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Changes in time perception during and following experiences of stress and relaxation are commonly reported, but little is known about the direction and nature of any time perception changes. In this experimental study, men and women ages 18 to 79 were randomly assigned to one of three conditions: stress (n = 39) - speech preparation and presentation, relaxation (n = 38) - a progressive muscle relaxation exercise, or control (n = 39) - listening to a biography on tape. Multiple measures of time production, time estimation, perceived rate, and attention to time domains (past, present, and future) were made before and after the experimental phase. Retrospective time estimates were made after the experimental phase. Self report, physiological, and biochemical measures of stress were used to evaluate response to the experimental conditions, and results were consistent with increased stress in the stress condition and increased relaxation in the relaxation condition. Measures of duration judgment were relatively consistent within individuals with larger variance from person to person. Some of the individual variance was associated with gender and age with women having generally larger duration judgment ratios (subjective/objective time) than did men ($t(110)=2.91$, $p<.01$) and age was significantly correlated with duration judgment ratio. Time was reported to pass slower than usual during relaxation ($t(34) = 5.37$, $p<.01$), but time spent relaxed was remembered as significantly shorter than time spent in the control activity ($F(2,108) = 9.88$, $p <.01$). Stress led to increases in subjective to objective time ratio ($t(37) = 2.34$, $p <.05$), and time following a period of stress was reported to pass quickly. Attention to the present was related to lower reported distress, whereas attention to the past was positively correlated with self-reported distress. These data imply that changes in time perception may reflect changes in experiences of stress or relaxation. Also, interventions to increase focus of attention on the present may be helpful to reduce distress.

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ABSTRACT

Title of Thesis: Effects of Stress and Relaxation on Time Perception

Bonnie Roberts Chavez Doctorate of Philosophy, 2003

Thesis directed by: Neil E. Grunberg, Ph.D.

Department of Medical and Clinical Psychology

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Effects of Stress and Relaxation on Time Perception

by

Bonnie Roberts Chavez

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INTRODUCTION

In 1890, William James wrote, “Empty our minds as we may, some form of changing process remains for us to feel, and cannot be expelled. And along with the sense of the process and its rhythm goes the sense of the length of time it lasts” (p.406). In other words, James believed that time perception was interwoven with individual psychological experiences. In 1934, Howard C. Warren wrote, “Time perception refers to the apprehension of amount of duration, rate of change, placement in time, order of occurrence, beginning and end, etc., of experiences.” According to Warren’s succinct summary of time perception and psychological experience, time perception involved several different elements that are affected by experience. The experience of stress is part of daily life, affects physical and mental health, and is inseparable from military service. Understanding how psychological stress affects the perception of time may enrich understanding of human experience and ultimately how to optimize health and performance.

Scientific exploration of the relationship between time perception and states of stress and relaxation has been historically sparse owing to conceptual and methodological limitations. However, empirical and clinical reports do provide some evidence of a link between states of stress and time perception, and most of the major theoretical models of time perception predict that stress and relaxation will alter perceived time. Indicators of a link between stress and time perception include clinical case reports of altered time perception in conditions of acute stress (Terr, 1979, 1983; Fraisse, 1963) and hundreds of interview and literary accounts of altered time perception in experiences of stress and relaxation reported in qualitative sociological research (Flaherty, 1999). Several key theoretical models of time perception include arousal as a component (e.g., Block, 1985, Gibbon & Church, 1984; Glicksohn, 2001) because arousal influences the rate of body processes potentially related to biological clocks or timers. Stress and relaxation influence cognitive factors, such as attention and memory (e.g., Al'absi, Hugdahl, & Lovallo, 2002; Lindsay & Morrison, 1996), and attention and memory are believed to play a role in time perception (e.g., Block & Zakay, 1997; Ornstein, 1969; Zakay, 1989). Results of the limited experimental time perception research to date suggest that experiential state does, in fact, affect time perception, but relatively little is known about the pattern of time perception changes in everyday experiences of stress and relaxation. Taken together, the available information is consistent with the concept that stress and relaxation have effects on time perception. These effects have broad implications in areas ranging from job performance to clinical stress intervention to theory development.

Experimental investigation of how states of stress and relaxation affect time perception has important practical relevance. One application is to optimize performance of time-sensitive tasks in stressful environments, such as military and emergency response environments. For example, paratroopers count the seconds before pulling a reserve parachute if the primary parachute fails to open. Improper timing of the count can lead to disastrous tangling of parachutes or to landing without adequate time for the reserve chute to open and slow the fall. If there are differences in time perception during the stress of combat as compared to practice jumps, then an understanding of time perception changes might allow the jumper to accommodate the count as needed for successful results. Similarly, if the time between breaths in cardio-pulmonary resuscitation (CPR) with a person on the verge of death is subjectively different than the same duration during CPR with a practice dummy, then adjustment may be required. Empirical answers to these questions might enhance development of appropriate training, strategies, or safeguards so individuals can best maintain desired performance.

More generally, stress is a contributing factor for a number of physical and mental health conditions. These health problems have significant costs in decreased quality of life, decreased productivity, and mortality. Relaxation therapies are now commonly used to reduce negative stress consequences and were included in treatments of more than two thirds of the most frequently reported medical conditions in the United States (Eisenberg et al., 1998). Little is known about the consequences of stress on perception or the consequences of relaxation on perception. Most relaxation techniques include a temporal perspective change with a focus of attention on the present moment and away from memories of the past and thoughts of the future. These changes of focus might change perception of the duration of time spent in relaxation or in the perceived rate of time passage during the procedure. It is unclear whether relaxation causes opposite changes in perception from stress or if relaxation causes changes similar to stress. Understanding perceptual changes caused by relaxation techniques may help fine-tune relaxation therapies and allow the use of time perception as an assessment tool or outcome measure of stress management and relaxation therapies.

Self-reports of time (such as the frequency and duration of health condition symptoms) are a mainstay of diagnostic evaluation and quality of life measures in health settings (Burrows & Brown, 1991). If patients perceive or remember time quite differently when experiencing stress or when relaxed, then measures relying heavily on self-reported time may be distorted and unreliable. Clarification of the effects of stress and relaxation on time perception may improve interpretation and use of time-related self-report tools.

The role of the experiences of stress and relaxation in the perception of time has important theoretical as well as practical significance. All experiences – actions, thoughts, and feelings – involve time. Time might even be called the common denominator of experience and it has long been pondered in philosophy and science. Experimental evidence of how stress and relaxation affect time perception is useful to distinguish among competing models of time perception and to refine existing models. For example, current theories of time duration perception hypothesize a role for arousal in time perception, but different theories predict somewhat different effects. The Scalar Timing Model (Church, 1984: Gibbon & Church, 1984), the Attention Gating Model (Block, 1996), and the Contextual Change Model (Block, 1985, 1992) predict that in conditions of increased arousal, perceived duration will be greater and, in conditions of decreased arousal, perceived duration will be less. In contrast, the Stimulus Complexity Model (Flaherty, 1999) and the Multiplicative Function Model (Glicksohn, 2001) predict that both high stress and extreme relaxation states will increase perceived duration. Time perception under relaxation as predicted by the various models is different because the implied processes and hypothesized mechanisms of action are quite different. Experimental testing of these opposing predictions can test these models. Sound theoretical models serve as a resource for shaping future research, elucidating potential mechanisms of action, and enabling clear communication in the research field.

<u>Organization of Background Information</u>

The relevant background material for introduction to this work is organized much as spokes around a wheel with the stress / relaxation – time perception relationship at the hub (See figure 1). The first section provides a brief history of time perception along with definitions and explanation of relevant measurement methods. Another section explains and critiques several relevant conceptual models of time perception. Additional sections provide historical background of stress and relaxation and how they are measured. Once the framework of spokes has been provided, the relevant experimental and non-experimental research pertaining to the relationship of stress and relaxation experiences to time perception is reviewed within the context of the historical and theoretical framework.

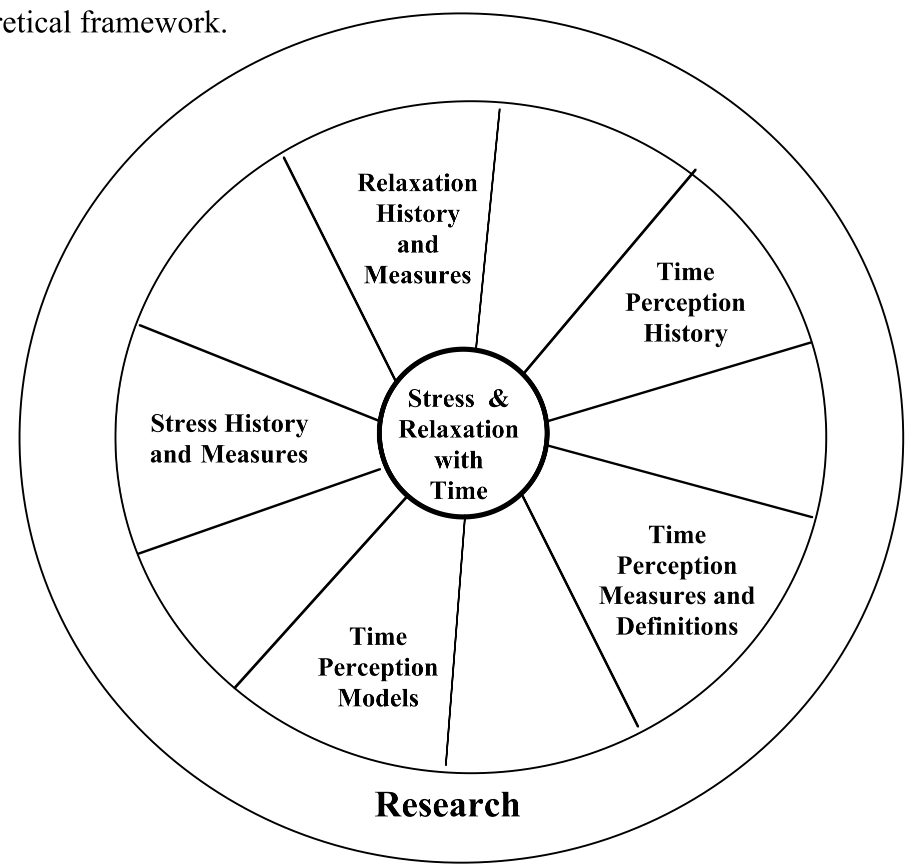

Figure 1: Diagram of the Organizational Format of the Background Information

Time Perception

History

Time perception is among the oldest topics in psychology. Theories of how people sense and experience time can be found among philosophies as far back as Aristotle and were included in the writings of such renowned philosophers as St. Augustine, Rene Descartes, Thomas Hobbes, John Lock, and Immanuel Kant (Nichols, 1890). In the decade following the start of the first experimental psychology studies of psychophysics (and at the urging of Leipzig professor of physiology, John Czermak), two German psychology laboratories began experimental studies of time perception in 1860, led by Karl von Vierordt at Tübingen and Ernst Mach at Graz (Nichols, 1890). William James devoted an entire chapter to time perception in *The Principles of Psychology* (James, 1890). Studies amassed over the years have greatly advanced knowledge, but key questions, raised more than a century ago by Nichols (1890) and James (1890) concerning the relationship of basic sensation, attention, memory, brain activities and physiology in the process of perceiving time, remain to be answered.

Definitions

A glossary of key terms and symbols is included in Appendix A. The distinction between **simultaneity** (events occurring together or at the same time) and **succession** (events occur one before another at different times) marks the most basic element of time perception. Of particular relevance to the proposed research is the concept of **duration**, the "length" of the segment of time between two momentary events or of a prolonged event (the start and end of the event then serves as the two momentary events). Duration may be measured in subjective time units or using an accepted standard of equivalent periodic events, usually a clock. In the past few years, a standard convention has been adopted to facilitate comparisons among studies and enable meta-analyses on topics of duration perception. The **duration judgment ratio** (described by Block, Zakay, & Hancock, 1999) is the ratio of subjective duration to clock duration. Of methodological and conceptual importance is the distinction between **prospective duration,** which is the duration that is judged when an individual knows in advance to attend to time, as distinct from **retrospective duration,** an estimate made after the duration has elapsed without forewarning to attend to the time. For convenience throughout this paper, the Greek letter theta (**θ**) is used to indicate prospective duration judgment ratio and the abbreviation **RT** (for remembered time) is used to indicate the retrospective duration judgment ratio. **Perceived rate (PR)** is the subjective impression of how quickly or slowly time passes.

Definitions of Related Temporal Concepts

Beyond perceiving sequences and numbers of events in time, people also develop beliefs and attitudes about time (collectively referred to as **temporal perspective**) that experiences may alter or affect. Temporal perspective includes the concepts of temporal horizon, temporal orientation, and domain attention. **Temporal horizon** refers to the extension of thought in time (e.g., when thinking of the future, is the thought to a time minutes away or decades away?). **Temporal orientation** is a term used to capture overall attitudes about past, present, and future. For example, an individual with a strong future orientation thinks about and makes plans for the future and believes in taking action in the present toward a goal in the future. Temporal orientation is different than "orientation to time" (whether or not an individual can tell the date and time), an important indicator of mental state in clinical cases of possible psychosis, dementia, or loss of consciousness, but seldom altered significantly in normal populations under ordinary circumstances. **Domain attention** is relative attention to past, present, and future. Temporal perspective may be an important individual difference variable influencing stress coping and possibly affected by chronic stress (e.g., Holman & Silver, 1998; Keough, Zimbardo, & Boyd, 1999, 1997; Lennings, 1996; Mahon, Yarcheski, & Yarcheski, 1997). In laboratory studies, temporal perspective factors are treated as individual differences similar to demographic variables.

Measuring Subjective Duration

Four methods have been used to measure duration perception in humans (Allan, 1979; Fraisse, 1984; Zakay, 1990): 1) the method of discrimination requires a subject to tell which of several presented stimulus intervals is longest; 2) the method of reproduction requires a subject to produce an interval of the same duration as a given stimulus interval; 3) the method of verbal estimation (**time estimation**) requires a subject to give a numerical estimate (usually in conventional time units of seconds or minutes) of the duration of a given interval period; 4) the method of production (**time production**) requires a subject to produce an interval given by the experimenter in conventional units (e.g., 1 minute). The last three methods allow the calculation of θ. For reproduction, θ is the produced duration (in clock units) divided by the stimulus duration (in clock units). For verbal estimation and production, θ is subjective duration divided by clock duration. Each of these methods has advantages and disadvantages. Verbal estimation and production require some mental concept of clock units. Discrimination and reproduction do not require a concept of clock time, so the methods can be used in studies with animals and children. However, reproduction may not be an appropriate method to detect alterations in subjective duration as a change in reproduced duration is difficult to interpret because perception of the stimulus duration or the produced duration may have changed. Hypothetically, both perception of stimulus and reproduced intervals could be altered in the same way and mask any change in perception (e.g., stimulus duration was perceived as longer and an accurate reproduction also was perceived as longer). Because of ease of interpretation of change, the methods of verbal estimation and production are most appropriate for studies of effects of acute laboratory manipulations on duration perception in adults.

Time Perception Theory

Several theoretical models of time perception point to an influence of stress on time perception. Although theories of how people discern and judge brief durations of less than one second and theories of how people gauge time of long duration from hours to days do not clearly involve an arousal or stress component, most models of time perception for the intervals of seconds to minutes include or infer a role for arousal or stress.

Scalar Timing Model. The Scalar Timing Model (Church, 1984; Gibbon & Church, 1984) has been the dominant model used in animal research. Arousal is believed to increase the rate of an internal pacemaker in the model (diagrammed in Appendix B figure B-1) that partially determines the amount of subjective time units that accumulate while a theoretical switch is open. The arousal effect on pacemaker was derived from pharmacological effects on timing behavior. Under the influence of stimulant drugs, animals reduce the delay time to a learned response indicating an increase in subjective duration. The delay time is increased with sedative or depressive drugs, suggesting a decrease in subjective duration. In the Scalar Timing Model, the amount of subjective units from the pacemaker that accumulate in working memory is compared to a reference memory to determine the subjective judgment of duration.

Contextual Change and Attention Gating Models. The Contextual Change Model (Block, 1985; see Appendix B figure B-2) is similar in structure to the Attention Gating Model (Block, 1996; see Appendix B figure B-3). The Attention Gating Model adds an attention gate in which the proportion of total attention devoted to temporal versus non-temporal information affects the subjective time units in the counter. In the Attentional Gate Model, the rate of the pacemaker is affected by arousal. In the Contextual Change Model of prospective timing, the number of items produced by the cognitively-based Context Generator (rather than an internal pacemaker) drives the potential number of subjective units. The attentional gate aspect of these models has been tested in experiments that have used multiple simultaneous information processing tasks and measured the effect of relative attention to time-related tasks. A Contextual Change Model (Block, 1992; Block & Reed, 1978) also has been proposed for retrospective duration (duration remembered when the individual is not explicitly timing the event) and it draws heavily from Ornstein's (1969) Storage Size Model of retrospective duration. Remembered duration is largely a function of amount of information about the event stored in and retrieved from memory, but the model proposes that the amount of information stored in memory is partially a function of arousal as well.

Multiplicative Function Model. Glicksohn (2001) theorized a multiplicative function in which subjective duration is not just the number of subjective time units but the product of the number of subjective time units and the size of the units. In the Multiplicative Function Model (see Appendix B figure B-4), subjective duration (Glicksohn uses the phrase apparent duration) is the product of arousal-dependent number of subjective time units and attention-dependent size of subjective time units. In this model, extreme stress states are associated with a larger number of units (a consequence of high arousal) leading to longer perceived duration, and extreme relaxation states are associated with larger sized units (a result of focused attention on elements of experience) also resulting in longer perceived duration.

Stimulus Complexity Model. Flaherty, a sociologist, recently proposed a theory constructed from interview and literary accounts of protracted duration (Flaherty, 1999). Flaherty's description of protracted duration corresponds to a sense that time is passing slowly (i.e., a reduction in perceived rate, PR). In the Stimulus Complexity Model (Appendix B figure B-5), PR is a "U" shaped function of stimulus complexity such that time seems to pass slowly when there is very little stimulation and when there is very much stimulation. Stress and relaxation indirectly affect perception of time via their effect on stimulus complexity in this model. Flaherty proposes that the effect of compressed duration (time seems to pass quickly) is an artifact of memory and is only possible in retrospect. Therefore, the Stimulus Complexity Model predicts only slowing of PR with changes in stimulus complexity from an individual's baseline comfort level of stimulation and not quickening.

