significant negative correlation with future orientation (r = -.20, p < .05).

Wudel (1979) had 67 subjects ages 17-25 estimate a 100-second interval after completing a series of scales, including the Eysenck Personality Questionnaire. Subjects who scored high in extraversion showed a significant association with shorter time estimation and greater confidence in the accuracy of their estimations. A survey of 102 psychotherapy tapes, each with a different client (Frederickson, 1988), revealed a relationship between temporal orientation and temporal pace. Each subject estimated the amount of time of their 40-minute sessions. Perceived speed of time related partially to past, present, or future temporal foci of current thoughts. An inverse correlation between past temporal orientation and time pace indicated that the relationship was one in which time seems to pass slower the more an individual focuses upon past events. When a subject thought about events of present or future orientation, the subject experienced a faster time pace.

Another study that examined active and passive images of time in relation to accuracy of time production (Krus & Fletcher, 1986) found that subjects with passive images of time experienced time as expanded

(underestimation), while subjects with active time images perceived time as accelerated (overestimation).

Social Values, Self-Concept, and Time Perception

Hulett (1944) speculated that a person's social role, his complex of attitudes comprising his personality, and his overt behavior in response to socially derived goals influence his time reference. When an individual enters a new group or when his group interactions shift, he has to adjust to a new interactional configuration to recast his self-organization. His skills at anticipating his and others' behavior, particularly responses, decrease. These skills rely upon his and the group's time perspectives. The person has undergone advance preparation for social participation, but the social process has defects in its predictive elements. His learned behavior will have a residue of responses from previous experiences that no longer are efficient at adjustment or interfere in efforts to attain adjustment in new situations. A condition of lag exists as behavior from earlier social experiences obstructs his adaptation to new situations.

Measurements of Time Judgment

Consistent Time Error

General effects of time error exist in most measurements of time judgment. Results from 109 male and 76 female college students who estimated their performance times in five simple tasks similar to daily activities revealed significant overestimations, with time error averaging

between 25% and 41% (Dudycha & Dudycha, 1938). There were no significant differences between genders regarding times for task completion or variability of judgment. Results did not suggest the presence of a general ability of persons to accurately estimate performance time. Other data (Harton, 1939) indicate that the average of time estimates of a group is nearer accuracy than the estimations of an individual taken at random from the group. Reliability of individual time estimates was relatively low.

Three Methods of Measurement

There are three methods to measure judgment of time--estimation, reproduction, and production (Bindra & Waksberg, 1956). In time estimation, a person experiences the duration of a time standard and verbally estimates the interval. In the method of reproduction, a person attempts to operatively replicate a previous time interval. In production, a person operatively delimits a time interval following instructions.

Many studies (McConchie & Rutschmann, 1971; Montare, 1983, 1988; Ochberg, Pollack, & Meyer, 1965; Saunders, 1985; Spivack & Levine, 1964) have investigated methods of time judgment and their differences. McConchie and Rutschmann (1971) used percentage of constant error (PCE), which is the difference between a judgment and the respective standard expressed as a signed percentage of the standard. Standards were in tenths of a second. Results showed that PCE was positive and large for production, negative and relatively small for estimation, and near zero for reproduction. Production had greater intersubject variability than estimation or reproduction. Another study

(Montare, 1988) found that verbal feedback significantly improved the accuracy of production and verbal estimation trials but did not significantly alter reproduction performance. The author suggested that the first two methods have verbal bases, which verbal feedback stimulates, while reproduction uses a nonlanguage temporal information-processing mechanism, which does not respond to verbal feedback.

Ochberg et al. (1965) concluded that estimation and reproduction are distinctly different tasks. Subjects gave more accurate scores of time judgment with reproduction than with estimation. Variance between subjects in estimation tasks were significant but not between subjects in reproduction tasks. Although reproduction might establish a baseline for general ability, perception, attention, cooperation, and intelligence, evidence does not indicate that reproduction represents a sense of time.

Examination of 671 cases of seven production trials (Saunders, 1985) yielded results revealing meaningful differences in the ratio of subjective to objective time as a function of time interval and meaningful differences between subjects in their adaptation to tasks. Some subjects speeded up while others slowed down.

Signaling Systems in Time Perception

Montare (1983) found evidence from production and reproduction trials of Pavlov's theory of first and second signaling systems. Pavlov suggested that the first signaling system is the animal brain, including sensations, perceptions, and direct impressions of the physical environment. The second signaling system is the human brain, containing

words as abstractions of reality. Ninety-one male college students completed learning tasks and time judgments by reproduction and production. Results indicated that reproduction is similar to the first signaling system, probably due to the method being a response to external stimuli, or a demonstrated interval. Production is similar to the second signaling system because the method depends upon verbal instructions without a standard of comparison.