To summarize, several theoretical models of time perception suggest an effect of stress and relaxation on time perception. All of them suggest that increased stress will increase θ (or in one case slow PR), but the predicted effects of relaxation are mixed.

Stress and Relaxation

Stress

History. Early research and theory on the concept of stress was the domain of physiology. Building on Claude Bernard's work on *Le Milieu Interne* (1865), Walter Cannon (1935) noted that organisms respond to events or challenges to internal homeostasis with reactions that tend to restore the balance. Cannon explored specific responses to various challenging agents and found common autonomic nervous system and adrenaline responses. He also recognized the value of the varied responses in enabling organism survival, epitomized in the term *fight-or-flight response*. Hans Selye conceptualized stress as a non-specific response of the body to demands for adaptation, primarily involving the Hypothalamic-Pituitary-Adrenal (HPA) Axis (Selye, 1973). Selye described the long-term effects of this adaptation response and its link to disease and health impairment. Psychologists studying the stress process recognized that various life events and non-physical (psychosocial) challenges to the organism also result in stress responses and attempted to quantify the stress-inducing events (Rahe & Arthur, 1978). However, the event alone cannot predict the stress response because perceptual factors in the appraisal of an event and the individual's coping resources available for adaptation have important effects on the ongoing process of response to the event (Glass & Singer, 1972; Lazarus, 1993; Lazarus & Folkman, 1984). Stress research has found that stress responses in almost all body systems include both non-specific components (particularly linked to appraisal and emotional response) and specific components based on the particular challenge (e.g., Mason, 1971; Taylor, Klein, Lewis, Gruenewald, Gurung, & Updegraff, 2000).

Definition. Overall, perception influences the process of stress from the event to the individual responses — responses that can involve a wide array of body systems in non-specific and specific reactions. **Stress** is defined as *a process in which internal or external events (**stressors**) threaten or challenge an organism's existence and well-being, and stress responses occur that are directed toward reducing the event's impact* (Baum, Singer, & Baum, 1981; Baum, Grunberg, & Singer, 1982; Baum, Gatchel, & Krantz, 1997). Psychological stress responses and biological stress responses interact in the complex stress process aimed at protecting the organism as a whole. Psychological stress responses include changes in mood, performance, cognition, and behaviors. Biological stress responses include autonomic arousal, activation of the Hypothalamic-Pituitary-Adrenal (HPA) axis, immune system response, and endocrine responses as well as other systemic responses, including brain systems (e.g., McEwen, 2000). To the extent that perception depends on psychological and biological systems, stress responses may include changes in perception. If stress does indeed change perception in general and, in regard to this work, time perception specifically, a pattern of non-specific changes and changes specific to the particular challenge would be expected.

Relaxation

History. The relaxation process is generally considered to counter balance the stress process. Because ongoing stress and states of anxiety and tension are associated with health problems, many methods have been developed and practiced to promote relaxation that often is used in stress management programs and to treat medical conditions (Eisenberg et al., 1998). Common relaxation methods include progressive muscle relaxation, meditation, imaging, autogenic training (self-hypnosis), listening to music, certain types of prayers, and activities that include techniques of breathing, movements, and postures such as Yoga and Tai Chi (Benson, 1996). Evolution of theories of relaxation closely parallels that of stress. Early interventions focused on the physiological components of relaxation. Edmund Jacobson (1925, p. 73) described his method of Progressive Relaxation as “a method to bring quiet to the nervous system,” and had participants systematically tense and relax various muscle groups to learn the sensations associated with the tension of each muscle and the contrasting sensation of relaxation. This procedure is thought to teach individuals to quickly sense even minute tensions and to completely relax the skeletal musculature.

Just as Selye (1973) hypothesized a non-specific physiological stress response, Bensen (1975) proposed a non-specific physiological “relaxation response” consisting of physiological changes and reduced sympathetic arousal. Bensen and Stark (1996) contrasted the physiological changes in the relaxation response with those of the fight-or-flight response (see Table 1). Davidson and Swartz (1976) argued for specific effects of different relaxation techniques and Lehrer and Woolfolk (1993) proposed that a combination of non-specific and specific effects result from relaxation methods. Scheufele’s (1999) experimental work comparing the effects of different relaxation conditions including progressive muscle relaxation, music, silence, and attentional control found that all reduced some stress effects, including lowering heart rate and improving performance on a task of attention. Different conditions varied in providing distraction from memories and thoughts of stressors. The progressive muscle relaxation condition, which employed a modified version of Jacobson’s technique (abbreviated and with hypnotic components), showed the greatest effect on behavioral and self-report measures of relaxation (Scheufele, 1999). Like stress, relaxation involves psychological and biological responses in specific and non-specific reactions involving a wide array of body systems.

Table 1. Comparison of the Physiologic Changes of the Fight-or-Flight Response and the Relaxation Response (Based on Benson, 1996).

PHYSIOLOGIC STATE	FIGHT-OR-FLIGHT RESPONSE	RELAXATION RESPONSE
Metabolism	Increases	Decreases
Blood Pressure	Increases	Decreases
Heart Rate	Increases	Decreases
Rate of Breathing	Increases	Decreases
Blood Flowing to the Muscles of the Arms and Legs	Increases	Stable/Decreases
Blood Flow to the Skin and Digestive Organs	Decreases	Increases
Muscle Tension	Increases	Decreases
Slow Brain Waves	Decrease	Increase

Definition. Assuming a somewhat parallel definition with stress, **relaxation** for the purpose of this work is defined as *a process in which directed awareness of internal or external events (**relaxors**) augment an organism's existence and well-being, and relaxation responses occur that are directed toward enhancing and preserving the organism's psychobiological resources.* Psychological relaxation responses and biological relaxation responses interact in the complex relaxation process aimed at protecting the organism as a whole. Psychological relaxation responses include changes in mood, performance, cognition, and behaviors. Biological relaxation responses include reduced sympathetic arousal, immune system response, and endocrine responses, as well as other systemic responses. Time perception will be affected by relaxation if the perception of time depends on these various systems.

Measuring Stress and Relaxation Responses

Stress and relaxation are processes, perhaps competing, independent processes, or perhaps opposite manifestations of an overarching psychobiological process of adaptation. Although processes cannot easily be measured, the consequences of the processes can be detected through various physiological, biochemical, behavioral, and self-report measures. Because responses may present as a combination of general and experience-specific changes, measurement in multiple modalities may best capture the landscape of the psychobiological profile at any given time (Baum, Grunberg, & Singer, 1982). Physiological measures commonly used include heart rate and blood pressure. Biochemical measures have become increasingly complex as technology has evolved to measure various catecholemines, corticosteroids and other hormones, neurotransmitters, and immune system substances among others. One of the least invasive and most established biochemical measures of stress is salivary cortisol (Kirschbaum & Hellhammer, 1989). Self-report measures have been widely used and validated in psychological research (e.g., Cohen, Kamarck, & Mermelstein, 1983). Behavioral measures include task performance and behavioral ratings from trained observers (e.g., Norton, Holm, & McSherry, 1997). Because complex processes manifest in multiple domains, it is necessary to measure these multiple domains to tap the processes.

Historical Overview Summary

From a historical perspective, stress and relaxation are adaptive experiential processes in which internal and external events lead to a series of biological and psychological responses aimed at protecting or nurturing the organism. Experiences spring from events and events - by definition - denote the passage of time. Time perception includes the judgment of the duration of events and a subjective idea of how quickly time is passing, possibly in relation to the pace of events in experience. Conceptual models of time perception predict changes in time perception during the experiences of stress and relaxation. However, the stress and relaxation processes are complex because they include general and specific responses from a broad range of biological and psychological systems within the individual. Additionally, perception mediates the experience of events in the stress and relaxation processes. Despite the complexity, there is strong conceptual support for a relationship between the experiences of stress and relaxation and how time is perceived in those experiences; the empirical support for this relationship is reviewed next.

Experimental Studies of Stress and Time Perception

Experimental time perception studies have not manipulated stress or relaxation explicitly as the stated independent variable, but several studies included conditions that may have induced these experiences. Experimental studies of time perception with probable stress components are reviewed in this section. Abstracts from a Psychlit® search for "time perception" and "time estimation" and from *The Concept of Time in Psychology: A Resource Book and Annotated Bibliography* (Roeckelein, 2000) were searched for experimental studies of time perception in which the conditions might reasonably have led to experiences of stress or relaxation. The references of relevant articles also were reviewed for inclusion criteria. The reviewed studies are representative of the literature on time perception and include those studies with particular conceptual or methodological relevance to the question of the relationship between stress and time perception. The literature review begins with several studies in which independent variable manipulations may involve stress. Next, studies using physical stressors such as electric shock, heat, and exercise are reviewed. Then, studies involving psychological stressors including failure and evaluation are reviewed followed by studies involving relevant individual difference variables. Finally, studies involving sensory stimulation that may alter psychobiological state are reviewed.

Studies with Possible Stress as an Independent Variable

Occupation. One of the earliest studies to consider the effect of "occupation" on time perception was conducted by Gulliksen (1927). In a study of verbal time estimates of a 200-second period in 326 college students, he reported significant differences in the estimates made while occupied with different activities, and some of these activities might have led to different experiences of stress or relaxation. In order of increasing θ, the conditions were: division (performing long division problems), dictation (dictating a text read aloud), mirror (performing mirror writing), pain (pressing the palm of the hand onto a pointed object), rapid metronome (listening to a metronome at 184 beats per minute), slow metronome (listening to a metronome at 66 beats per minute), fatigue (holding the arms extended), and rest (placing the head on the desk with eyes closed). The findings of this study indicate that time estimates are different when engaged in different activities, but no information was provided about why the estimates differ. Whether any of these conditions was more stress-inducing or relaxing than the others might depend on the individual, and no indices of stress, arousal, or emotional reaction were reported.

Danger. Langer, Wapner, and Werner (1961) put blindfolded subjects on a motorized cart that led them either toward a stairway and drop-off (danger) or away from the potential fall (no-danger). While on the moving cart, subjects produced a 5-second duration by pushing a button to indicate the end of the time period. The procedure was performed using two different initial distances from the stairway (15 feet and 20 feet). The danger conditions led to significantly shorter productions (an average of 3.32 seconds compared to 4.11 seconds for the no danger conditions, $p<0.01$). Shorter production time results in greater values for θ because production time is the denominator. There was no main effect for distance but there was a non-significant trend for an interaction between danger and distance with the shortest productions in the 15-foot danger condition. The order of increasing θ corresponded to the order of increasing danger among the conditions. This study has several strengths, including within-subject design and strong manipulation of the independent variable while holding other factors constant (e.g., task information processing demands) across conditions. Although it is likely that moving toward the drop-off would be experienced as stressful or arousing, there were no measures of subjects' experience of the conditions or their state during the conditions to confirm this assumption. Studies that include measures of stress responses are needed to clarify the findings of different time perception in different experiences.

Witnessing crime. Loftus, Schooler, Boone, and Kline (1987) used a crude stress measure in their time perception study. The experiment was based on the observed tendency for eye-witnesses of crimes to overestimate remembered duration of the event. Subjects watched one of two 28-second video-tapes of a bank robbery. The low stress version of the tape depicted the robber entering the bank and calmly handing a note to the teller. The high stress version of the tape depicted the robber displaying an automatic pistol, and using profane and threatening language. The participants returned to the laboratory 48 hours later and estimated the duration of the tape along with answering questions about the details of the robbery and giving a 1- 6 rating of how upsetting they found the video tape. Both versions were significantly overestimated (large RT). The high stress version was estimated as significantly longer (an average of 79 seconds compared to 63 seconds: $F(1,133) = 1.99$, $p<0.01$) than the low stress version. Women made significantly longer estimates than men ($F(1,133) = 6.09$, $p<0.02$). Upset ratings for the high-stress tape were higher than for the low-stress tape, and women reported higher stress than did men. However, there was no significant correlation between stress rating and time estimate nor was there a correlation between time estimate and remembered information. By group, magnitude of the self-reported rating of stress followed the same pattern as RT. The lack of correlation between the two measures may be a reflection of considerable individual difference in RT (which might have been better captured with a baseline for comparison) and of questionable reliability of the stress measure (the scale range was overly limited as most participants rated only a 1 or 2 of a possible 6). The study suggests that stress experience increases remembered time but the relationship would be clearer if the study had better measures of stress experience.

Physical Stressors

Electric shock. Several studies have investigated the effect of physical stressors on duration perception with most finding an increase of θ (i.e. subjective time / clock time) under conditions of the stressor. For example, several studies have reported that estimations of short time intervals terminated by electric shock were greater than no-shock estimates (θ shock > θ control: Frankenhauser, 1959; Hare, 1964). Falk and Bindra (1954) reported significantly shorter productions (i.e., larger θ) of 15 second intervals in a group in which half of the trials terminated in shock compared to a no-shock control group. However, results depended upon method. Frankenhauser (1959) had subjects make repeated 1-second productions during each interval with a verbal estimate of the complete duration at the end. The verbal estimate was significantly longer in shock compared to no-shock trials, but the number of produced seconds during the period was unchanged. Evidently, participants counted seconds the same in shock or no shock trials. In Frankenhauser's study, the participants did not know from trial to trial which would end in shock. Once shocked, the period was estimated as longer. In the experiment of Falk and Bindra (1954), the participants determined the end of the production before knowing whether or not it was a shock trial and their productions were compared with a separate no-shock control group. Participants had larger θ when intervals ended in shock and a group of participants who might get shocked had a larger θ than a no-shock control group. The findings suggest that whether compared within participants or between groups of participants, θ is greater with stress, but the conclusion is based on the assumption that anticipating electric shock or receiving a shock causes a stress experience. This assumption could be verified in laboratory studies of stress and time perception by measuring various stress responses.

Heat. Hoagland (1933) evaluated the relationship of body temperature to minutes produced by counting seconds. He reported that θ increased with body temperature and followed a log-linear function. His interpretation of the finding as an effect of body temperature *per se* is questionable because the sole subject was his wife during a bout of influenza. Her body temperature and time estimates may have reflected her state of illness. Hoagland (1933) repeated the experiment on a volunteer subject by manipulating temperature through exposure to "high frequency alternating current until his temperature (by mouth) registered 38.8° C" (Hoagland, 1933, p. 270) with the same result that θ increased with body temperature. Based on the definition of stress described previously, any challenge to an organism resulting in such a large (3° F) change from homeostatic body temperature would reflect the stress process. Hancock (1993) conducted more careful experiments of temperature and time production with silent counting (intervals of 1s, 11s, and 41s). Change in head temperature was induced by a heated helmet and measured in the ear. A within-subject design and 12 subjects were used and four conditions were included: control (no helmet, no heat), placebo (helmet, no heat), heat 1 (helmet, mild heat =0.75° elevation), heat 2 (more severe heating = 1.5° elevation). The pattern of resulting θ's in increasing order by condition was heat 1, placebo, control, heat 2. Mild increases in temperature seem to decrease θ, whereas more severe heating increases θ. Although it is likely that the higher heat condition involved stress, stress or relaxation experience was not measured and is unclear in the other conditions. Studies intending to measure stress and time perception need to measure stress responses.

<u>Exercise</u>. An increase in θ was reported during strenuous exercise compared to pre or post exercise (Vercruyssen, Hancock, & Mihaly, 1989). One of the difficulties in time perception measures is their large variability. Vercruyssen and colleagues reduced variability by training subjects on the first day by giving feedback on the 10-second productions. On the subsequent two trial days, the subjects produced the 10-second interval five times in each of the work phases (before, during, and after exercise at 60% maximum aerobic capacity on a cycle ergometer). Training and familiarity decreased variability. In non-exercise productions average productions for the 11 subjects were

9.96 seconds and 10.00 seconds, with a standard deviation of 0.42 seconds and 0.45 seconds. Productions were decreased somewhat during exercise to an average of 9.62 seconds with a standard deviation of 0.54 seconds. Even with specific training on the production of an interval, strenuous exercise still affected subjective duration, increasing θ. This study reported heart rate, which ranged from 70 to 80 bpm before exercise, from 109-119 bpm during exercise, and from 80-90 bpm after exercise. Using heart rate as an index of stress, θ was highest when stress was highest.

Summary of physical stressors. Overall, electric shock, heat associated with a rise in internal body temperature of at least 1° C, and strenuous exercise all increase θ over baseline conditions. Results are mixed for heat conditions that raised internal body temperature less than 1° C with Hoagland (1933) reporting a log-linear function of counting speed and the inverse of temperature and Hancock (1993) reporting consistent decreases in θ with increases in heat less than 1° C. These studies were not intended to induce stress *per se* or to measure stress responses, but taken together, the results provide some evidence of an effect of physical stressors on time perception. Additional studies are needed to determine whether the more common psychological stress and relaxation experiences of daily life similarly affect time perception.

Psychological Stressors

In modern life, humans face more psychological challenges such as performance demands, appraisal of worth, and social relations than physical challenges for survival. There is a body of literature involving studies of various cognitive tasks and time perception but those studies were not designed to evaluate effects of stress or relaxation and they cannot be clearly interpreted in that context. This section reviews the handful of time perception experiments in which psychological experience was manipulated in ways that might have been stressful to most people.

Failure and evaluation. Several experiments compared time estimation in conditions of different performance demands. Rosenzweig and Koht (1933) gave unsolvable puzzles in two instruction conditions (alone for practice and with an experimenter watching in a test of intelligence). Overall, subjects estimated the test period as longer than the practice period (θ test > θ practice) but statistical analysis of the data was not reported. Rosenzweig and Koht (1933) reported a possible relation between subjects' attitudes expressed at the debrief interview and their estimates, "When (the subject) is bored or feels despair time seems long; when he is interested and eager, time seems short" (p. 759). How the demand of the instruction condition affected time perception depended upon the individual reactions to the demand, highlighting the need for measures of individual responses to any experimental event to determine actual experience.

Harton (1939) compared the estimation of time engaged in successfully solving maze puzzles to failure trials on the task. The failure trials were estimated to be longer than success trials (θ failure > θ success). The findings suggest that the greater psychological stress of failure was associated with greater θ, but stress was not measured. Harton attributed the differences in time perception to greater psychological closure on completed tasks as compared to uncompleted tasks. Assuming that experiences of evaluation and failure are stressful, greater stress results in greater θ, but the assumption should be verified with measures of stress responses in a study designed to evaluate effects of stress on time perception.

Individual differences and psychological stressors. Because individuals differ in their perception and appraisal of events, not all people experience an event the same way. In particular, individual traits may dispose a person to experience an event as more or less stressful. Several studies have compared individuals with different levels of trait anxiety or situational fears in the course of various task demands on time perception. Dubey and Sharma (1978) studied 60 students (30 male and 30 female) classified as high, medium, or low anxiety on a self-report instrument given to 300 undergraduate students for a study of time estimation. The subjects performed a mathematics task and were asked to retrospectively estimate the time on the task after the stop signal was given (20, 40, or 60 minutes with separate groups of 60 subjects in each time condition). In each time group the order of increasing remembered duration (RT) was low anxiety, medium anxiety, high anxiety (RT low < RT medium < RT high) and each of the groups was different at $p<0.05$. The anxiety group effect held for both men and women but the women made significantly longer estimates than did the men ($p<0.05$). If trait anxiety was an indicator of the actual stress experience during the mathematics task, then RT increased with stress experience in the experiment.

Sarason and Stoops (1978) conducted a similar study with three levels of test anxiety and two experimental conditions. In the neutral condition participants were told to wait while the experimenter went to get some materials. In the achievement-oriented condition, the participants were told that they were about to take an important test to determine their intelligence and that they would later find out how their scores compared with others. The participants made a retrospective estimate of the wait time (4 minutes). The participants then completed a difficult version of the digit symbol task and after 4 minutes were asked to estimate the time spent on the task. There was a significant effect for test anxiety ($F(2,108) = 3.57$, $p<.05$) and conditions, ($F(1,108) = 5.03$, $p<.01$) for the RT of the waiting period. There was a main effect for test anxiety on the estimate of digit symbol task duration ($F(2,108) = 5.13$, $p<.01$) and an anxiety by condition interaction ($F(2,108) = 7.81$, $p<.001$) with the high anxiety achievement condition group significantly longer (greater RT) than all other combinations. The pattern of results was reflected in a similar pattern of performance scores on the task with poorer scores in the anxious group. In their replication of the study, Sarason and Stoops (1978) included a questionnaire asking about distraction and interfering thoughts that occurred during the experiment. Anxious-achievement subjects reported significantly more cognitive distractions and worries than the other groups. The interfering thoughts were interpreted as maladaptive responses to stress that affected both task performance and time estimation. The study makes at least three important points. First, stressful conditions affect time perception (increasing RT). Second, the effect depends upon an interaction of the environmental situation and the individual's appraisal and coping in response to the situation (consistent with appraisal and coping mechanisms in the stress process). Third, cognitive mechanisms such as distraction may account for the results. Additional research is needed to determine time perception and individual stress responses to an experimental stress condition and to clarify the mechanisms of effect.

Watts and Sharrock (1984) also examined the relationship between individual characteristics (fear of spiders) and time estimates by asking normal volunteers and volunteers with spider phobia to estimate a 45-second period spent looking at a spider. The estimates by individuals with spider phobia were more variable but were significantly longer than normal individuals' estimates for the second period (θ spider phobics > θ normal) with a non-significant trend in the first estimation period. Individuals with greater fear in this situation had greater θ's, but carefully designed studies of stress and time perception are needed to draw causal conclusions.

Sensory Environment. Many of the studies that have attempted to test the arousal component of conceptual models of time perception have used sensory stimulation to manipulate arousal. Sensory stimulation has been reported to influence experiences of stress or relaxation. For example, Glass and Singer (1972) reported increases in measures of stress responses in participants following exposure to noise that was moderated by perceived control of the stimulus. Listening to classical music has been reported to induce decreases in measures of stress (i.e., increase relaxation: Scheufele, 2000). Several studies have used auditory click trains (usually 5 seconds long and at a frequency of 5 or 25 Hz) to precede a duration to be judged by various methods. These studies reported increased θ following the higher frequency pre-exposure, consistent with an increase in the rate of a theorized pacemaker (e.g., Burle & Casini, 2001; Penton-Voak, Edwards, Percival & Wearden, 1996). Visual flicker has been similarly presented preceding a duration to be judged with the same result as auditory studies, a pattern of increased θ with some rates and decreased θ with other flicker rates (Treisman & Brogan, 1992). Subjects produced 15-second or 2-minute durations in each of a series of four different conditions of light and tone in random order. No differences were reported among the time productions in the four conditions, but a significant order effect was reported. When participants experienced the tone condition (continuous presentation of an auditory tone) first, their duration judgment ratio (θ) was greater for all subsequent stimulus conditions as compared to θ for subjects beginning with one of the other three conditions (Epson & Kafka, 1952). This finding is consistent with a stress response following the noise exposure (i.e., aftereffect) leading to general increases in θ, but the study was designed to study the effects of stimulation, not stress, so stress responses were not measured.

Glicksohn (1992) further explored the effect of altered sensory environments on time perception. Subjects produced 4, 8, 16, and 32 second intervals on the first day in the control conditions and on the second day in one of 12 experimental conditions in a 3 x 4 factorial design. Glicksohn used three conditions of visual stimuli (visual Ganzfeld - tennis balls over the eyes with red light; normal room lighting; or visual overload - flashing lights with multiple projections of colored slides) and four conditions of auditory stimuli (no auditory stimulation, white noise, stereophonic presentation of music, and dichotic presentation of two sources of music - different music to each ear). There was a significant interaction between visual and auditory stimulus conditions in their effect on time production. Visual overload with white noise and visual Ganzfeld with dichotic music increased θ compared to white noise with visual Ganzfeld or visual overload with dichotic music. Dual sensory deprivation and dual sensory overload resulted in larger θ than did input to only one sense with deprivation to the other. If arousal is a function of sensory stimulation, then time perception follows a curvilinear relationship like the Yerkes and Dodson (1906) arousal inverted U. Perhaps lack of sensory stimuli and sensory overload may be experienced as more stressful than sensation in one modality or overload may be arousing and deprivation may be relaxing. To the extent that sensory stimulation relates to experiences of stress and relaxation, this study suggests interesting relationships between those experiences and time perception that merit further exploration.

Overall, sensory environment influences time duration perception. The effects may be consistent with changes in arousal with sensory stimulation or with sensory-induced experiences of stress or relaxation. Conclusions must be tentative, however, because studies have not adequately validated whether or not changes in arousal or stress have, in fact, occurred in the experimental conditions.

Experimental summary

In general, conditions that are presumed to increase stress, including shock, danger, performance evaluation, and noise, also increase θ and RT. Few of the studies have measured stress responses, and those that have measured stress responses have generally used a single modality of measure (e.g., self-report or heart rate). Even less is known about the effects of relaxation manipulations on time perception. Also, little is known about the effects of experiences of stress or relaxation on how quickly or slowly people perceive time to pass, or perceived rate (PR). Factors that influence individual's appraisal and coping in the experimental situation (such as trait anxiety) significantly influence the estimation of the experimental duration. Individual differences in temporal perspective and, in particular, attention to past, present, and future has not been measured in studies of experience and time perception and might provide useful information about individual responses to experience.

Other Literature Related to Stress and Time Perception

In addition to the experimental literature, field studies, clinical case studies, and qualitative research offer important background for time perception during experiences of stress and relaxation.

Clinical observations

Trauma. Case accounts of acute stress experiences (lasting less than a day) are accompanied by time lengthening. Of 30 patients interviewed about their experience of a major traumatic event (e.g., airliner crash, kidnapping, witnessing the murder of a family member), six spontaneously reported that time moved slowly during the event (slower PR) and no patients talked about time moving more quickly (Terr, 1983). Terr's quotes from these patients suggest that some of the patients believed that the duration had been longer than it was (greater θ or RT), while some realized that minutes were minutes yet the time seemed to pass slowly (slower PR) (Terr, 1979, 1983).

Pain. Pain is both a source of stress and a partial effect of stress processes. In a clinical study of pain patients, interval estimates of patients in pain were longer than estimates from normal volunteers (θ pain > θ normal), and the rank of θ correlated significantly with the clinician ratings of patient pain (based on clinical diagnosis) with a rank correlation coefficient of $r = 0.88$ (Biltine et al., 1983). Additionally, acute pain patients had greater θ than the chronic pain patients did, and θ decreased significantly after treatment for the pain (Biltine et al., 1983).

Field and qualitative studies

Natural disasters. Earthquake survivors surveyed 30 days after a minor earthquake overestimated the duration of the quake (RT > 1), and individuals located in the zip code of the quake epicenter gave significantly longer estimates than did individuals outside the epicenter zone (Buckhout, Fox, & Rabinowitz, 1989). The experience of stress would be expected to be most pronounced near the epicenter, but the actual duration of the vibration was probably longer in the more distant zone as the wave slowed with distance from its source. The investigators were hesitant to interpret the results and expressed concern that individuals might have inflated their estimates because of social influences such as the desire to appear credible.

Cases of protracted duration. Flaherty (1999) gathered 705 "first person accounts of situations in which the passage of time was perceived to slow noticeably," a phenomenon he calls "protracted duration" (p. 41). Of these accounts, 389 cases came from popular press, books and biographical literature, and 316 cases were from student interviews. Flaherty (1999) categorized the accounts into seven groupings: suffering and intense emotion (28.6%), violence and danger (27.4%), waiting and boredom (23.1%), altered states (9.1%), concentration and meditation (5.4%), shock and novelty (4.4%), and other (2.0%). The percentile distributions were similar between the archival sources and the student interviews. Several of these categories are relevant to the research questions. More than half of these cases fell into the categories of suffering and intense emotion or violence and danger. Almost certainly, these were situations involving increased stress. Boredom may itself be a source of stress and has been reported as a stressor in military field research (e.g., Bartone, 1998). Two of the categories, accounting for about 1 in 6 of Flaherty's cases, may relate to relaxation: altered states, and concentration and meditation. This qualitative information suggests that PR increases under experiences of extreme stress and relaxation.

Previous Research and Preliminary Studies

Yatko (2001) and preliminary studies have found a relationship between stress and time perception suggesting a need for follow-up research to experimentally test the relationships suggested by survey and pilot results. When surveyed, people report that their proportion of attention to the past, present, and future changes with stress. Women reported continuing to think about minor psychological stressors for a longer time than did men. Perceived stress was found to vary as a quadratic relationship of how quickly or slowly individuals reported time to usually pass (PR). Participants had greater θ from productions of one minute and 2.25 minutes following strenuous exercise as compared to baseline days in a pilot study.

Perception of Time and the Senses Survey Studies

Three survey studies examined the relationship between stress and time perception (Yatko, 2001). The Perception of Time and the Senses Survey (PTSS), a self-report measure of usual and stress-related time perception, was developed and administered to 412 people in the first study and was revised and extended to a broader sample (N=939) in the second study. In the third study, a revised version of the Perception of Time and the Senses Survey was administered in the laboratory with other measures of time perception, stress, and mood (N=64). Participants reported that relative attention to past, present, and future changed with stress to a greater than usual focus on the present and future under stress (each change in each study $p<.01$). Women think about psychological stressors after they have passed significantly longer than men do according to the survey results (all studies $p<.05$; see figure 2).

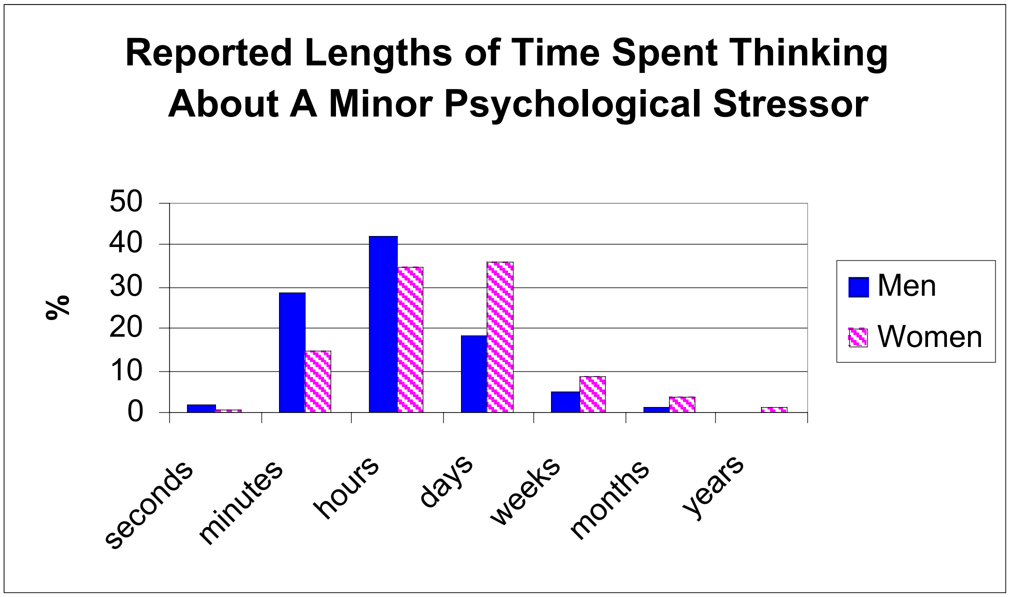

Figure 2. Percentage of men and women who continue to think about a minor psychological stressor.

The results of the self-report measures of perceived stress and perceived rate of passage of time followed a quadratic function. Perceived Stress Scale (PSS) scores fit a U-shape quadratic function of PR measured on a 5-point scale ($F(2, 60) = 4.85$, $p=.01$) such that participants who reported neutral time passage (not slow or fast) had the lowest average stress scores. Participants who reported that time passes very quickly or very slowly had the highest average stress scores.

These results suggest the following. First, the feeling that time is passing quickly or slowly may be related to perceived stress in a quadratic function. Second, the consequences of stress on time perception may be partly the result of attentional shifts such as decreased attention to the past (or memories) and increased attention to the present (current stimuli or sensations) and to the future (perhaps coping appraisal). Third, gender differences may affect the stress-time relationship such that women have longer active memory of some kinds of stressors or show different stress response patterns from men. In experimental studies of stress and time perception, therefore, perceived rate and domain attention should be measured. Because gender differences in response may exist, it is important that the sample include a balanced representation of each gender.

Preliminary Study

Preliminary research was conducted on the effects of exercise stress on time perception as part of a larger study of exercise performance. Fourteen healthy male volunteers produced 1-minute and 2.25-minute duration immediately following a treadmill exercise test to determine maximum aerobic capacity. They also produced 1-minute and 2.25-minute duration during non-stress baseline days prior to training on other cognitive and performance measures being used in the study. Time productions following the exercise test were significantly shorter (larger θ) than on the first baseline day ($t(13) = 2.59$, $p<.05$, $t(13) = 2.28$, $p<.05$, and $t(13) = 2.82$, $p<.05$, respectively for one minute, 2.25-minute, and average θ). Exercise stress increased θ relative to baseline in men. Additional research is needed to determine the effect minor psychological stress experiences have on time perception in men and women.

Key Gaps in Previous Research

Although the research reviewed above suggests that experiences of stress affect time perception by increasing θ, RT, and PR with suggestions of a relaxation effect of decreasing PR, key gaps need to be filled. Case reports and qualitative research rely on retrospective self-reports and leave questions about causality and mechanisms that can only be addressed experimentally. Few of the time perception experiments were intended to alter stress. Related constructs such as anxiety have been generally treated as individual traits. For these reasons, stress responses have seldom been measured in time perception studies. The handful of studies that considered stress at all either assumed that arousal changes occurred as a result of the experimental conditions without actually measuring arousal or used only a single modality measure of stress, such as a single item scale. Studies of exercise stress have used broader measures of stress response but have used restricted samples. Research using psychological stress conditions is needed to determine the extent to which the changes of time perception in exercise stress are responses to stress in general or to exercise in particular. Few experimental studies have considered relaxation effects, although results would help distinguish between competing theoretical models of time perception because some models predict increases in PR and θ with relaxation whereas others predict decreases. Studies of the effects of relaxation on time perception might contribute to greater understanding of relaxation therapies. Experimental studies have not measured perceived rate (PR) but have relied on measures of duration judgment in keeping with an interest in people's accuracy at judging time. However, when understanding the experience of interest, subjective sense of the passage of time is important to consider along with how duration is judged. Inclusion of PR and duration judgment measures will help to understand the relationship between the feeling of passing time and the judgment of time duration.

Overview

A human laboratory experiment was conducted to determine how stress and relaxation affect time perception. Subjects (58 men and 58 women, ages 18-80) were assigned to one of three experimental conditions (a common speech stress procedure, a progressive muscle relaxation procedure, or a control condition consisting of listening to a passage from a biography on tape). Measures of subjective time duration and PR were obtained before and after the experimental manipulation. Individual responses to the laboratory setting and experimental manipulation were measured through multiple stress-relaxation indices: heart rate, blood pressure, salivary cortisol, and self-report measures.

The study differed from previous time perception research in several important ways. Psychobiological state, the independent variable, was manipulated via stress and relaxation procedures to provide information about how each of these states affects time perception. Multiple biological and psychological responses were measured to evaluate the effect of the experimental manipulation. An important aspect of time perception seldom included in experimental studies, perceived rate, was measured along with commonly used measures of duration perception to better understand the subjective aspects of the time experience.

Hypotheses

1. Acute stress increases duration judgment ratio: θ stress > θ baseline; Δθ stress > Δθ control.

Rationale: In conditions generally associated with higher stress, such as danger (Langer, Wopner, & Wagner, 1957), electric shock (e.g. Falk & Bindra, 1964), failure (Harton, 1939), and evaluation (Rosenzweig & Koht, 1933), θ was larger than in normal or low-stress condition. Theoretical models previously reviewed predict increased subjective duration in conditions of increased arousal associated with stress (Block, 1985, 1990; Gibbon & Church, 1984; Glicksohn 2001).