Individual variability in time judgment appears consistently (Spivack & Levine, 1964). When a person uses a constant technique for keeping track of time, such as counting or visualizing a clock, individual differences are relatively constant whether the person produces intervals as short as 8 seconds or as long as 64 seconds. If a person uses a less constant or different method of tracking time, his time productions show some degree of correlation but the consistency of individual differences is not as great as when he produces intervals using a constant method. The rate of counting is probably not constant for longer time intervals and new variables enter. Subjects reported impatience and boredom while waiting for longer time intervals to pass, showing a tendency to increase or decrease their counts because they perceived that they were going too fast or too slow. The authors concluded that different methods of time judgment fail to yield entirely comparable data with no indication of which technique is best for studying personality.

Time-Order Error

The time-order error, which Fechner discovered in the late 19th century, is the tendency of persons to perceive the second of two equal

stimuli as larger (Stevens, 1957). Time-order error can affect Class I continua. Class I continua comprise a perceptual process relating to quantity (prothetic). Class I continua represent type and location (metathetic). Class I continua are nonlinear because persons vary greatly in their sensitivity to differences. This class includes apparent length, area, numerousness, heaviness, lightness, brightness, and duration. Time-order error is usually small, and later research data has questioned the use of "time" in the expression of this error. Simultaneous judgments of stimuli produce time-order error, and factors other than time, such as brightness and heaviness, produce time-order error, which has no association with order. Stevens (1957) maintained that the effect is one of category judgments that comes from asymmetry of the relativity of discrimination.

To avoid time-order error, many researchers have subjects use the production method or estimate a duration in traditional units or in category units, or use absolute judgment (Fraisse, 1984). Research has shown that reproduction has a central tendency effect of overestimation of short intervals and underestimation of long intervals, particularly after many trials. Also, repetition of estimation diminishes their sizes, although this is not true when the subject counts to himself.

Research in Arousal/Time Perception

Some experiments in time judgment have attempted to utilize arousal as an independent variable. Falk and Bindra (1954) had 40 college students produce a 15-second time interval. An experimental group was aware that they would receive electric shock following

unspecified trials. The control group received no shock. Subjects could not count seconds to themselves while producing time intervals. No significant differences existed between shock and nonshock trials for the experimental group, possibly because the knowledge that shock might be forthcoming on a trial affected production on all trials. The experimental group produced greater overestimation of the interval than the control group, possibly due to anxiety of shock expectation. The experiment did not measure any physiological level during trials to determine arousal or have subjects produce more than one specific interval (15 seconds). Also, the design restricted subjects from counting to themselves, which might have limited their accuracy of production.

In an attempt to create arousal, Gupta and Cummings (1986) gave caffeine to an experimental group and had this group and control subjects estimate the elapsed time of a task. Results indicated that subjects who experienced high arousal had the lowest task satisfaction and also overestimated perceived time on task. Subjects who experienced low arousal sensed the highest task satisfaction and also underestimated time on task. Experimental subjects' physiological level was drug-induced and Gupta and Cummings assumed levels of arousal from the results of a semantic differential measure, not a physiological one.

Rosenzweig and Koht (1933) used the subjective measure of self-report to ascertain degrees of need-tension. The authors defined need-tension as a state of strain, sometimes with emotional excitement, that appears whenever someone arouses a need. Subjects were 89 undergraduates who attempted to complete four-piece, unsolvable jigsaw puzzles. Subjects attempted to solve a puzzle during a practice

period, then heard that they would receive an intelligence test in order to compare scores with other persons taking the test. The intelligence test was another unsolvable jigsaw puzzle. Following testing, subjects wrote statements describing feelings they had during testing and their estimation of elapsed time of testing. Results indicated a correlation between perceptions of the two testing periods and time estimation. When subjects described themselves as bored or experiencing despair, time seemed long. When they were interested and eager, time seemed short. Greater need-tension, however, correlated positively with underestimation and lesser need-tension correlated with overestimation. Results provided no data of time judgment prior to testing or physiological measures of subjects during testing. The method of estimation probably did not reflect a sense of time as accurately as production represents it.

Singh (1971) tested 68 students to determine if anxiety affected the performance of time reproduction by key pressing. The task was to press a key within a 20-25-second interval. Low anxiety subjects performed better than high-anxiety participants in three pretraining conditions and significantly better in the no-pretraining condition after 50 minutes of testing. Researchers obtained subjects' anxiety levels by use of the Manifest Anxiety Scale, a personality self-assessment instrument that attempts to measure an emotional state through cognitive awareness. There was no measurement of physiological arousal by more objective means and the method of judgment was reproduction, not production. Responses were only to a single interval.

Research which measured subjects' pulse rates, heart rates, breathing rates, and blood pressure (Schaefer & Gilliland, 1938), while

subjects estimated intervals of 4 and 27 seconds found extended periods of estimation and fatiguing exercise did not cause subjects to estimate time as being longer or shorter. Subjects estimated intervals in series of 10, each subject making 100 estimates on each of 2 days. Intervals were unfilled time bounded by two clicks, which subjects estimated without counting to themselves. In a second phase, subjects ran up and down steps vigorously to increase physiological functioning and repeated the 100 estimations. Subjects performed second-phase tasks for 2 days. Results showed that physiological changes varied greatly but differences in individual estimations did not show any constant or definite relationship to these changes in physiological functioning. There was no significant difference in errors between estimations when the subjects were at rest and when the subjects were in a condition of high physical activity. Newman (1972) discovered similar results from subjects walking at various accelerated rates on a treadmill while producing time intervals. Although Schaefer and Gilliland (1938) determined arousal by measurement of physiological levels, stimulation of arousal was vigorous physical activity and not perceptive stimuli. Additionally, estimation, not production, was the means of time judgment.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

Subjects

Subjects came from a department of more than 600 on-campus counselor education and counseling psychology graduate students at a Midwestern university. The department was located in a college of education. Subjects were solicited by letter (see Appendix A) with an enclosed return form (see Appendix B) following random selection. Letters went to 175 students and 133 students responded. Seven students participated in the original study (see Procedure below) and 94 participated in a revised design.

Subjects were assigned randomly to one of three groups: a control group and two experimental groups. In the revised experiment, there were 67 females and 27 males with a mean age of 36.97. The women's mean age was 36.96 and the men's mean age was 38.85. Age ranges for females were 23-61 and 24-53 for males. Ethnic composition of subjects was 3 Black females, 3 Black males, 1 American Indian female, 3 Asian/Pacific females, 1 Asian/Pacific male, 60 White females, and 23 White males. Ten women and three men were left-handed, representing 13.83% of the sample.

Subjects were randomly assigned to groups and order of task presentations. Thirty subjects were in experimental Group A and the control group, and 29 participants were in experimental Group B. Some

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subjects in the experimental group failed to respond to the design's primary treatment. (See Procedure below.)

Subjects were screened by questionnaire for presence of heart disease, high blood pressure, persistent headaches, ulcers, and other diseases related to increased arousal (see Appendix C). No subject had a condition that disqualified him or her.

Apparatus

Subjects' level of arousal was measured objectively using a Thought Technology HR/BVP 100T Biofeedback System (1984). The apparatus (see Appendix D) tabletop was 3½ x 4 feet and was constructed of ½-inch plywood. The subjects and examiner were separated by a 2 x1½ foot, ½-inch plywood partition mounted across the middle of the tabletop. Standard red, green, and white 12-volt pilot lights were displayed, each accompanied by a limited set of instructions. An electric timer was used to measure subjects' attempts to produce time intervals.

Procedure

Prior to and during testing, the subjects' heart rates were measured by the HR/BVP 110T biofeedback instrument to determine that heart rates did not exceed 140 beats per minute. Arousal was defined as 10% or greater increase from resting heart rate. The testing limit was 140 beats per minute; however, no subject reached this level. Subjects maintained the plethysmograph probe of the biofeedback instrument on the forefingers of their nondominant hands throughout testing to measure heart rate. Five subjects in the experimental groups

failed to achieve the 10% level of arousal on any trial, and their times were not used in data analysis.

Subjects in the control and experimental groups signed consent forms prior to testing (see Appendix E). Consent forms notified subjects that they would produce time intervals as part of an experiment. Also, the consent form notified them that they might participate in rapid breathing. Subjects in experimental Group A did not receive additional information about the experiment. However, subjects in experimental Group B received additional data as follows:

> You will estimate three different time periods. After this, you will engage in rapid breathing to accelerate your heart beat. While your heart beat accelerates, you will again estimate the three time intervals. Do you have any questions?

The following pretest instructions were provided to subjects in all groups?

> Before you are three lights of different colors with instructions for each. The lights will go on one at a time, remain lit for approximately 5 seconds, and go off. Read the instruction associated with a light when it activates. After a light goes off and you begin to estimate the appropriate time interval, press the button on top of the box in front of you and release it. This starts the timer inside. When you think the appropriate time has passed, press the button on top of the box again to stop the timer. When the red light goes off, press the button to start the timer and again to stop it after 15 seconds. When the white light goes off, press the button to start and stop the timer to produce 30 seconds. And when the green light goes off, press the button to start and stop the timer to produce 45 seconds. You will have enough time between the lighting of the bulbs to activate and deactivate the timer to produce different time intervals. The lights will not light up in any order, so be ready to respond to any bulb that lights. While you are working, be sure to relax and keep still the hand which contains the probe of the biofeedback mechanism. You will not see the timer.

> On instructional Plate 1 (see Appendix D) was the statement,

"When this light goes out, produce 15 seconds." Instructional Plate 2 contained the statement, "When this light goes out, produce 30 seconds." Instructional Plate 3 had the statement, "When this light goes out, produce 45 seconds." Subjects' time production to hundredths of a second along with their accompanying heart beats per minute were recorded.