2. Relaxation increases duration judgment ratio: θ relaxation > θ baseline; Δθ relaxation > Δθ control.

Rationale: The Multiplicative Function Model (Glicksohn, 2001) predicts "increased apparent duration" in conditions of relaxation and the Stimulus Complexity Model (Flaherty, 1999) predicts "protracted duration" in conditions of low stimulus complexity found in relaxation. Although the Scalar Timing (Church, 1984; Gibbon & Church, 1984), Attention Gating (Block, 1996), and Contextual Change (Block, 1985) models predict that subjective duration as a direct function of arousal will change with relaxation to *decrease* θ, a non-linear function is hypothesized here based upon the qualitative data from Flaherty (1999).

3. Acute stress decreases perceived rate, PR (i.e., time seems to pass more slowly): PR stress < PR usual; ΔPR stress < ΔPR control.

    Rationale: There are numerous accounts of individuals reporting the experience of time passing slowly under conditions of acute stress (e.g., Flaherty, 1999; Terr, 1983). Also, an increase in subjective to objective duration (θ) would logically be associated with a perception that objective events are passing slowly.

4. Relaxation decreases perceived rate, PR (time seems to pass more slowly): PR relaxation < PR usual; ΔPR relaxation < ΔPR control.

    Rationale: There are accounts of individuals reporting the experience of time passing slowly under conditions of relaxation (Flaherty, 1999). An increase in θ would logically be associated with a perception that objective events are passing slowly.

5. Perceived stress relates to usual perceived rate (PR usual) in a quadratic function such that higher perceived stress corresponds to very low and very high values of PR.

    Rationale: Previous research (Yatko, 2001) reported a quadratic relationship between perceived stress and reported usual rate of time passage such that time passing very quickly or slowly is associated with higher levels of perceived stress, and time passing not slow or fast is associated with low stress levels.

METHODS

Subjects

Men and women between the ages of 18 and 80 were recruited through posted signs and newspaper advertisements (Appendix C) in the Washington, D.C., area to participate in a study of perception. A phone-screening interview (Appendix D) was used to determine participation eligibility. Individuals who reported difficulty understanding or reading English or who reported uncorrected hearing impairment were excluded (2 individuals) because of potential difficulty in completing the experimental measures. Additionally, individuals who reported current use of psychotropic medication or current treatment for or diagnosis of a DSM IV (American Psychiatric Association, Diagnostic and Statistical Manual of Mental Disorders 4th edition, 1994) Axis I mental illness were excluded (17 individuals). Individuals with a current diagnosis of a major medical condition (e.g., heart condition, hypertension, or diabetes) were excluded to avoid potential health risks of experimentally-induced arousal (21 individuals). Scheduled volunteers were provided written directions to the laboratory by mail or email and were given a phone call reminder for their appointment one to two days in advance. A total of 129 participants came to a laboratory session (65 men and 64 women). Informed consent was obtained using a written informed consent document (Appendix E) which was explained orally and reviewed with any questions answered at the beginning of the laboratory session. Twelve participants (7 men and 5 women) were determined not to meet the eligibility requirements for inclusion during their participation in the study (1 unreported hypertension, 1 neurological impairment, and 10 undiagnosed cases of psychopathology as evidenced by high symptom reporting and suicidal ideation on the

Brief Symptom Inventory). One participant came to the study sick and was unable to complete the protocol. The data from those 13 people were excluded from analyses. The remaining 116 participants (58 men and 58 women) were randomly assigned to each of the three experimental conditions by ten-year age blocks to enable the assignment of 19 to 20 men and 19 to 20 women to each condition. Because age might relate to time perception, participants were randomized by 10-year age blocks to improve the likelihood of comparable ages in each condition.

Sample Characteristics

Recruitment sample size was based on a statistical power of .80 with a medium (0.5) to large (0.8) effect size (Cohen, 1969). Participants ranged in age from 18.1 to 79.7 years with a mean age of 38.5 years. The highest level of education that participants had completed ranged from 8th grade to doctorate degrees with most of the participants (75) holding a bachelors degree or higher. Demographic distribution was Asian: 7%, African American or Black: 18%, Hispanic or Latino: 6%, White: 66%, and Other: 3%. Volunteers (with the exception of the four military volunteers) were compensated $30 for their participation.

Sample Size

Sample size was estimated in several ways. Effect size for duration judgment ratio (θ) was estimated from preliminary research and studies in the literature (Langer, Wapner, & Werner, 1961; Loftus, Schooler, Boone, & Kline, 1987; Sarason & Stoops, 1978). Effect size for biological stress measures was estimated from previous research using speech stressors and progressive muscle relaxation (Schuefele, 1999). Preliminary research comparing production of 1-minute and 2.25-minute productions at baseline and immediately following a strenuous exercise stressor found an effect size (Cohen's d) of 0.609 for the 2.25 minute production, 0.692 for the 1-minute production, and 0.754 for the average θ. Effect size was calculated from the published results in a study that used 5-second time production in conditions of danger and no danger (Langer, Wapner, & Werner, 1961) as d = 0.71. These effects are medium (0.5) to large (0.8) according to Cohen's definitions (Cohen, 1969). Effect size between time estimates of a 4-minute interval of anticipation of performing a task that was described as a practice activity (low stress) or an intelligence test (high stress) was calculated from the published results to be d = 0.43 (Sarason & Stoops, 1978). Loftus, Schooler, Boone, and Kline (1987) compared retrospective time estimates for subjects watching a 28-second robbery video that was either lower or higher stress (e.g., including profanity and a weapon in view). Effect size calculated from published results was d = 0.362.

Calculation of effect size for measures used for validating the independent variable were conducted from results published by Scheufele (1999) for effects of an anticipatory speech stressor. Effects of stress on heart rate, blood pressure, and Profile of Mood states Tension Scale were calculated as d = 1.72, 1.03, and 0.77, respectively. Changes in salivary cortisol from baseline to peak using a combined speech and mental arithmetic stressor ranged from d = 0.95 to 2.62 in a series of studies published by Kirschbaum, Wust, and Hellhammer (1992). Estimating power from the smallest estimated effect size of d = 0.64 (conservative estimate of effect of stress on change in θ from baseline), a sample size of 40 per group (N = 120) has a statistical power of 80%.

Design

The experiment was a mixed factorial design with three treatment groups of experience state (stress, control, and relaxation) with repeated measures before and after treatment designed to examine the effect of experience state on time perception. Participants within 10-year age blocks were randomly assigned to experimental groups using a random number generator procedure. Final sample sizes and mean ages for each condition and gender were: **stress** (20 women, 40.9 years; 19 men, 37.0 years), **control** (19 women, 38.6 years; 20 men, 38.8 years), and **relaxation** (19 women, 38.9 years; 19 men, 36.8 years).

Setting

The experiment was conducted in a 10’x 7’ x 6.5’ sound-attenuated room with no windows. Chamber temperature was maintained between 70 and 72 degrees Fahrenheit and lighting was provided using four 60-Watt bulbs in recessed overhead lighting. The room was equipped with a video camera, two chairs, and two small tables on wheels. A water bottle, an ice bucket, pens and pencils were placed on the participant’s table. The table was rolled in front of the chair or to the side as needed during the experiment. Two laptop computers were located on the experimenter’s table such that the screens were not in the participant’s view during the experiment. Speakers were located on a shelf behind the participant and the physiological equipment console was located under the participant’s chair. No clocks or time-keeping devices were visible to the subjects.

Independent Variable

Experience state (relaxation, control, or psychological stress) was manipulated in the experiment.

Relaxation

In the relaxation condition, participants listened to a 16-minute audio-tape used previously by Scheufele (2000) with instructions adopted from published procedures (Fair, 1989). The participants sat in an upright chair and followed the instructions on the tape. The taped instructions lead them through a series of 10 muscle contraction-relaxation sequences designed to help people relax. The procedure has been effective for relaxation in previous research (e.g., Hoelscher, Lichstein, Fisher, & Hegarty, 1987; Sherman, 1982; Scheufele, 1999).

Control

The control (neutral state) condition consisted of listening to an excerpt from John Adams (McCullough, 2001), a book on tape read by Edward Herrmann and published by Simon & Schuster Inc., and answering a few opinion questions about the tape.

Stress

The stress condition consisted of two speech preparation periods and the presentation of two video-taped speeches (4-minute preparation, 4-minute speech, 2-minute preparation, and 2.5-minute speech for a total of 16 minutes including instructions). The directions given to the participants for the stress procedure are detailed in the Procedures section. The speech stressor procedure has been used in previous stress research and has been shown to be an effective, mild stressor with no lasting, deleterious effects (e.g., Morokoff, Baum, McKinnon & Gillilland, 1987; Rozanski et al., 1988;

Scheufele, 1999). The speech stress procedure significantly alters various stress indices including salivary cortisol (Kirschbaum, Wust, & Hellhammer, 1992), heart rate and blood pressure (Scheufele, 2000), and self-report of stress (Scheufele, 2000). The instructions for the undesirable habit speech were adapted from Scheufele (1999). The instructions for the shoplifting scenario speech were adapted from Zautra and colleagues (2000). The instructions were modified slightly to eliminate references to specific time periods.

Although the experimenter was not blind to the hypotheses, instructions and manipulations were administered primarily through audio recordings to maintain consistency and reduce potential experimenter-induced effects. Additionally, all sessions were videotaped in order to reliably clock the time productions and insure the consistency of the experimental protocol.

To assess the effectiveness of the manipulation of experience state (stress or relaxation), physiological measures (blood pressure and heart rate), psychological self-report (visual analogue scale and Profile of Mood States), and a biochemical measure (salivary cortisol) were used. These measures are described in detail in the Measures section.

Measures

Subject Characteristics

Copies of pencil and paper measures are included in Appendix F.

Background Questionnaire. The background questionnaire was written for this study to acquire demographic information. Demographic information was used to determine the extent to which the participants comprise a representative sample of the population. Questions ask about caffeine consumption because chronic caffeine use is associated with duration judgment ratios from time estimates (Stine, O'Connel, Yatko, Klein, & Grunberg, 2002) and about tobacco use because nicotine affects stress responses (USDHHS, 1988). A question about oral contraceptive use for women was included because oral contraceptives affect salivary cortisol in women (Kirschbaum, Kudielka, Gaab, Schommer, & Hellhammer, 1999). The background questionnaire variables were used in the analysis to determine the comparability of the three experimental groups.

Brief Symptom Inventory. (BSI-18; Derogatis & Melisartos, 1983). The BSI-18 is an 18-item, multi-dimensional instrument drawn from the original 90-item instrument (SCL-90-R) designed to measure nine symptom clusters including anxiety, depression, and somatization. The Brief Symptom Inventory has been used to assess the psychological symptom status of psychiatric patients, medical patients, and non-patient individuals. The BSI was included to identify participants with extreme scores as a potential indicator of psychopathology. The experimenter screened the responses during the laboratory session and provided assessment and appropriate referral during debriefing when there were prominent indicators of psychopathology including self-reported thoughts of ending life or significant elevation on most of the items on the overall scale. Chronbach's α of the BSI-18 in this sample was 0.85.

Perception of Time and the Senses Survey (PTSS: Short Form). This survey is a shortened adaptation of the Perception of Time and the Senses Survey developed in previous research (Yatko, 2001). This instrument measures usual time rate (how quickly or slowly time usually passes), domain attention (relative attention to past, present, and future), temporal extension (how far into the past and future one thinks), and stress extension (how long a person continues to think about different kinds of stressful events). Internal reliability for the 3-item Temporal Extension sub-scale and the 4-item Stress Extension sub-scale ranged from $\alpha = .48$ to .52 and $\alpha = .67$ to .71, respectively, in a college and community sample (Yatko, 2001) and were $\alpha = .64$ and $\alpha = .61$ in the current study sample.

Perceived Stress Scale. (PSS: Cohen, Kamarck, & Mermelstein, 1983). This measure has a 10-item version with five-point response and is a widely used measure of an individual's perceived level of stress in the past month. Internal reliability for the PSS was $\alpha =.85$ in a college sample reported by Cohen et al. (1983), was $\alpha = 0.81$ in previous research related to time perception (Yatko, 2001), and was $\alpha = 0.85$ in the current sample.

Effect of Experimental Manipulations

Several different types of measures were used to evaluate the effectiveness of the experimental manipulation (IV) in creating a state of increased stress or relaxation including psychophysiological measures, biochemical measures, and self-report measures.

Heart Rate and Blood Pressure. Participants' Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) were measured during four time periods in the experiment simultaneous with the saliva sample collection periods. During each of the four periods (two before and two after the experimental manipulation), three blood pressure readings were taken using a Dinamap blood pressure monitor. Heart rate (HR) was measured throughout the experiment using Biopac Systems Model MP-150.

Salivary Cortisol. is a widely used, noninvasive, biochemical marker of stress (e.g., Kirschbaum & Hellhammer, 1989). Saliva samples were collected using a cotton Salivette (Sarstedt Inc., Newton, N.C.). This collection method does not interfere with the measure of cortisol in the collected saliva (Shirtcliff, Granger, Schwartz, & Curran, 2001). The correlation between blood serum and saliva levels of cortisol is high ($r \geq .90$: Kirschbaum & Hellhammer, 1989). Salivary cortisol is stable at room temperature for several days and is stable when stored at 4° C or below for more than one year. Samples were labeled with date and subject number and stored in a locked freezer at 4° C until assayed. Because leakage of blood into saliva can interfere with accurate measures of salivary cortisol (Malamud & Tabak, 1993), assay for the blood protein, transferrin, was conducted prior to cortisol assay using Salimetrics' Salivary Blood Contamination Enzyme Immunoassay (Catalog No. 1301/1302). Transferrin is present in abundance in blood but normally only in trace amounts in saliva. Four samples with probable blood contamination, as indicated by elevated levels of transferrin, were excluded from cortisol assay. Prior to assay for cortisol, the remaining samples were combined into pools by gender, condition, and six categories of age at each of the four sampling points (2 x 3 x 6 = 36 pools for each of 4 times). Cortisol assay was conducted using enzyme immunoassay according to the manufacturer's protocol (Salimetrics, LLC HS-Cortisol High Sensitivity Salivary Cortisol Enzyme Immunoassay Kit Catalog No. 0101/0102, see Appendix G for kit insert).

Immediately following the fourth saliva sample, women were asked to provide another saliva sample through a different collection method (spitting through a straw) because cotton collection alters estradiol measures (Shirtcliff, et al., 2001). This sample was stored for future assay of estradiol if there were significant baseline differences in cortisol among the groups of women. Phase of menstrual cycle and use of oral contraceptives both affect salivary cortisol levels in women through altered levels of estrogen (Kirschbaum, et al., 1999). This assay was not performed because there were no significant differences at baseline among groups of women.

Visual Analogue Scale (VAS). This questionnaire was adapted from Scheufele (1999) for this experiment to measure self-reported states of stress, interest, and attention. It consisted of four visual analog scale (VAS) items, each directing the participant to place a mark on a 10-centimeter line to indicate to what extent they are experiencing the qualities denoted at either pole. Stress was assessed using the descriptors "Very Tense" and "Very Relaxed" and using "Very Anxious" and "Very Calm." Interest was assessed using the descriptors "Extremely Interested" and "Extremely Bored." Attention was assessed using the descriptors "Extremely Focused" and "Extremely Distracted."

Profile of Mood States. (POMS-SF; Shacham, 1983). The Profile of Mood States has been widely used to measure psychological distress. The short form version (POMS-SF) uses 37 of the 65 mood adjectives on the original self-report form in a 5-point Likert response format. The POMS-SF provides a global distress score (Total Mood Disturbance) and six sub-scale scores: Fatigue-Inertia, Vigor-Activity, Tension-Anxiety, Depression-Dejection, Anger-Hostility, and Confusion-Bewilderment. The Total Mood Disturbance from the short form is reported to correlate with the original form (all r's > 0.95) with good internal consistencies of the scales (α's ranging from 0.8 to 0.91) (Shacham, 1983; Curran, Andrykowski, & Studts, 1995). For this study only the Vigor-Activity, Tension-Anxiety, Confusion-Bewilderment, and Depression-Dejection subscales were included (24 adjectives). These scales were chosen because Tension-Anxiety is a mood state associated with state stress. Vigor was included to provide a positive mood state scale. Confusion was included to evaluate if there was a self-reported change in cognitive state. Depression-Dejection was included as a measure of depressed mood. Internal reliabilities of the scales in this sample were: Vigor-Activity $\alpha = 0.95$, Tension-Anxiety $\alpha = 0.80$, Confusion-Bewilderment $\alpha = 0.80$, and Depression-Dejection $\alpha = 0.79$.

Dependent Variables

Time Production. (1-minute empty time production and 2.25-minute empty time production). Time production is one of the four methods of measuring duration perception (e.g., Allan,1979; Fraisse, 1984; Zakay, 1990). Time production consists of asking an individual to produce a stated duration. The following directions were given for the 1-minute production and the 2.25-minute production respectively:

> *"When I tell you to start, please let me know when you think a minute has gone by. Try not to count. Just estimate when a minute has elapsed. When I say start, you will begin and you will say, 'stop' in a loud, clear voice when the time has passed. Ready. Start."*
>
> *"Now, when I tell you to start, please let me know when two and a quarter minutes have gone by. Try not to count. Just estimate when two and a quarter minutes have elapsed. When I say start, you will begin and you will say, "stop" in a loud, clear voice when the time has passed. Ready. Start."*

The procedure was timed to the nearest 1 second using the timing function on a computer clock to measure the elapsed duration between the words "start" and "stop."

The duration judgment ratio, θ (subjective to objective duration), was used for analyses. For the 1-minute production, the duration judgment ratio is 60 divided by clocked seconds. For the 2.25-minute production, the ratio is 135 divided by clocked seconds. The 1-minute interval was produced on two different occasions before the experimental procedure and on two different occasions after the experimental procedure for a total of four productions. The 2.25-minute interval was produced once before and once after the experimental procedure for a total of two productions. The periods are considered "empty time" because the participants were not tasked with any other demands during the production period. Empty time was selected to ensure uniform processing demands across experimental groups. Although previous research has reported time production to have considerable inter-subject variability (Block & Zakay, 1997), repeated productions by the same individuals are relatively stable. For example, in the study of exercise stress (described in the Introduction), 14 participants were asked to make 1 and 2.25-minute productions a total of 20 times in different conditions and days. The Chronbach's alpha calculated by treating these repeated productions as scale items was 0.945. Therefore, repeated measures detect changes in θ resulting from the experimental manipulation better than a single measure because the effects of mild manipulations of experience might be too subtle to detect with the large variance among individuals in a single measure.

<u>Prospective Time Estimation.</u> (47-second time estimate, 18-second time estimate). Verbal time estimation is another commonly used method for measuring perceived duration. The participant provides a verbal estimate of the length of the stimulus duration in seconds. The estimate period in this research was chosen as 47 seconds to be

comparable with previous research (e.g., Yatko, 2001). The 18-second interval was chosen to include a shorter interval for comparison. Again, the stimulus period is considered "empty time" because the participants are tasked with no other demands during the period. The procedure is prospective because participants know in advance to attend to the time period because they are estimating its duration. The following instructions were given:

> *"In a moment I will say, 'START,' and after a period of time I will say 'STOP.' When I say stop, please say how much time you feel went by from start to stop. Try not to count, just say in a loud, clear voice how much time it felt like in seconds. Ready. Start. (47s or 18s) Stop. Now say how long in seconds it felt like from start to stop."*

The participants were asked to estimate each interval before and after the experimental procedure. The estimate was converted to θ for analysis (estimate in seconds divided by 47 seconds or 18 seconds). Similar to time production, time estimation often has high inter-subject variability. For example, standard deviations of the θ's in the three studies described by Yatko (2001) ranged from 0.48 to 0.68. However, the estimates show high within-subject consistency over time. For example, θ's of two different intervals (87s and 42 s) separated by approximately half an hour had a correlation of 0.73 and repeated-measures t-test indicating no significant differences between the two estimates p=0.75 (Yatko, 2001). Because of the variability from person to person and to have information about the change of individual experience, repeated time estimation measures were used to assess effects of the experimental manipulation.

Retrospective Time Estimations. (16-minute and 6-minute retrospective verbal time estimation). Retrospective time estimation consists of asking a participant either immediately or after some delay to estimate the duration of a completed event. The participant does not know in advance that an estimate will be required. Retrospective time estimation is believed to be a function of memory processes (Ornstein, 1969) as compared to prospective methods that have been more closely linked to attention (Block & Zakay, 1997). Participants were asked on two items of a questionnaire to estimate the time in minutes spent in the experimental manipulation (i.e., listening to the relaxation tape, preparing and giving speeches, or listening to the control tape) and the time spent wearing headphones for a measure that is part of another study. In each case the actual clock intervals were 16 minutes and 6 minutes, respectively. Measures of retrospective time estimation were included to assess the effect of stress and relaxation on remembered time.

Visual Analogue Time Rate (PR). This measure was designed for this study to obtain a measure of perceived rate (PR, how quickly or slowly time passes during a specific time point). The scale was a refinement of a a Likert-scale item measure used in previous research that asked how quickly or slowly “time passes usually” (Yatko 2001). The visual analogue format allows a greater range of responses and sensitivity to change and the instructions were reworded to measure PR for usual experience but also during portions of the laboratory experience. Participants were asked to indicate on two 10 cm lines from “Extremely Slowly” to “Extremely Quickly” how time passed *during the experimental manipulation* (i.e., listening to the relaxation tape, preparing and giving speeches, or listening to the control tape) and how time is passing *right now*.

Attention Measures

Cognitive models of time perception hypothesize that prospective judgment of duration depends on attention (Block, 1996). Several measures of attention were included in this study to determine if the experimental manipulation altered attention.

Acute Domain Attention. This measure was adapted for this study from an item on the Perception of Time and the Senses Survey (Yatko, 2001) and asks participants to indicate the proportion of their time during the experimental manipulation that they spent thinking about the past, the present, and the future (so that the total percentage of time adds to 100). Participants answered the question at the beginning of the study for their usual distribution of attention and immediately after the experimental phase for their distribution during the experimental phase. Domain attention measures the distribution of attention to aspects of time and is not a measure of overall attention. In survey research, people reported that the way their attention is distributed among past, present, and future changes during stress. This measure was included to test whether or not distribution of attention in time shifts during mild experimental manipulations of experience.

Nonverbal Cancellation Task. (NVCT; Mesulam, 1985). NVCT is a symbol cancellation task that was used as a behavioral measure of attention. The NVCT is a paper-and-pencil instrument consisting of standard size pages with 374 symbols arranged in rows. Participants were administered one half of the page before and one half of the page after the experimental manipulation. The target symbols were identical in placement on each of the half pages but the distracter symbols were in different positions. Participants were instructed to circle all of the target symbols on the page as quickly and accurately as possible. Similar tasks have been used to measure attention in previous work on stress and relaxation and were sensitive to manipulations of these states (e.g., Scheufele, 2000). Errors of omission (failing to circle a target symbol), errors of commission (circling a non-target symbol), and completion time were measured. This brief performance task was used to detect any marked changes in attentional resources over the course of the study that might partially mediate changes in time perception.

Incidental Awareness of Beeping Noises. Three soft electronic beeping sounds were randomly presented in the background during the experimental phase. At the end of the session, participants were asked whether or not they noticed any beeping sounds and, if so, how many. This procedure was included as a simple measure of awareness of external environment during the experimental phase experience and incidental memory for the stimuli.

Procedures

The sequence of activities is provided below in Table 2.

Table 2. Study Timeline.

Activity	**Time Perception Measures**	**Physiological Measures**	**Time (min)**
Introductory Dialogue			5
Informed Consent / Remove Watches Rinse/ Attach Equipment			10
Questionnaire 1	Temporal Perspective VAS Rate		10-20
Saliva Sample 1 and Rinse	Comparison Rating Period	Blood Pressure Baseline 1	3
Time Baseline Set 1	Production 60s Production 135s Estimation 47s	Heart Rate Baseline 1	4-7
NVCT Baseline			1-2
Acoustic Startle (Wearing Headphone) (6 min)	Retrospective Estimation Period		6
Saliva 2	Comparison Period	Blood Pressure Baseline 2	3
Time Baseline Set 2	Production 60s Estimation 18s	Heart Rate Baseline 2	3
Experimental Phase Relaxation Tape / Control Tape and Questions / Speech Preparation and Speech	Retrospective Estimation Period	Heart Rate Experimental	16
Rinse / Questionnaire 2	VAS Rate Retrospective Est.		2
Time Post Set 1 1 min production 2.25 min prod 47 s estimate	Production 60s Production 135s Estimation 47s	Heart Rate Post 1	4-7
Saliva 3 / Rinse	Comparison Period	Blood Pressure Post 1	3
NVCT Post			1-2
Acoustic Startle (Wearing Headphone) (6 min)			6
Time Post Set 2	Production 60s Estimation 18s	Heart Rate Post 2	3
Questionnaire 3			3-10
Saliva 4 Saliva for Estradiol (Women)		Blood Pressure Post 2	5
Sensory Measures			5
Debrief			5-15

(Total time in all: 90-120 min)			

Introduction

Upon arrival, participants were greeted at the building entrance, thanked for coming, given an opportunity to use the restroom, and taken to the experimental area. Each participant then was given the following introductory monologue.

"As we discussed on the phone, this is a study of perception and physiology during different experiences. I will be asking you to fill out some questionnaires today and to listen to and follow some recorded instructions. I will be measuring your heart rate and blood pressure, and some muscle responses at various times during the study. Are you right handed or left handed? (Participant response). I will be attaching the

electrodes to each wrist, your right ankle, your neck and your right/left (non-dominant) forearm and fingertips. I will be asking you for some saliva samples. This is used to measure cortisol, a chemical in your body that varies with different psychological states and stresses. For women, the final saliva samples will be used to measure estradiol, a chemical that fluctuates at different times. The session is videotaped. This is primarily for quality assurance of the study and also to record some of your non-written responses."

Phase I

Informed consent. Participants were provided with a consent document to review. The experimenter reviewed the consent document using the script in Appendix E and gave participants the opportunity to ask questions. Participants signed in the presence of a witness that they agreed to participate in the study. They were then instructed:

> "*Before I attach the physiological equipment, I will ask that you remove any watches, pagers, or cell phones.*"

Any phones were turned off and the items were placed in a covered cardboard box. The consent forms were placed with the box, and the box was placed in the corner of the room on the floor. Locations for electrode placement were wiped with sterile alcohol wipes. The blood pressure cuff was placed on the non-dominant arm. Electrodes were applied to each wrist for electrocardiograph (ECG) leads and on the right lower leg just above the ankle for the ground lead. Electrode gel was applied to the electrodes for the electromyograph (EMG) leads and which were then applied at the location of the extensor muscle on the non-dominant forearm with one lead about 5 cm distal to the elbow and one lead 12-15 cm distal to the elbow and on the neck with one lead just below the ear behind the jawbone and one lead approximately 5 cm down the neck along the SCM muscle. Electrolytic gel was applied to the galvanic skin response (GSR) leads which then were attached to the index and middle fingertips of the non-dominant hand. The EMG and GSR measures were part of another study. Participants were instructed:

> *"The blood pressure cuff will inflate from time to time throughout the study. Just ignore it and continue with the directed task and try to keep your arm still if possible."*

Mouth rinse. At least 10 minutes prior to each of the saliva samplings, it was necessary for participants to rinse their mouths to reduce the amount of materials from the mouth in the saliva sample without diluting the actual sample (Klein, 2001, personal communication). A water bottle was placed on the participant's table. Participants were instructed:

"At this time, please rinse out your mouth with water from the sports bottle on the table and swallow."

Preliminary questionnaires. The participants then completed the first questionnaire packet which contained the Background Questionnaire, the Brief Time Survey, the Brief Symptom Inventory, the Perceived Stress Scale (10 item), and the Profile of Mood States. The experimenter handed the participant a folder containing the questionnaires and the following instructions were given:

"The blue folder contains a questionnaire packet that asks about some of your background and experiences. Please read the instructions on each page of the questionnaire carefully. You may use either pencil or pen provided on the table, whichever you prefer. For the multiple choice type questions, use an 'X' in the box to indicate your choice. When you finish place the packet back in the blue folder and wait for further instructions."

The experimenter collected the folder of questionnaires and started a blood pressure reading.

Saliva sample. Participants were given the following instructions:

"Now, I would like to collect the first saliva sample. You will be handed this cotton wad in the plastic tube. Do not touch the cotton with your hands. When you hear the direction 'start' just tip the tube (demonstrate) so that the cotton goes into your mouth and roll the cotton around on your tongue or chew it lightly until you hear the direction 'stop.' Try not let the cotton get down under your tongue or between your cheek and gum. It may be dry at first but it will moisten up as you go. Do you have any questions?

Ready, start."

During the 2 minute saliva collection time, the experimenter recorded the blood pressure reading and took two additional blood pressure readings at approximately 1-minute intervals.

"*Stop. Now spit the cotton into the larger collection tube."*

The cap was placed firmly on the collection tube and the saliva sample was placed in the ice bucket. Participants were instructed:

"*From here on, your instructions will be given by recording so it is just the same for each participant. Please do your best to follow all of the instructions carefully and I will remain in the room in case you need anything."*

Instructions were recorded in computer audio files. One of the laptop computers was connected to the speakers behind the participant. Where indicated, the pre-recorded instructions were played individually by opening the appropriate icon. The experimenter waited for the participant to follow the instruction before playing the next instruction.

<u>Mouth rinse</u>. Recording: "*Please rinse out your mouth with water from the bottle on the table and swallow."*

<u>Time production</u>. Recording: *"When I tell you to start, please let me know when you think that 1 <u>minute</u> has gone by. Try not to count. Just estimate when 1 <u>minute</u> has elapsed. When I say start, you will begin and you will say, 'stop' in a loud, clear voice when the time has passed. Ready. Start."*

The experimenter recorded the time when the recording played "start" and when the participant said "stop." The elapsed duration between start and stop was also timed later from the videotape in some instances.

Recording: *"Now, when I tell you to start, please let me know when* $2^{1}/_{4}$ *minutes have gone by. Try not to count. Just estimate when* $2^{1}/_{4}$ *minutes have elapsed. When I say start, you will begin and you will say, "stop" in a loud, clear voice when the time has passed. Ready. Start."*

The experimenter recorded the time when the recording played 'start' and when the participant said 'stop.' The elapsed duration between start and stop was also timed later from the videotape in some instances.

Time estimation. Recording: *"In a moment I will say, 'start' and after a period of time I will say 'stop.' When I say stop, please say how much time you feel went by from start to stop. Try not to count, just say in a loud, clear voice how much time it felt like in seconds. Ready. Start. (47s) Stop. Now say how long in seconds it felt like from start to stop."*

The experimenter recorded the estimate and then handed the participant the symbol sheet and an index card with the large handwritten target symbol.

Nonverbal Cancellation Test. Recording*: "This is the target symbol (show card with symbol). When I tell you to start, I want you to circle all of the target symbols on this page as quickly and as accurately as you can. When you finish, turn your paper over and say, 'done.' Ready. Start."*

Acoustic Startle. Experimenter, *"I am going to place a pair of headphones on you. You will hear a series of loud and abrupt bursts of static through the headphones. The sound has been tested and will not affect your hearing but if at any time you find it painful, then please tell me right away. Otherwise, I ask that you sit still and quiet while you are listening to the sounds."*

The experimenter placed the headphones on the participant and adjusted them for fit as appropriate. After the 6-minute series of sounds the experimenter said, "*I will remove the headphones now,"* and removed the headphones.

Saliva Sample: Experimenter, *"Please collect a saliva sample the same way you did before.* (Participant was handed the tube containing the cotton wad). *Ready, start."*

During the 2 minute saliva collection time, the experimenter recorded the blood pressure reading and took two additional blood pressure readings at approximately 1-minute intervals.

"*Stop. Now spit the cotton into the larger collection tube."*

Cap was placed firmly on the collection tube and the sample was placed in the ice bucket.

Time production. Recording: "*When I tell you to start, please let me know when you think that one minute has gone by. Try not to count. Just estimate when one minute has elapsed. When I say start, you will begin and you will say, "stop" in a loud, clear voice when the time has passed. Ready. Start."*

Time estimation. Recording: "*In a moment I will say, 'start' and after a period of time I will say 'stop.' When I say stop, please say how much time you feel went by from start to stop. Try not to count, just say in a loud, clear voice how much time it felt like in seconds. Ready. Start.* (18s) *Stop. Now say how long in seconds it felt like from start to stop."*

Phase II

Recording: "Phase two of this experiment will begin shortly. Continue to follow the instructions on the tape."

Relaxation Condition. Relaxation tape (16 minutes). A transcript of the tape is included in Appendix I.

Control Condition. "*You will hear a taped passage from a biography of a famous person. After the passage you will be asked a few questions about the passage and what you thought of it*."

Adams biography passage. (15.5 minutes)

"Now please answer these questions in a loud, clear voice."

"Who was the passage about?"

"On a scale of 1 to 10, with 1 being disliking it very much and 10 being liking it very much, how would you rate this passage?"

"On a scale of 1 to 10, with 1 being very boring and 10 being extremely interesting, how would you rate this passage?"

Stress Condition. "*You are now to prepare a speech concerning your personal faults or undesirable habits; those aspects of your behavior or personality with which you are not happy. Please do not divulge information on any illegal activities. The speech will be video-taped, and will be evaluated by a panel of psychologists for the quality of the speech, the style of presentation, and the content of the speech. Try to make the speech as organized as possible because the quality, content, and style will be evaluated. Begin preparing your speech now. Do not begin giving your speech until instructed to do so* (4 minutes)."

"*Ok, your planning time is over and it is time to begin. Remember to speak for the entire time until I say stop, continuing to speak to the psychologists* *watching the video tape. Remain seated and look toward the video-camera. Start speaking now (4 minutes). STOP speaking now."*

"We would like you to give another speech. Again the speech will be video-taped, and a panel of psychologists will listen to what you say in your speech, and how <u>*well*</u> *you say it. I'm going to read you a hypothetical situation where you're accused of shoplifting, Then I'll ask you to prepare and deliver a speech in defense of yourself as if you were appearing before a judge. After I describe the situation to you, you will have some time to plan your story. Do not begin giving your speech until instructed to do so. You must speak for the entire time allowed until I say, 'stop.'"*

"You are shopping in a department store and you pick up a pair of sunglasses to look at them. All of a sudden you feel a hand grab you on the shoulder, turn you around, and a voice say, 'Okay, I saw you steal those sunglasses.' You then realize that you are being accused by a department store security guard of stealing store merchandise which, of course, you didn't do. You are brought back to the department store security office where you are formally charged with shoplifting. Your attempts to explain the situation are ignored. Describe what you will say to the judge in your own defense and include the following:

1. *What you think should happen to the security guard for his error.*
2. *What you think should happen to the department store for hiring the security guard.*
3. *How you should be compensated."*

"There is a sheet of paper on the table with these points listed on it. You'll need to speak for the full time until you are directed to STOP. If you run out of things to say, then repeat the points you made. Begin preparation now (2 minutes)."

"*Ok, your planning time is over and it is time to begin. Remember to speak for the entire time, continuing to talk to the psychologists watching the video-tape as if we were the store manager and security personnel. Start speaking now* (2.5 minutes). *Stop speaking now*."

<u>Phase III</u>

<u>Mouth rinse</u>. The participants rinsed their mouths.

<u>Self-report measures</u>. Participants completed a series of self-report measures (VAS stress, VAS rate, Retrospective Time Estimation, Domain Attention).

<u>Time production</u>. Participants produced 1 minute and 2.25 minutes using the same procedure and recorded instructions as previously described.

<u>Time estimation</u>. Participants estimated a 47-second interval using the same procedure and recorded instructions as previously described.

<u>Saliva sample</u>. Participants provided the third saliva sample using the same procedure and instructions as previously described.

<u>Mouth rinse</u>. Participants rinsed their mouths out.

<u>Nonverbal Cancellation Task</u>. Participants completed the second half-page of the task following the recording instructions previously described.

<u>Acoustic Startle</u>. Participants listen to a series of abrupt noise bursts on a headphone while EMG reflexes were measured.

Time production. Participants produced 1 minute following recorded instructions described previously.

Time estimation. Participants estimated an 18-second interval following the previously described recorded instructions.

Final questionnaire. Participants completed a second Profile of Mood States short form and the Debrief Questionnaire.