Following pretest trials, subjects in both experimental groups performed rapid breathing to accelerate their heart beats by 10% during posttest trials. Control subjects performed posttest trials free of rapid breathing. This treatment was in a revised design of the research. Originally, experimental subjects participated in a 10-minute anagram test with inflated achievement ranges in order to increase their heart beats. After trials with 7 subjects indicated that this procedure would not gain the desired heart-rate increase, rapid breathing became the primary treatment. The original study received approval from the university's Human Subjects Institutional Review Board (see Appendix F) as did the revised study (see Appendix G).

Posttest time production tasks followed the same procedure as pretest trials, with time production and accompanying heart rate recorded. Experimental subjects received the following instructions:

> In a few moments, you will again estimate three time periods
> as you did previously. Before you do this, I will ask you to
> breathe rapidly, like this (experimenter demonstrates).
> Actually, it is similar to panting. I do not want this breathing
> to be painful for you. I am monitoring your heart beat and I
> will stop you when it reaches a moderate level. I might ask
> you to breathe rapidly again if your heart beat returns to its
> present, calm level. If you feel uncomfortable at any time,
> notify me and we will stop immediately. While you are
> breathing rapidly, or shortly thereafter, a bulb will activate
> for you to produce a time interval. Follow the same

procedure and start and stop the button to produce each time period. As before, lights will not activate in any order. Please keep still the hand containing the probe. Begin breathing rapidly now, and while you are testing, listen for any further instructions I might give you.

Subjects were allowed to follow any procedure for producing time, including silent counting and various forms of imagery. Watches were removed prior to trials.

Following posttest trials, the researcher debriefed each subject and requested confidentiality.

CHAPTER IV

DATA ANALYSIS

Data Accumulation

Experimental data were trial results associated with subjects' heart beat increases of 10% or greater over resting rate. To determine percentage of increases, the heart beat reading at the end of a pretest (resting rate) was compared with the heart beat reading at the close of the posttest. Subjects in experimental Group A produced qualified data in 25 of 30 fifteen-second trials, 23 of 30 thirty-second trials, and 20 of 30 forty-five second trials. Experimental Group B subjects produced qualified data in 23 of 29 fifteen-second trials and thirty-second trials, and 26 of 29 forty-five second trials. Results of 30 control subjects required no qualification. The probability (p) level chosen for this study was .05.

Data Analysis

Outcomes of Primary and Secondary Treatments

Preliminary testing revealed that a one-way analysis of variance (ANOVA) was appropriate to compare the experimental groups on absolute and raw differences. Examination of the slopes of pre- and posttest linearity with the homogeneity of regression slopes test showed that both slopes were parallel and did not intersect. Parallelism of the slopes

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indicated that either an analysis of covariance (ANCOVA) or analysis of variance (ANOVA) was appropriate. Because the experiment was a within-subjects design without interaction between subjects, ANOVA became the appropriate method of analysis. The ANOVA tested the null hypothesis (H_0) of no differences between (among) groups. If the F ratio was significant, the H_0 was rejected.

ANOVA showed that there was no significance differences of raw scores (signs plus [+] and minus [-]) ($p < .0659$) between the pre- and posttest change scores of the experimental Groups A and B due to secondary treatment. This treatment was Group B subjects receiving early descriptors of the experimental design. (See Table 1.) Results indicated that overproduction and underproduction of time intervals were not significantly different. The same ANOVA showed no significance ($p < .1110$) between the combined experimental groups and the control group on primary treatment, or increased arousal, again using differences between pretest and posttest times. (See Table 1.)

Table 1

One-Way ANOVA on Raw Differences Between Pretest
and Posttest Change Scores

Change scores	p value	Significance
$\overline{X}_{A(pre-post)} = \overline{X}_{B\ (pre-post)}$	.0659	NS
$\overline{X}_{A(pre-post)/B(pre-post)} = \overline{X}_{C(pre-post)}$	.1110	NS

Differences between pretest and posttest times were converted to absolute values, changing all signs to plus (+). Absolute values account

for the complete magnitude of differences, including overproduction and underproduction. ANOVA revealed no significant difference between experimental Groups A and B (p < .5385). However, a significant difference (p < .0133) was noted between experimental Group A and the control group and a highly significant difference (p > .0001 was found between experimental Group B and the control group. (See Table 2.) Although there were no significant differences between experimental Groups A and B, there were significant differences between their 15-second trials (p < .0412) and 30-second trials (p < .0278). Group A results showed only its 45-second trial as significant (p < .0035) from the same trial as the control group while all trials of Group B differed significantly with trials of the control group (see Table 2).

Results from raw scores (signs + and -) revealed no significant differences between overproduction and underproduction of time tasks between Groups A and B and Groups A and C. (See Table 3.) Significant differences (p < .0025) occurred between experimental Group B and the control group.