Saliva sample. The fourth saliva sample was collected using the same procedure and description as previously described.

> (For women only). "The final saliva sample is collected differently because it is for measuring estrogen. It works best if you just build up saliva in your mouth for a while and, when you feel the need to swallow, just let the saliva run through the straw right into the collection tube. This often takes a while and several rounds until the tube is filled up to the line. While you are collecting the sample, I will be disconnecting the physiological equipment."

Sensory ratings. Subjects were asked to touch six different materials (satin, polished stone, cotton, sponge, concrete, burlap). Each material was presented in a small box. Subjects rated each texture on two scales: Rough (1) to Smooth (7) and Pleasant (1) to Unpleasant (7). Subjects were asked to smell six different materials (rose oil, vanilla extract, fish oil, white vinegar, water, dry rice). Each material was presented in a small vial. Subjects rated each odor on two scales: Odorless (1) to Strong Odor (7) and Pleasant (1) to Unpleasant (7). This measure was a pilot for other research.

Debrief

The debrief monologue followed a basic format. The experimenter paraphrased the debrief information for each individual subject. The following is the basic information included in the debriefing:

> We appreciate the time that you have taken to participate in our study. We will take your responses, along with about 100 other people, to better understand people's perceptions and physiological reactions in different experiences of everyday life. There are different groups with different lab experiences.
>
> **Relaxation**: The group you were in was designed to determine how relaxation affects perception and particularly how you perceive time.
>
> **Control**: The group you were in was designed to see how paying attention to something neutral affects perception and particularly how you perceive time.
>
> **Stress**: The group you were in was designed to see how the stress response affects perception and particularly how you perceive time. For that reason, you were asked to speak before the camera because most people find this stressful. No panel of psychologists will rate your speeches. The tape will be used to time your responses and to make sure the experiment was conducted the same way each time. I apologize if this caused you any discomfort.
>
> Now that you are finished with these questionnaires, I'll be happy to answer any questions you have regarding the study or hear any comments you have about the study experience. (Questions were answered.)

Debrief Psychopathology Assessment and Referral

During the session the experimenter reviewed the BSI, POMS, and PSS. Any participant indicating recent thoughts of suicide on the BSI or any participant that showed high endorsement of many of the symptoms on the BSI along with a pattern of distress on the PSS and POMS were further assessed, counseled, and provided with appropriate referrals during debrief (see Appendix I).

After answering any questions, the examiner gave participants their checks or told them to expect the check by mail and returned participants' belongings. Participants were then escorted to the exit.

Data Analytic Strategy

The experiment used a repeated-measures between-subjects design to examine the effects of a stress condition, a relaxation condition, and a control condition on perceived duration and perceived rate of time passage of healthy, adult men and women. Measures of physiology, biochemistry, and self-report were collected to verify the independent variable of psychobiological state. Additionally, scales of trait time-perception were administered at baseline. Self-reported interest and focus along with a performance task of attention were also given before and after experimental manipulation. Several different statistical techniques were employed to measure the relationships among the variables including Analysis of Variance, Multiple Analysis of Variance, Repeated-Measures Analysis of Variance (using Covariates as appropriate), Non-Parametric tests, and Correlations. Non-Parametric analysis using Kruskal-Wallis tests were performed on the demographic and background variables to evaluate comparability of groups across condition. Conceptually unique variables compared across a single sampling point were tested for differences across conditions using Analysis of Variance with the Bonferroni correction procedure to guard against Type I error when several variables were tested at one time. Planned comparisons were conducted using t-tests. Where indicated, Post-Hoc testing used the Tukey's Honestly Significant Differences Test. All tests were two tailed with an alpha of 0.05.

Calculation of data skew and kurtosis statistics for parametric variables and scatter plots were used to determine if outliers existed. All duration perception measures were converted to θ ratios (subjective / objective time). A transformation of the θ ratios was done to enable equivalent values for inverse ratios. For example a 30 second objective production of a subjective minute has a $\theta = 60/30 = 2$ and a 120 second objective production of a subjective minute has a $\theta = 60/120 = 0.5$. Using the θ ratio, the 120 second estimate appears more accurate (closer to 1) but in actuality each of the productions is proportionally equal distance (but opposite in direction) from $\theta = 1$. By taking the logarithm of the θ, the θ of 2 becomes 0.301 and the θ of 0.5 becomes -0.301 and the proportionate distances of interest are represented equivalently. After making this transformation, any values more than three standard deviations from the mean were excluded. The conservative exclusion criterion of three standard deviations was used for the dependent variables and psychobiological state index variables. Using this criterion, no more than three data points were excluded for any measure. There were three participants who did not understand the directions for completing the Visual Analogue Scales and marked all ten scales at the very beginning or end of each line as if it were a forced choice. These responses were not included in the analyses of the Visual Analogue Scales. Using these procedures, no other data were excluded from analysis.

Retrospective time estimates, Perception of Time and the Senses Subscales, Visual Analogues Scales of Boredom-Interest and Distraction-Focus, Age, and Baseline Non-Verbal Cancellation Task indices were tested using ANOVA's. Multiple Analysis of Variance was used to compare sets of conceptually-related variables across a single sampling point. The MANOVA test was used for baseline physiological measures (heart rates, systolic blood pressure, diastolic blood pressure), for self-reported stress-related measures (PSS, POMS Tension Scale, BSI, VAS Relaxed-Tense, and VAS Calm-Anxious), and for initial prospective duration perception ratios (Minute Production, 2.25 Minute Production, 47 Second Time Estimation). Repeated-measures Analysis of Variance was used to test for changes in repeated measures from before to after experimental manipulation on the repeated variables of heart rate, blood pressure, duration perception ratio (θ) for one-minute productions, and salivary cortisol concentration, covarying for the initial sampling point value in each instance. Although there were no hypotheses concerning gender or age differences, analyses were conducted to evaluate the contributions of these demographic factors to the variables.

For hypothesis testing, planned comparisons were conducted between measures of θ pre and post in the stress condition, θ pre and post in the relaxation condition, interaction of time and relaxation compared to time and control, and interaction between time and stress compared to time and control. A curve estimation Regression Analysis was conducted with Perceived Stress Scale scores entered as a dependent variable and the Visual Analogue Scale for Usual Time Rate (PR-usual) entered as the independent variable in a regression analysis to test the hypothesized fit to a quadratic function. Correlations were calculated between trait time perception and psychological self-report measures to compare findings with previous research.

RESULTS

Study results are organized beginning with characteristics of the study sample including description of who was measured and how groups compared at the start of the experiment. Next, results are presented for the measures that were included in the study to evaluate the experimental conditions' effectiveness in altering experiences of stress and relaxation. These independent variable check-measures include self-report measures, physiological measures, and salivary cortisol. The results of the dependent variable time perception measures are then presented followed by results for related dependent measures. Analyses of the relationships among the various time perception and self-report measures are then presented. Finally, the results are reviewed relative to the experimental hypotheses.

Sample Characteristics and Baseline Measures

Demographics

Appendix K presents tables of demographic information for each experimental group along with means and data analyses. Tests revealed no differences among groups in any of the measured demographic variables or in tobacco use, number of caffeinated beverages consumed per day, or (for women) use of oral contraceptives.

Baseline Self-Report Measures Related To Stress

Table L-1 in Appendix L presents the means and results from multivariate data analyses for the self-report measures related to stress administered during the baseline period. Although the various self-report inventories measure somewhat different constructs (e.g., immediate mood, perceived stress over the past month, extent to which the subject is bothered by mental and physical symptoms related to stress), they all tap the underlying construct of baseline stress experience as conceptualized in this research. The Perceived Stress Scale (PSS) measures perceived stress during the past month. The Brief Symptom Inventory asks how much participants have been bothered by emotional and physical symptoms of psychological distress during the past two weeks. The Profile of Mood States Short Form (POMS-SF) Tension Subscale requires participants to rate how much each tension-related adjective describes them at that moment. The Visual Analogue Scales of Relaxation-Tension and Calm-Anxious are 100 mm lines on which participants place a mark to indicate how they feel on the descriptor-continuum at the moment. There was no difference among groups at baseline for any of these measures.

Baseline Measures of Temporal Perspective

Various aspects of temporal perspective, which encompasses trait-like attitudes and thoughts toward the past, present, and future, were measured at baseline in the Perception of Time Survey Short Form. Table K-8 in Appendix K presents group means for the different temporal perspective scales and results from the data analyses. No differences were found across groups on the measures of how participants feel about their present or their future, on temporal extension, on stress extension, or on percentage of thought usually directed to the present and past. Significant differences were evident on the percentage of thought usually directed to the future ($F(2,113) = 3.60$, $p<.05$) and participants' feelings about their past ($F(2,113) = 3.76$, $p<.05$). Post hoc analyses revealed that the Relaxation group reported thinking about the future a larger percentage of time than did the Stress group ($p<.05$). The Relaxation group reported feeling better about the past than did the Control group ($p<.05$). Because there were baseline differences in attention to the past among groups, differences in domain attention during the experimental manipulation were assessed as change scores from baseline scores.

Independent Variable Effectiveness Measures

Self-report scales, heart rate, blood pressure, and salivary cortisol levels were measured in the experiment to evaluate the subjective, physiological, and chemical aspects of the experimental experience. These data are used to assess the effectiveness of the experimental manipulations to induce the experiences of stress and relaxation.

Self-Report Scales

Visual Analogue Scales. Visual-Analogue Scales of self-reported state were completed at the beginning of the laboratory session and immediately following the experimental manipulation phase (e.g., relaxation tape, control tape, or speech). Figure 3 presents results for the Relaxed-Tense scale and figure 4 presents results for the Calm-Anxious scale. As expected, participants in the stress condition experienced increased tension and anxiety. Participants in the control condition and, even more so, the relaxation condition experienced increased relaxation and calm as reported on the visual analogue scales. There were no *a priori* hypotheses of differences between genders and among ages in experience of stress or relaxation, but statistical analyses revealed differences in tension among ages from baseline with the oldest third of participants reporting less tension. Analyses also revealed differences between genders in response to the stress condition with women reporting greater increases in tension than did men.

Repeated-measures Analysis of Variance revealed differences among experimental conditions for the Relaxed-Tense ($F(2,92) = 25.61$, $p<.01$) and Calm-Anxious ($F(2, 92) = 18.82$, $p<.01$) scales over time. Post hoc tests revealed that the stress

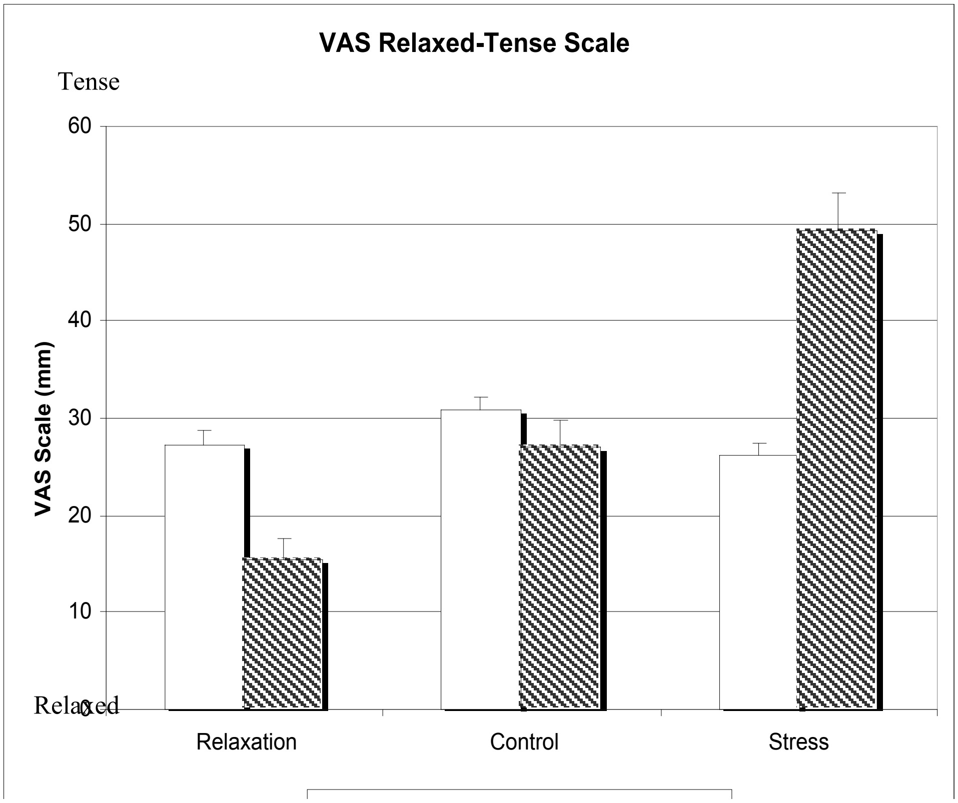

Figure 3: VAS Relaxed-Tense Scale

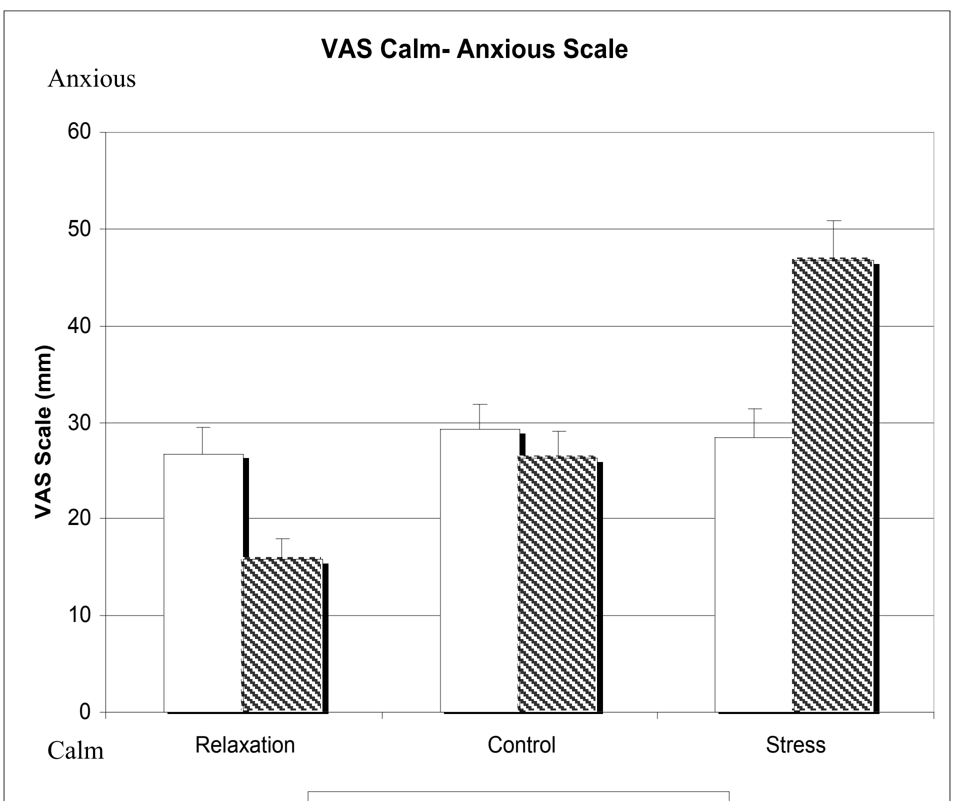

Figure 4: VAS Calm-Anxious Scale

condition was higher than control or relaxation (see Table L-2 in Appendix L for means and analyses). T-tests for repeated measures in each condition revealed that both values decreased after the relaxation manipulation ($t(34) = 4.10$, $p<.001$; $t(34) = 3.86$, $p<.01$ for Relaxed-Tense and Calm Anxious respectively) and increased after the stress manipulation ($t(34) = -5.77$, $p<.01$; $t(34) = -4.44$, $p<.01$ for Relaxed-Tense and Calm Anxious, respectively), remaining the same in the control condition. There were between age-group differences for the Relaxed-Tense scale with the oldest group reporting lower tension at all time points ($F(2,110) = 4.95$, $p<.01$). There was an interaction of the experimental condition effect with gender for the Relaxed-Tense scale ($F(2,94) = 3.76$, $p<.05$) with women exhibiting greater rises of self-report of tension in the stress condition than did men. Age and gender effects were not observed for the Calm-Anxious scale. Basically, as reported on these scales, the experimental manipulations altered subjective experiences in the intended ways.

<u>POMS-SF</u>. Four subscales from the Profile of Mood States Short Form (POMS-SF) were administered at the beginning of the laboratory session and at the end of the laboratory session. Figure 5 presents the results of the POMS-SF Tension Subscale for each experimental condition at each measuring point. Tables L-3 to L-7 in Appendix L present the means and results of analyses for the POMS-SF subscales. Repeated-measures Analysis of Variance revealed an interaction between conditions with time ($F(2,94) = 6.30$, $p<.01$). Post hoc tests revealed that the stress condition participants reported significantly more tension following the experimental manipulation than did the relaxation condition participants ($p<.05$). The oldest age-group endorsed fewer tension related adjectives on both measures ($F(2,110)=9.11$,

p<.001). There were decreases in the scores for the subscales of depression and vigor over time (F(1,96)=8.25, p<.05 and F(1,96)=22.23, p<.001, respectively) with no differences between conditions for vigor. The decreases in depression were seen in the control and relaxation conditions without change in the stress condition. The confusion subscale did not reveal changes. In general, the experimental manipulations differentially affected mood experience of tension but not vigor, or confusion, so the experimental conditions had the intended effects without unintended side-effects.