Subjects' Skills at Time Production

Comparison of pretest (baseline) means to mean change scores of trials showed consistent distortion in subjects' attempts to replicate their original time productions (pretests) both by trial and group (see Table 4). The original time productions (pretest) served as baseline data. Mean percentage of time production distortion was 28.49% for Group A, 28.32% for Group B, and 14.71% for Group C.

Table 2

One-Way ANOVA on Absolute Mean Differences Between
Pretest and Posttest Change Scores for All Trials

	F value	p value	Significance
Group A $\bar{X}$ versus Group B $\bar{X}$			
Trial 1	4.41	.0412	S
Trial 2	5.18	.0278	S
Trial 3	1.02	.3187	NS
Total	0.38	.5385	NS
Group A $\bar{X}$ versus Group C $\bar{X}$			
Trial 1	0.35	.5543	NS
Trial 2	0.22	.6393	NS
Trial 3	9.45	.0035	S
Total	6.28	.0133	S
Group B $\bar{X}$ versus Group C $\bar{X}$			
Trial 1	8.12	.0063	S
Trial 2	7.34	.0092	S
Trial 3	9.54	.0032	S
Total	20.52	.0001	S

Table 3

One-Way ANOVA on Raw Differences Between Pretest and Posttest Change Scores for All Trials

	F value	p value	Significance
Group A $\bar{X}$ versus Group B $\bar{X}$			
Trial 1	1.36	.2495	NS
Trial 2	0.33	.5685	NS
Trial 3	3.14	.0832	NS
Total	3.44	.0659	NS
Group A $\bar{X}$ versus Group C $\bar{X}$			
Trial 1	3.39	.0713	NS
Trial 2	8.04	.0066	S
Trial 3	2.37	.1301	NS
Total	0.02	.8870	NS
Group B $\bar{X}$ versus Group C $\bar{X}$			
Trial 1	6.58	.0133	S
Trial 2	8.13	.0063	S
Trial 3	1.13	.2920	NS
Total	9.46	.0025	S

Table 4

Percentages of Time Production Inaccuracy:
Pretest Means Versus Change-Score Means

Group	Trial	n	Pretest $\overline{X}$	Posttest $\overline{X}$	Change scores $|\overline{X}|$	Percent inaccur	Change scores $|\overline{\overline{X}}|$	Percent inaccur
A	1	25	13.70	13.64	2.81	20.51		
	2	23	26.50	26.50	25.40	5.86		
	3	20	41.43	51.93	17.74	42.84		
	Total						8.23	31.45
B	1	22	17.30	15.43	4.61	26.63		
	2	23	30.08	27.35	9.37	31.15		
	3	26	47.90	47.37	13.02	27.18		
	Total						9.23	28.27
C	1	30	16.15	17.61	2.29	14.18		
	2	30	30.33	34.57	5.20	17.14		
	3	30	47.33	50.48	6.06	12.80		
	Total						4.52	14.44

Distortion appeared to decrease progressively with fewer particip-
ants tending to distort at greater percentage ranges (see Table 5). The
highest range of 91-100% shows more subjects than preceding ranges
due to including all percentages over 100% in the range.

Comparison of pretest (baseline) means against mean absolute
change scores revealed that females had greater percentages of time

Table 5

Frequencies of Percent Distortion by Trial

Percentage range	Trial 1	Trial 2	Trial 3
0-10	28	23	30
11-20	24	19	14
21-30	11	12	9
31-40	8	8	1?
41-50	2	4	1
51-60	1	5	3
61-70	1	2	1
No observed percentages in the 71-80 and 81-90 ranges			
91-100[a]	3	3	6

[a]Any percentages over 100% were set equal to 100%.

distortion than males in Groups A and C but less distortion production in Group B (see Appendix H). The limited number of subjects by gender in the groups did not justify calculation of possible significance and do not indicate gender differences or similarities.

Subjects who are left-handed had a higher percentage of distortion among Group A subjects than right-handed subjects but produced less distortion in Groups B and C (see Appendix I). Again, a limited number of subjects, especially left-handed participants, in the groups did not justify calculation of significance and allows for no conclusions about similarities or differences.

Inspection of Group A data suggests probable abnormality. Group A's distortion from pre- to posttest trials seems to have an increasing trend as subjects move from trial to trial, while the other two groups do not show this tendency. Groups B and C generally follow the normal distribution curve but Group A appears deviant. This trend in Group A data prohibits conclusions of probability when comparisons are made to other groups.

Subjects in both experimental groups reported nearly unanimously having experienced difficulty in producing posttest times because rapid breathing interfered with techniques they had used to produce pretest times (see Discussion--<u>Significance of Arousal</u>).

CHAPTER V

SUMMARY, DISCUSSION, AND RECOMMENDATIONS

Summary

This study examined the effect of physiological arousal on subjects' skills of time production. Additionally, data revealed time production error among all groups.