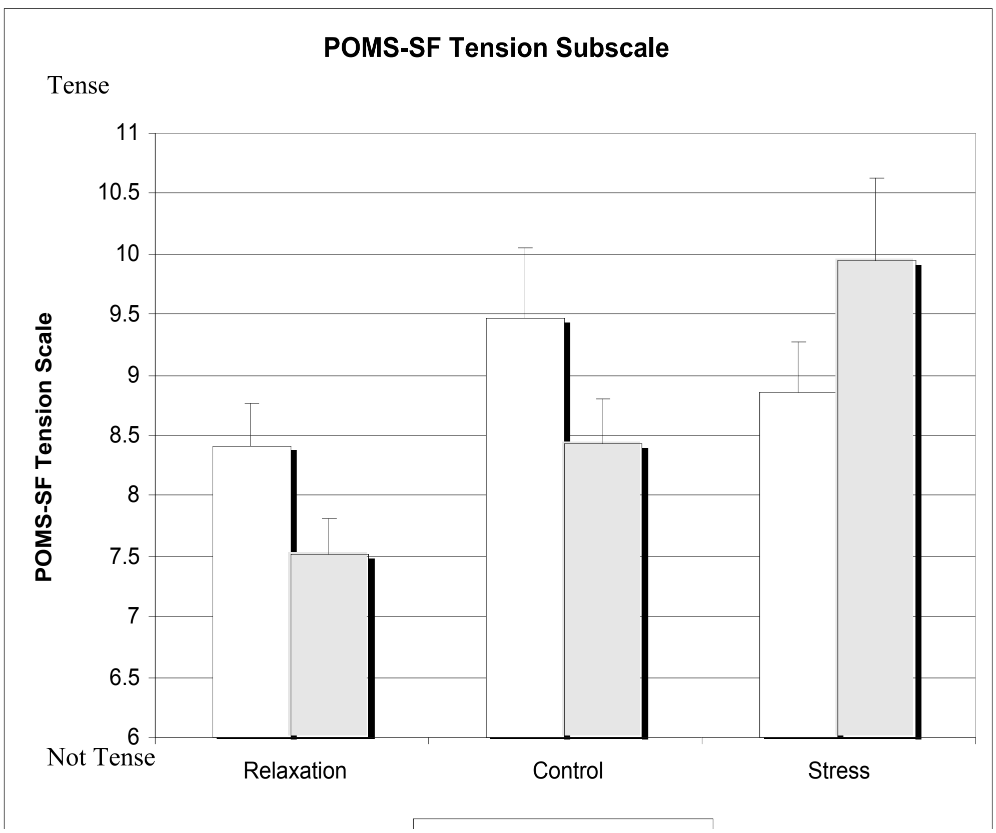

Figure 5: Profile of Mood States- Short Form Tensions Subscale by Condition

<u>Physiological and Biochemical Measures</u>

<u>Heart Rate</u>. Electrocardiograph (ECG) measures were taken continuously during the experiment. From the ECG measure, average heart rate for each of five measurement

periods was calculated. Measurement periods were: 1) during the first set of baseline prospective time perception measures, 2) during the second set of baseline prospective time measures, 3) during the experimental manipulation phase, 4) during the first set of post-manipulation prospective time measures, and 5) during the second set of post-manipulation prospective time measures. Figure 6 displays the average heart rate for each experimental condition. An arrow indicates when the experimental manipulation took place. Tables M-6 and M-7 in Appendix M present means and results of analyses for the heart rate data. Repeated-measures analyses of variance using the first baseline measure as a covariate revealed differences among conditions (F(6,180) = 12.49, p<.01).

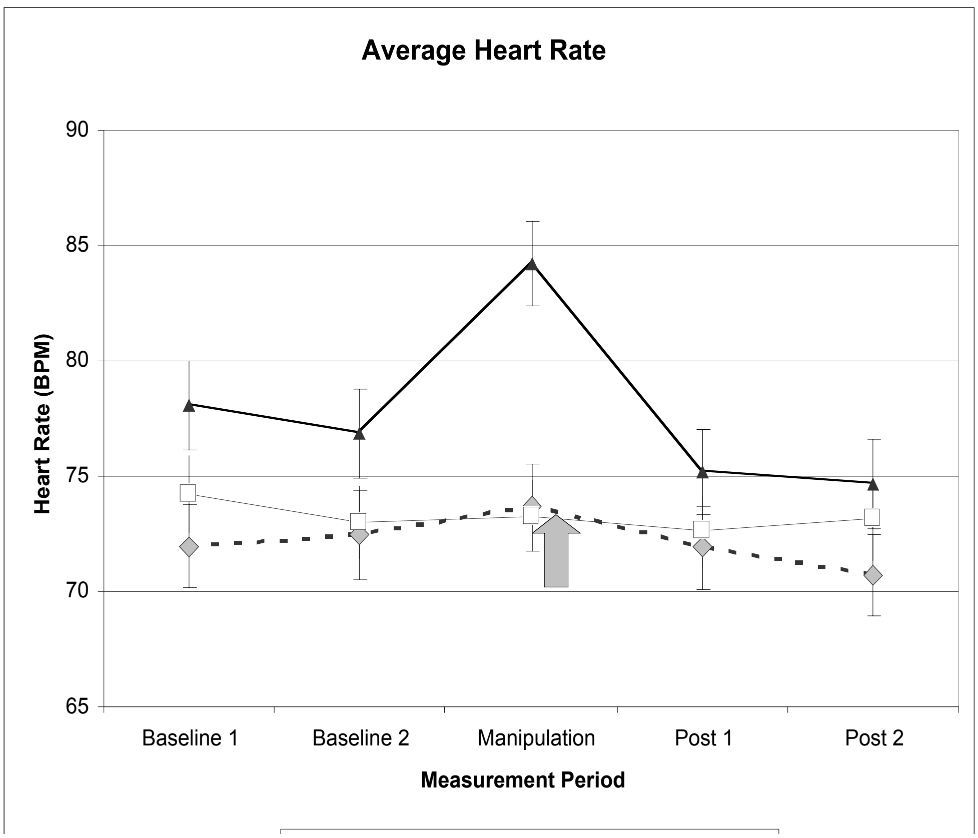

Figure 6: Average Heart Rate by Experimental Condition

Analyses of Variance for each measurement point indicated a significant difference among groups only during the experimental manipulation period (F(2,110) = 12.47, p<.01) when the heart rate for the stress condition was higher than the other groups rate (p<.01). Clearly, heart increased during the stress manipulation but returned to baseline levels or lower soon after the completion of the stress manipulation. Heart rate in the relaxation and control conditions did not change markedly over the course of the lab session. This pattern was found consistently across gender and age groupings. The heart rate results suggest that participants in the stress condition experienced increased autonomic arousal consistent with the experience of stress during the experimental condition.

Blood Pressure. Blood pressure was measured during four periods in the experiment coincident with collection of saliva samples at the following times: 1) immediately before first baseline time perception measures, 2) immediately before second baseline time perception measures, 3) after the first post-manipulation time perception measures, and 4) at the end of the session. At each sampling period, three measures of blood pressure were obtained. No measure was taken during the experimental manipulation to avoid possible distraction or time cues introduced by the inflating cuff. Figures 7 and 8 display the average systolic and diastolic blood pressure by condition for each sampling period. Arrows indicate when the experimental manipulation occurred. Tables M-8 and M-9 in Appendix M show the means and statistical tests for blood pressure. Repeated-measures Analysis of Variance revealed no significant difference among conditions for systolic or diastolic blood pressure. Although changes in blood pressure were expected during experiences of stress and relaxation, if the blood pressure changes were as brief-lived as were the heart-rate changes, then they would not have been revealed by the measures before and after the experimental phase.

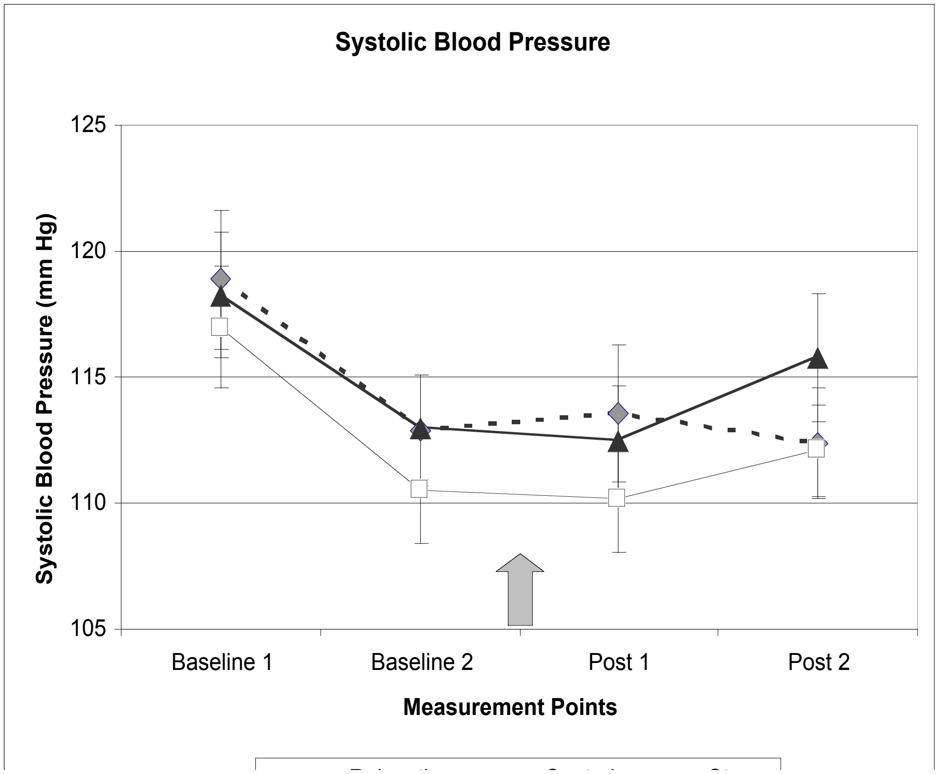

Figure 7: Average Systolic Blood Pressure by Condition

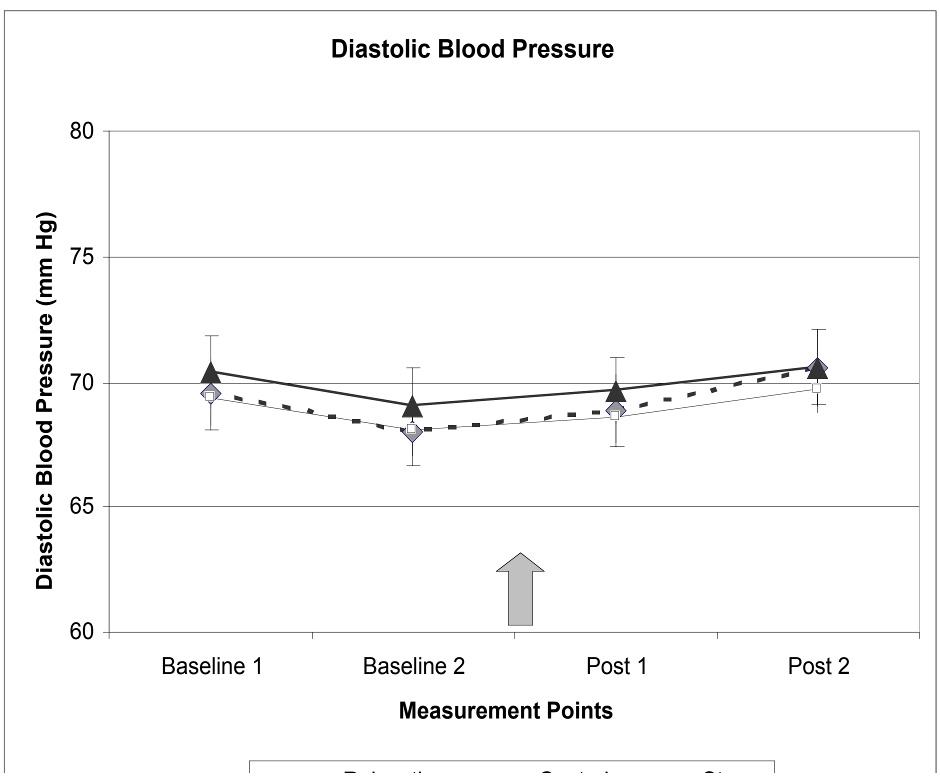

Figure 8: Average Diastolic Blood Pressure by Condition

Salivary Cortisol. Cortisol is an indicator of Hypothalamic-Pituitary-Adrenal Axis activity and generally follows a circadian rhythm which peaks in the early morning and declines in levels through the afternoon in the absence of an acute response to experience. Figure 9 displays the weighted mean values of the salivary cortisol concentration at each measurement point for women and men. Because there were between-groups differences for age ($F(2,17) = 5.93$, $p<.05$) and gender ($F(1,29) = 7.74$, $p<.01$), repeated-measures analysis was calculated for the cortisol concentration at measures 2, 3, and 4 (using measure 1 as a covariate) with gender and with three levels of age (18-27.4, 27.5-44.1, 44.2-80). The analysis revealed significant within-subjects effects for condition with time ($F(4,34) = 3.21$, $p<.05$) and for age with time ($F(4,34) = 3.05$, $p<.05$). Overall, cortisol concentration rose from before to after stress in men and women while decreasing over the same interval in the control condition. Interactions with gender were also observed with a trend of gender by condition with time ($F(4,34) = 2.50$, $p=.06$) and a significant effect of gender by age with time ($F(4,34) = 3.76$, $p<.05$). Cortisol concentration rose from before to after relaxation in men but decreased in women.

In summary, the experimental conditions did alter cortisol levels. On average for women and men, cortisol levels increased following the stress manipulation. A rise in cortisol is an indicator of hypothalamic-pituitary-adrenal axis activation in the experience of stress. The effects of relaxation depended on gender and age suggesting that individual experiences in the relaxation condition were more varied. In particular, cortisol rose in men following the relaxation exercise, perhaps due to a greater influence of the muscle tension as opposed to the relaxation portion of the exercise. The pattern of increase in cortisol following the stress manipulation lies in noteworthy contrast to the natural circadian rhythm for the afternoon reflected in the consistent decline in cortisol levels found across age and gender in the control condition.

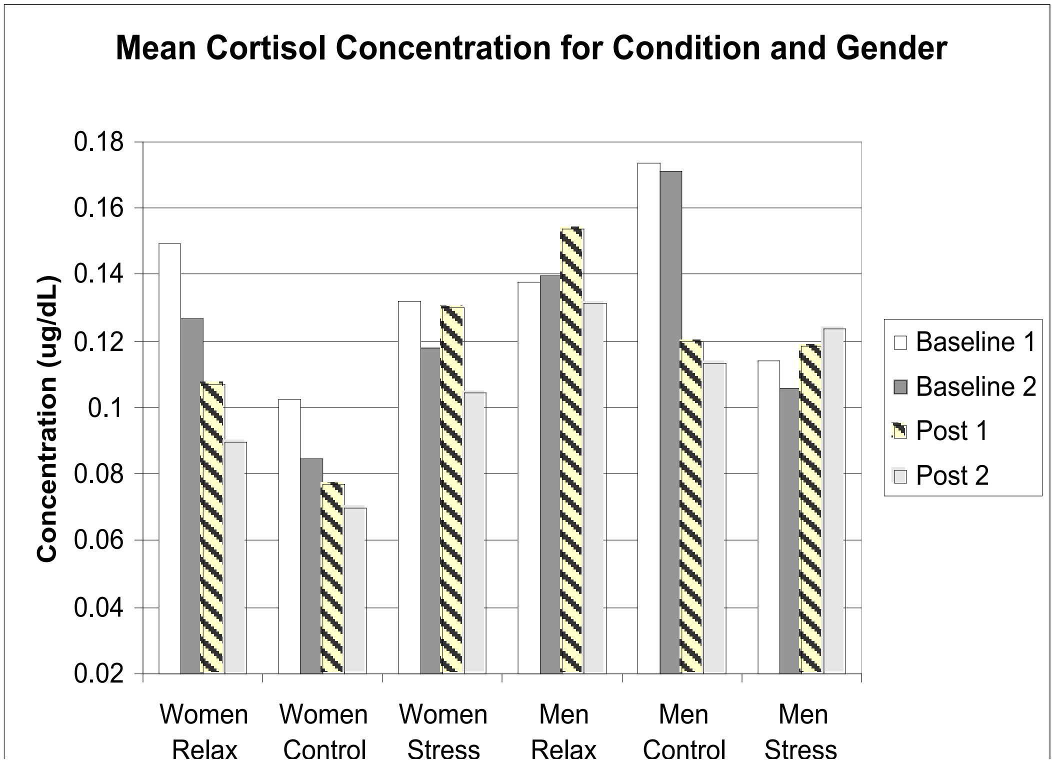

Figure 9: Weighted mean values of salivary cortisol concentration (Note: columns represent the weighted means of the cortisol levels taken at each baseline and at each measure post-manipulation. Each pooled value was weighted by the number of samples contributing to that pool. Standard error bars are not included because the bars are weighted means with some pools containing only one sample.)

<u>Time Perception</u>

Prospective duration perception (θ) and perceived rate (PR) were measured before and after the experimental manipulation. Retrospective duration perception (RT) was measured after the experimental manipulation.

<u>Prospective Duration Perception</u>.

Prospective duration perception was measured using the methods of production and verbal estimation. Two different duration periods were used for each method (1 minute and 2.25 minute for production, and 47 second and 18 second for estimation).

Two sets of prospective measures were conducted before the manipulation and two sets were collected afterwards. All measures were converted to the duration judgment ratio (subjective to objective time, θ). Log transformations were performed for each θ with subsequent removal of outliers that were more than three standard deviations from the mean resulting in the exclusion of between 0 and 3 cases per measure. Analyses and results reported are based on the final sets of values for log(θ). The data are described in terms of individual consistencies in θ, measurement method differences in θ and, finally, the effects of the experimental conditions on θ.

Individual consistency. Duration perception appears to be relatively consistent in individuals across the experiment. The correlations between each of the 10 different log(θ) were significant in each case ranging from $r(112) = +.31$ to +.78. Table N-10 in Appendix N presents the correlations among the log(θ). Taken together as a scale of an individual trait for θ, the internal reliability is $\alpha = .93$. The correlation among repeated θ across different methods and intervals suggests that individuals are relatively consistent in their perception of time. However, θ varies considerably from person to person. Part of the variance among individuals is accounted for by gender and age. Age is correlated with all of the 1-minute production log(θ) with $r(112) = +.25$ to +.39, accounting for between 6% and 10% of the variance in that measure. Women have significantly higher ratios than do men for all but one of the production measures, but there are no significant differences between men and women for estimation measures (see Table N-7 in Appendix N for results of t-tests between genders).