Subjects were 94 graduate students, including 67 females and 27 males. They were assigned randomly to three groups: a control group and experimental Groups A and B. All subjects performed 15-, 30-, and 45-second pretest and posttest time production trials. Primary treatment for experimental groups was rapid breathing to increase subjects' heart beats at least 10% above resting rate. Heart beats were measured by a HR/BVP 110T biofeedback instrument. Testing limit was 140 heart beats per minute. Secondary treatment for experimental Group B was knowledge which subjects received prior to trials about the experimental design.

A one-way ANOVA of standard, raw data revealed no significance between experimental groups from secondary treatment and none between Group A and the control group from primary treatment, but there was significance between Group B and the control group. Conversion of raw data to absolute values produced results of significance between Group A and the control group and Group B and the control group from primary treatment. An abnormal distribution curve seemed

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probable.

All groups experienced difficulty in reproducing accurate time intervals in relation to pretest (baseline) times. Change score means compared to pretest means showed moderate-high percentages of time distortion, including the control group.

Discussion

Significance of Arousal

Subjects' reports of interference from rapid breathing affecting their ability to accurately produce time intervals identifies a possible confounding variable to treatment. The intention of the treatment was to create moderate arousal (defined as a 10% or greater increase in resting heart beat). However, the procedure apparently interfered with the simple cognitive task of silent counting or imagery. Most subjects reported that they used silent counting to produce pretest times, and that rapid breathing produced a quicker count which interfered with the longer count of a second. Subjects agreed generally that the cognitive focus needed to breathe rapidly was simple and limited. Subjects who participated in the experimental groups but failed to reach arousal despite rapid breathing might have provided a comparison to subjects who did reach arousal but the number of the former group (five) was not sufficient to justify assessing possible significance.

The apparent abnormal distribution of data in Group A appears to have affected the group's results, probably decreasing the degree of significance between the group and the control group. This apparent

abnormality possibly affected the relationship of Group A with Group B by distorting differences and possibly leading to failure to reach significance. This condition clouds any comparison of the two groups.

Although Group B received some knowledge of the experimental design prior to testing, all groups received general information on tasks both in a letter requesting their participation and in the consent form. This information might have equalized all groups and weakened the secondary treatment of early knowledge for Group B.

Even if rapid breathing creates a quicker count (because it may interfere with cognitive processes), there is no evidence that this is not a concomitant part of the arousal process. Without attempting to breathe rapidly, persons tend to increase their breathing rate when aroused, which might create a rhythm or count that interferes with a more accurate sense of time which operates at individuals' resting rates. Data (p < .0133 for Group A versus Group C; p < .0001 for Group B versus Group C) indicate significant differences in absolute time production between aroused subjects and control subjects in an experimental environment designed to provide simple cognitive tasks. Although subjects might have been involved in intense cognitive processing while entering experimentation, the design did not support such cognitive levels, and the experimenter worked to relieve subjects of stress, urgency, or demand by using humor and other social devices when subjects were not involved in trials.

Learning during trials seems minimal because subjects received no feedback about their pretrial accuracy. Progressive error (B. J. Underwood, 1966) from a practice effect seems to have been negligible.

Results suggest that physiological arousal without intense positive or negative cognitive content/process causes significant distortion of time. Perhaps more important are results which indicate that persons have difficulty producing or estimating time when unaroused. Examining absolute differences, percentages of time production error are nearly double for aroused subjects compared to control subjects, but the latter group averaged more than 14% distortion while their heart beat was at resting rate. With samples of this type, it is probable that persons' sense of time is extremely variable, and possibly highly vulnerable to fluctuation. The degree of arousal necessary to cause fluctuation might be low. Despite development of time concepts (Bradley, 1947; Oakden & Sturt, 1922; Pistor, 1940; Springer, 1952), and probability of an internal clock (Fraisse, 1984; Hoagland, 1933, 1943) and personal tempo (Rimoidi, 1951; Smoll, 1975), persons might sense time with a consistently high degree of inaccuracy. These findings are consistent with earlier research (Dudycha & Dudycha, 1938; Harton, 1939) that discovered that individuals inaccurately estimate time. The number of subjects and the short duration of trials limit generalization of data to longer time periods, but indicate the value of further research.

Clinical Implications

Some practitioners (Brown & Beck, 1989; Ellis, 1987) have identified demandingness as a vital cognitive element of dysfunction. When a person demands rather than prefers, the individual experiences absolute, necessitous thought, which causes anxiety and, often, depression. Demand requires immediacy or urgency, a time variable whose pressure

for one acceptable consequence often associates with time distortion. If individuals have difficulty in maintaining a sense of accurate time, whether in short or long intervals, they might be highly susceptible to demandingness. If physiological arousal increases time error, the condition might prompt a person to demand or sense time urgency. Arousal, coupled with a generous amount of absolute, necessitous cognitive content, probably produces a much higher state of anxiety and demand, elevating the dysfunctional condition and leaving the person limited or bereft of coping skills.

In the Type A behavior pattern (Matthews, 1982; Rosenman & Friedman, 1977), time urgency is more consistent than episodic and a major factor sustaining the condition. After extensive observation of heart patients, L. Wright (1988) concluded that time urgency is a concern over a few seconds, not long intervals. If this is valid, persons' sense of 15-, 30-, and 45-second intervals appear vital to their functioning. In this research, persons not only found it difficult to produce target times (15, 30, and 45 seconds) but were unable to replicate their earlier estimates, producing considerable change score inaccuracy. The results of the present research place in question an individual's ability to maintain his own relatively accurate time sense, reaffirming McConchie and Rutschmann (1971) who discovered that production had larger inter-subject variability than did estimation and reproduction.

Recommendations

Further research into the relation of time production and arousal free of extensive cognitive content/process would benefit from treatment

which produces arousal without interference with task skills. The use of drugs can cause arousal but might jeopardize awareness and produce other side effects. Extensive physical exercise to gain arousal can create problems of measurement. Research which is free of cognitive involvement allows assumptions about the effects of physiological process on time production. Research that includes both arousal and high cognitive content/process can be of comparative value to the former. Also, measurement which averages heart rate over tasks is more definitive than readings of heart beat at task's end.

Clinically, professionals might serve clients more competently by being alert to the possibilities of clients' difficulties in sensing time accurately and their possible vulnerability toward a tendency of demandingness, both overt and subtle.

APPENDICES

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Appendix A

Letter Soliciting Subjects

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College of Education
Counselor Education and Counseling Psychology

Kalamazoo, Michigan 49008-5195
616 387-5100

WESTERN MICHIGAN UNIVERSITY

Dear

From a list of students in the Department of Counselor Education and Counseling Psychology, you have been selected to participate in a research study. This research is a project of doctoral student Keith Cardwell under the supervision of John Geisler, Ed.D., professor and doctoral committee chair. The experiment is designed to be convenient and reasonably brief. The Center for Counseling and Psychological Services (Sangren Hall 3109) will be the site of this research, which should require approximately 45 minutes for each participant.

The success of this research depends upon you and other selected students in our program. Generally, participation involves time tasks and breathing exercises. In order for this research to occur, commitment and participation by our graduate students are necessary. We would very much appreciate your assistance in making this study a success.

Additionally, participation affords you an opportunity to earn entry into a lottery with a first prize of $75.00 and a second prize of $25.00.

We hope that you will be able to participate with us in this project. Please complete the enclosed form and use the return envelope to respond.

Thank you for your consideration.

Sincerely,

J. Keith Cardwell, M.A.
Doctoral Candidate

John S. Geisler, Ed.D.
Professor

Appendix B

Return Form of Participation/Interest

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Keith Cardwell
Center for Counseling & Psychological Services
3109 Sangren Hall
Western Michigan University
Kalamazoo, MI 49008-5195

Check One and Return by April 9, 1993:

_____ I would like to participate in your study. Please contact me at _____,
(home phone)

_____ to make arrangements.
(work phone)

_____ I am interested in your study but would like more information. Please contact me at

_____, _____.
(home phone)   (work phone)

_____   _____
Print name   Date

Appendix C

Subject Medical Questionnaire

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SUBJECT MEDICAL QUESTIONNAIRE

1. Have you ever had or suspected that you have any heart problem or condition?

2. Have you ever had or suspected that you have high blood pressure?

3. Have you ever had chronic or persistent headaches?

4. Have you ever had or suspected that you have ulcers or stomach problems?

5. Have you ever had or suspected that you have colitis?

6. Have you ever had a physical or psychological condition that caused you to experience prolonged emotional or physical stress?

7. If you take any medication, please specify it.

8. Have you had any illness or accident that made you bedridden for at least one week?
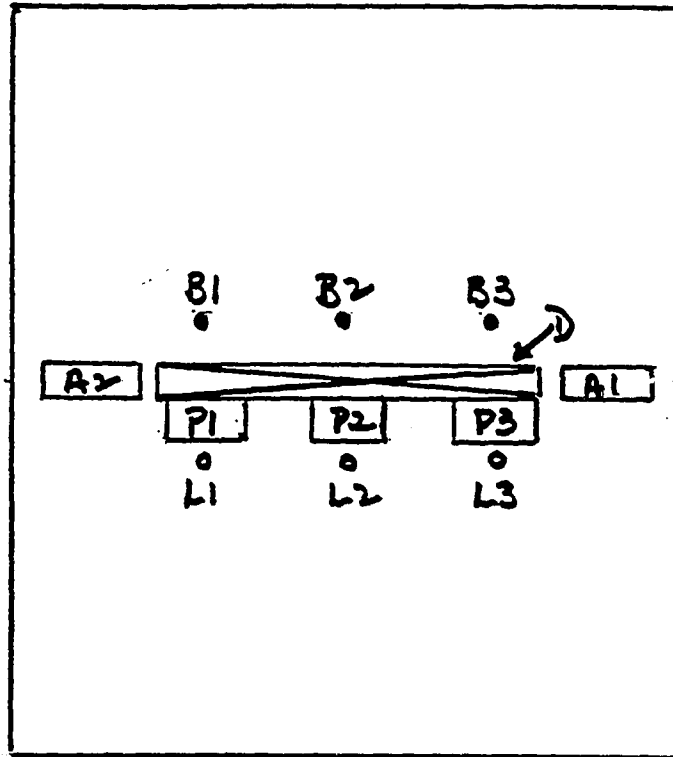
9. Do you already experience any symptoms from an illness or accident?

10. Have you ever had a seizure?

11. Have you ever had a respiratory illness or problem, especially one affecting your breathing?

12. Have you ever had fainting spells?

Appendix D

Diagram of Apparatus

LEGEND

A1, A2	— Electric timer (in position A1 for dominant right hand, position A2 for dominant left hand).	P1	— Plate with instructions to produce 15 seconds.
		P2	— Plate with instructions to produce 30 seconds.
B1, B2, B3	— Activating buttons.	P3	— Plate with instructions to produce 45 seconds.
L1	— 12-volt pilot light (red)		
L2	— 12-volt pilot light (white)	D	— Divider (2 x 1½ feet) mounted on table (3½ x 4 feet)..
L3	— 12-volt pilot light (green)		

Appendix E

Consent Form

CONSENT FORM

I agree to participate in a dissertation study conducted by doctoral candidate Keith Cardwell under the supervision of John Geisler, Ed.D., professor in the Department of Counselor Education and Counseling Psychology at Western Michigan University. I understand that this study intends to further the knowledge of human behavior, and that my participation includes the production of time intervals and, potentially, attempts to solve scrambled word puzzles. I understand that the word puzzles vary in degree of difficulty, and that my participation should require one session of approximately 45 minutes. Subjects will be randomly assigned to one of three groups. I understand that during participation my heart rate will be monitored by a painless probe attached to the forefinger of my nondominant hand. Further, I understand that Keith Cardwell under the supervision of Dr. John Geisler will assign a code number to me which will be used to identify all information used for analysis in this research. Name and number coding will be destroyed following analysis of data.

Although there are no physical risks involved, neither the experimenter or university assume liability. At any time prior to or during my participation, I may withdraw my consent and leave the area. I realize a primary benefit of participation is the possibility of being entered into a lottery for money. I realize that prior to or during my participation, the administrator can stop the experiment and excuse me from participation. If I have any questions following my participation, I may call Keith Cardwell at 387-5104 (office) or 373-6118 (home).

Signed_____

Date_____

Appendix F

Protocol Clearance From the Human Subjects
Institutional Review Board

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Human Subjects Institutional Review Board

WESTERN MICHIGAN UNIVERSITY

Kalamazoo, Michigan 49008-3899

Date: December 10, 1992

To: Joseph Keith Cardwell

From: M. Michele Burnette, Chair *M. Michele Burnette gk3*

Re: HSIRB Project Number 92-11-36

This letter will serve as confirmation that your research protocol, "The effects of arousal on time perception" has been approved after full review by the HSIRB. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the approval application.

You must seek reapproval for any change in this design. You must also seek reapproval if the project extends beyond the termination date.

The Board wishes you success in the pursuit of your research goals.

xc: Geisler, CECP

Approval Termination: December 10, 1993

Appendix G

Protocol Clearance From the Human Subjects
Institutional Review Board (Revised)

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Human Subjects Institutional Review Board

Kalamazoo, Michigan 49008-3899

WESTERN MICHIGAN UNIVERSITY

Date: March 10, 1993

To: Joseph Keith Cardwell

From: M. Michele Burnette, Chair

Re: HSIRB Project Number 92-11-36

This letter will serve as confirmation that the revisions to your research project entitled "The effects of arousal on time perception" have been **approved** by the Human Subjects Institutional Review Board after full review. You may now continue the research with the revised procedure.

xc: Geisler, CECP

Appendix H

Percentages of Distortion by Gender

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Percentages of Distortion by Gender

		Trials			
		15 seconds	30 seconds	45 seconds	$\bar{X}$
Group A	Female	19.92	23.90	48.35	30.72
	Male	16.20	17.67	26.52	20.13
Group B	Female	23.40	29.20	24.15	25.58
	Male	34.78	35.40	31.05	33.74
Group C	Female	13.87	20.70	13.53	16.03
	Male	15.05	9.38	11.10	11.84

Appendix I

Percentages of Distortion by Handedness

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Percentages of Distortion by Handedness

| | | Trials | | | |
		15 seconds	30 seconds	45 seconds	$\bar{X}$
Group A	Right	15.79	21.87	41.44	26.37
	Left	48.56	24.65	51.90	41.70
Group B	Right	29.89	33.37	27.25	30.17
	Left	26.40	26.25	26.88	26.51
Group C	Right	14.14	17.95	13.21	15.10
	Left	14.45	12.19	10.10	12.25

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