Measurement effects. All but large differences in the estimation measures tend to become overwhelmed by the "ballpark effect," or tendency for people to estimate time in rounded units. For example, over 20% of the participants estimated that the 47s interval was 60 seconds long and only 4% of people estimated values that were not a multiple of five. Figure 10 presents the mean values for log(θ) for men and women in each experimental condition. The first set of baseline duration perception measures differed significantly from all other sets of measures (t(108) = 4.15, p<.01; t(109) = 2.87, p<.01; t(108) = 4.52, p<.01 for baseline 1 compared to baseline 2, post 1, and post 2, respectively). The difference between the first set of measures and the others is assumed to be a novelty effect of the task, so the first set is treated as a practice trial.

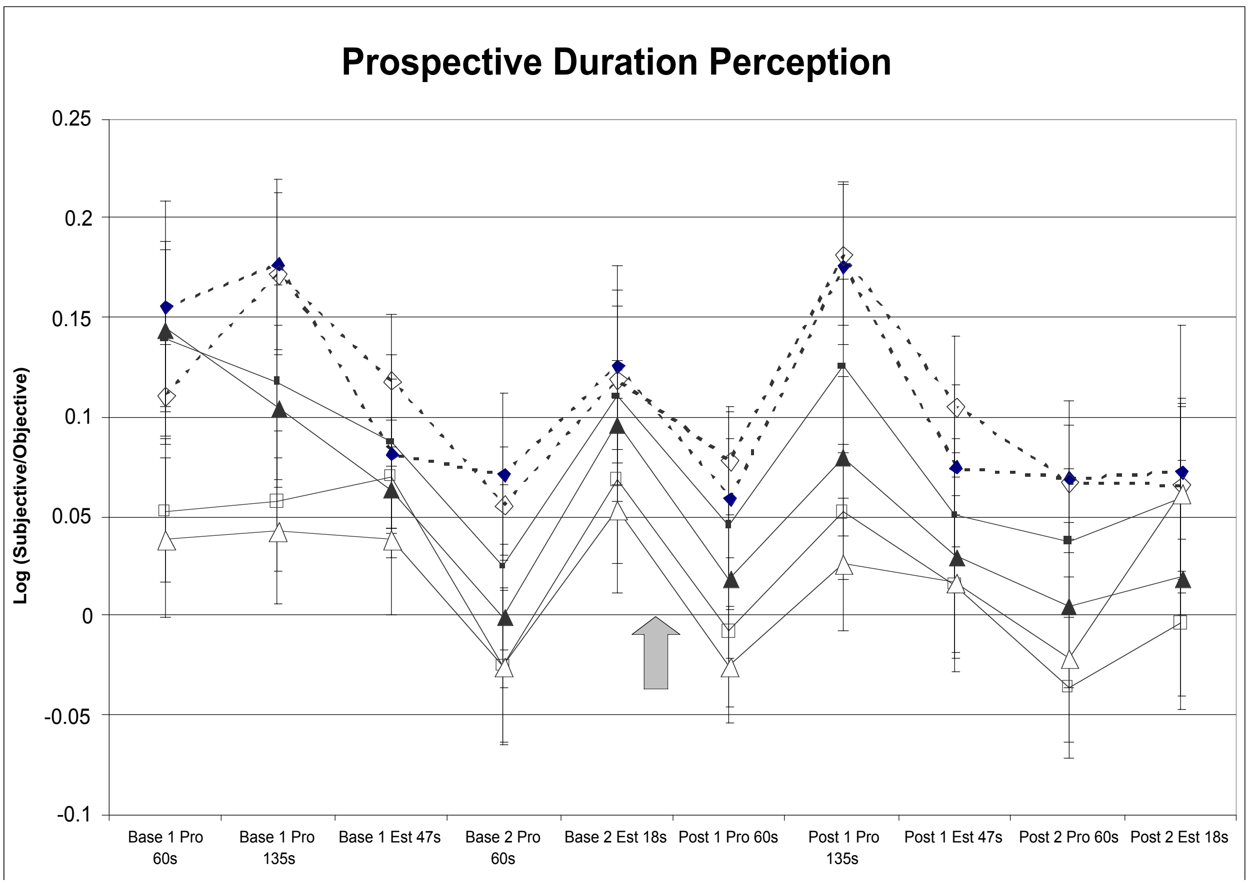

Figure 10: Mean values of log(θ) for men and women in each experimental condition.

Experimental condition effects. Condition effects on duration perception were analyzed two different ways. Because the only measure repeated in all four sets was the 1-minute production, the log(θ) for the minute productions were analyzed as repeated measures. In a separate analysis, the average log(θ) for each set was analyzed as a repeated measure. In each case, the first baseline value and age were used as covariates with condition and gender as between-groups factors. Repeated-measures analysis of the average log(θ) revealed a significant interaction of condition and gender with time ($F(4,188) = 2.98$, $p<.05$). For men, the relaxation group was significantly greater than the stress group in the measure set immediately after the experimental manipulation (post 1). Figure 11 presents the average duration perception ratios for women and men in each condition.

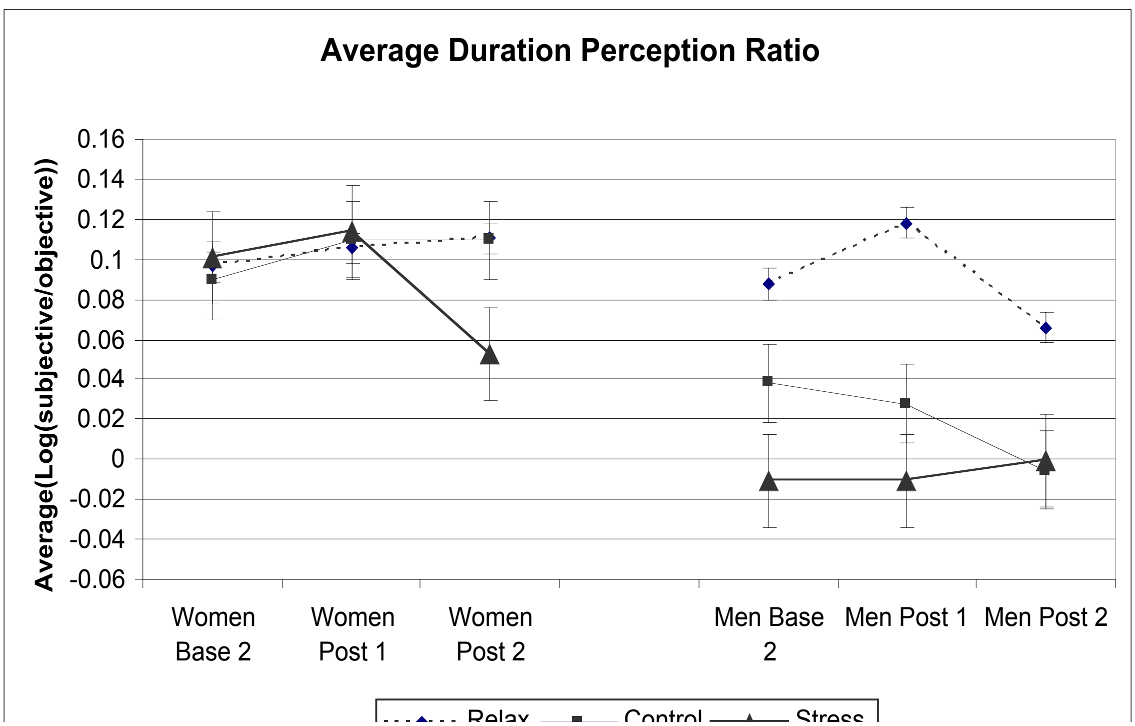

Figure 11: Average duration perception ratio for women and men in each condition. Measures were conducted during baseline, immediately after the experimental manipulation (Post 1) and approximately 15-20 minutes following the experimental manipulation (Post 2).

Repeated-measures analyses of the one-minute production ratios revealed no differences among conditions. The significant time by gender effect ($F(2,100) = 3.69$, $p<.05$) is presented in Figure 12 in the contrasting patterns between men and women in the relaxation and control conditions. In the stress condition, men and women had increases in θ from the second baseline measure to the first post-manipulation measure with a decrease again by the final measure. Planned comparisons for θ in the stress and relaxation conditions from before to after the experimental manipulation revealed a significant increase in the stress condition ($t(37) = -2.35$, $p<.05$) and no significant change in the relaxation condition ($t(34) = -.57$, $p=.57$).

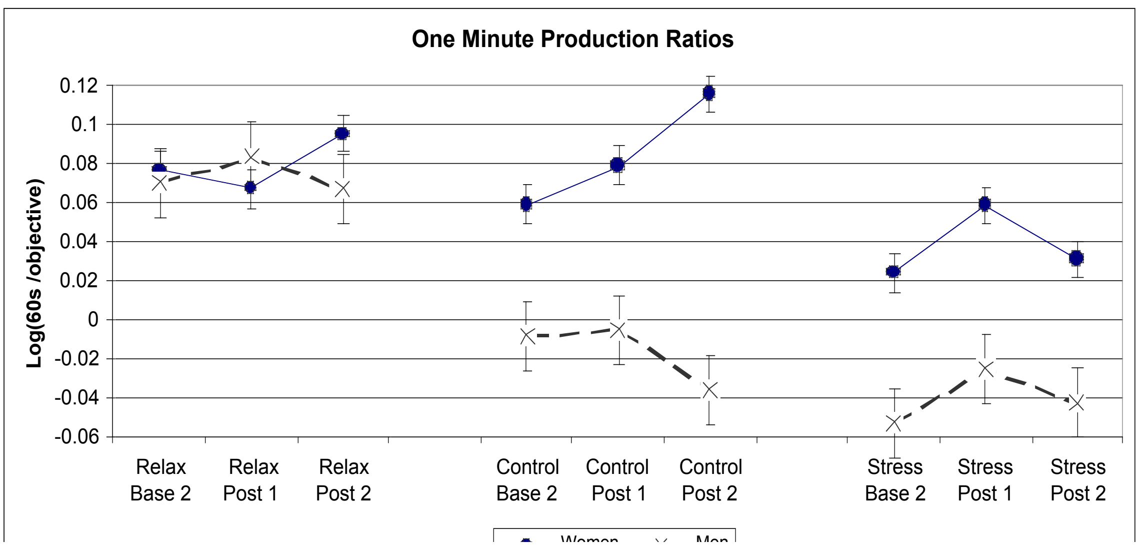

Figure 12: One minute production ratios for men and women by condition.

Perceived Rate of the Passage of Time (PR)

Participants completed two Visual Analogue Scales at the beginning of the experiment and two immediately after the experimental manipulation to indicate how quickly or slowly time usually passes, was passing at the beginning of the laboratory session, passed during the experimental phase, and was passing immediately after the experimental phase. Figure 13 displays the mean of the VAS scores for each of the four measures in the different experimental conditions. Participants indicated that time usually passes rather quickly (with an average mark at 66 mm on the scale and a standard deviation of 20.5 mm). Time passed more slowly during the laboratory session (mean of 53 mm, standard deviation 19 mm). During the experience of being in the laboratory, time passed more slowly than usual. The experiences of the relaxation and control conditions slowed PR even more (means of 44 mm during control and 40 mm during relaxation with standard deviations of 20 mm). Responses were more variable in the stress conditions with no overall change from baseline (mean of 52 mm and a standard deviation of 28 mm). Participants indicated that time seemed to pass more quickly after than during the experimental manipulation.

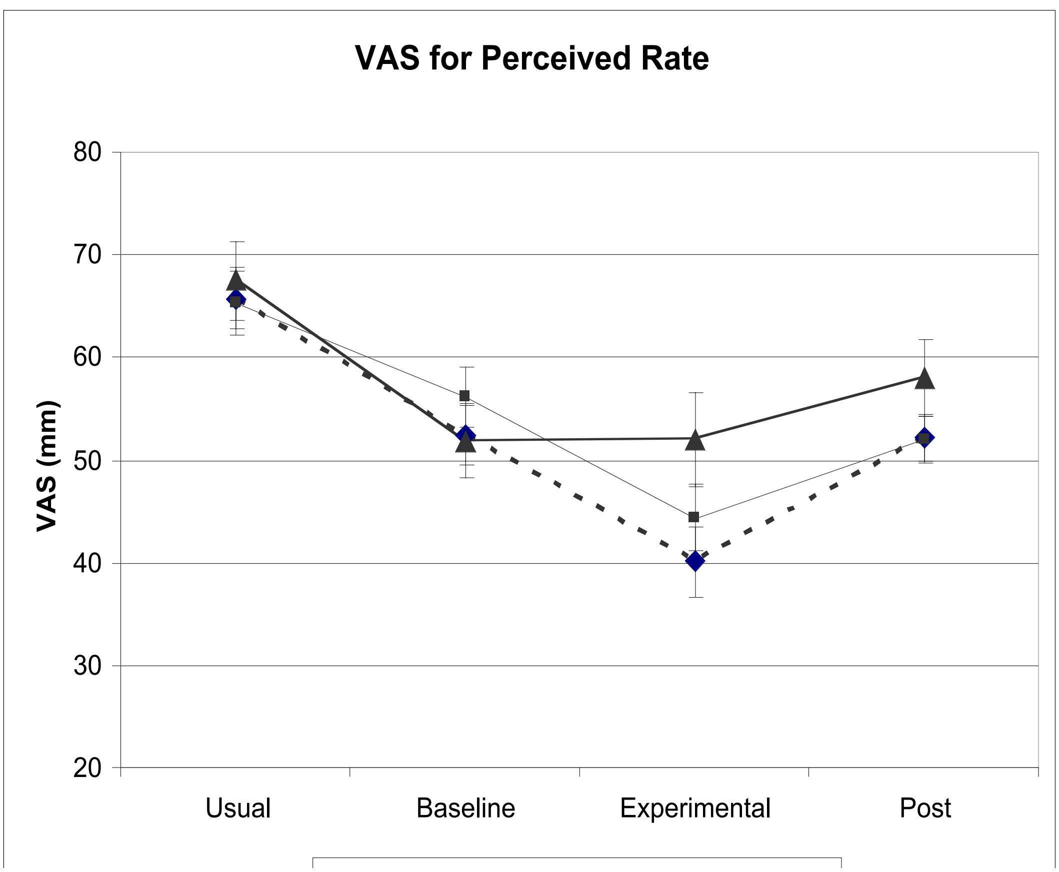

Figure 13: VAS Perceived Rate (PR) over the experimental by condition.

Repeated-measures Analysis of Variance of the baseline, experimental, and post measures suggests a trend for differences with time by condition (F(2,212) =2.38, p=.097 for a linear contrast) and for a gender by condition with time interaction (F(2,212) = 2.46, p=.090 for a quadratic contrast). However, the large variance in the stress condition reduced the statistical power. Figure 14 displays the perceived rate for each condition from baseline to post-experiment for men and women.

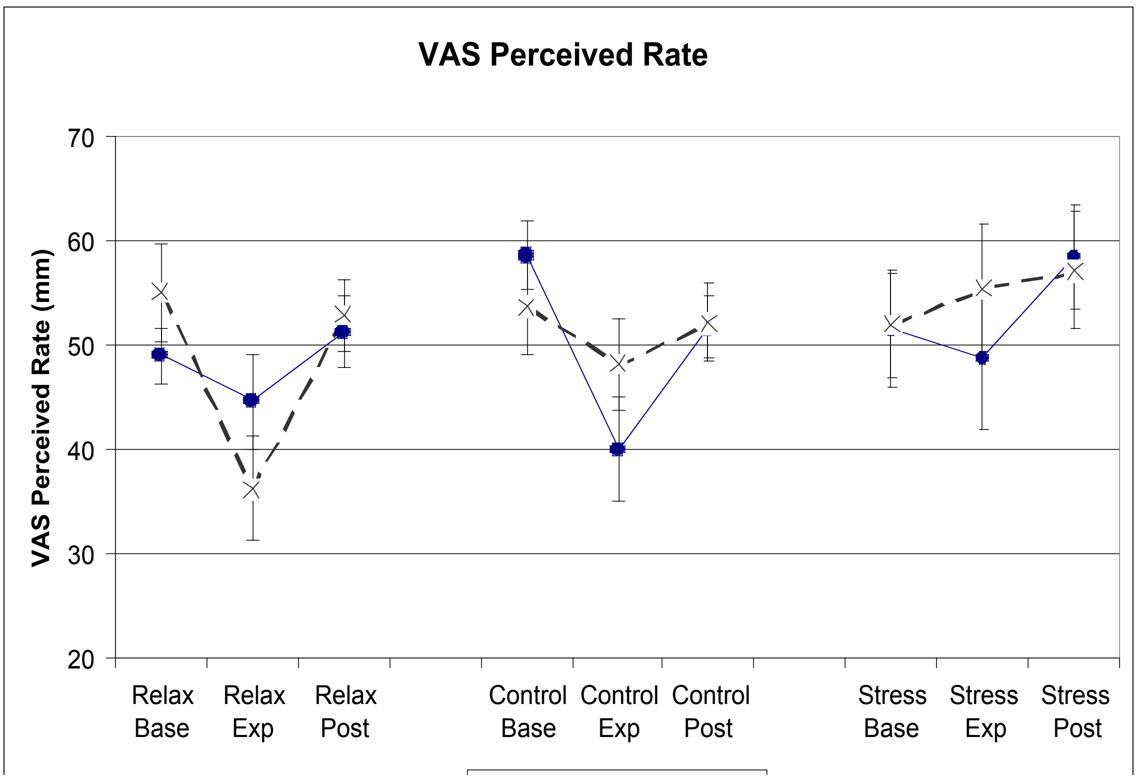

Figure 14: VAS Perceived Rate from baseline to post-experiment for men and women by experimental condition.

<u>Retrospective Estimates (RT)</u>

In retrospective time estimates the participant is asked only after an experience has passed for the remembered duration without prior direction to attend to time. Repeated measures of retrospective duration are, therefore, not practical, so retrospective time was measured only after the experimental manipulation. Participants were asked to estimate the time spent in the experimental manipulation and the time spent wearing headphones during the baseline period. Analyses of Variance revealed group differences among conditions on retrospective time estimates for the experimental phase (16 minutes), with the relaxation group significantly shorter (smaller θ) than the control group (F(2,108)=9.88, p<.01). RT for the time spent wearing headphones during the baseline phase showed a similar pattern of differences between conditions that did not reach statistical significance (F(2,111)=1.81, p=.169).

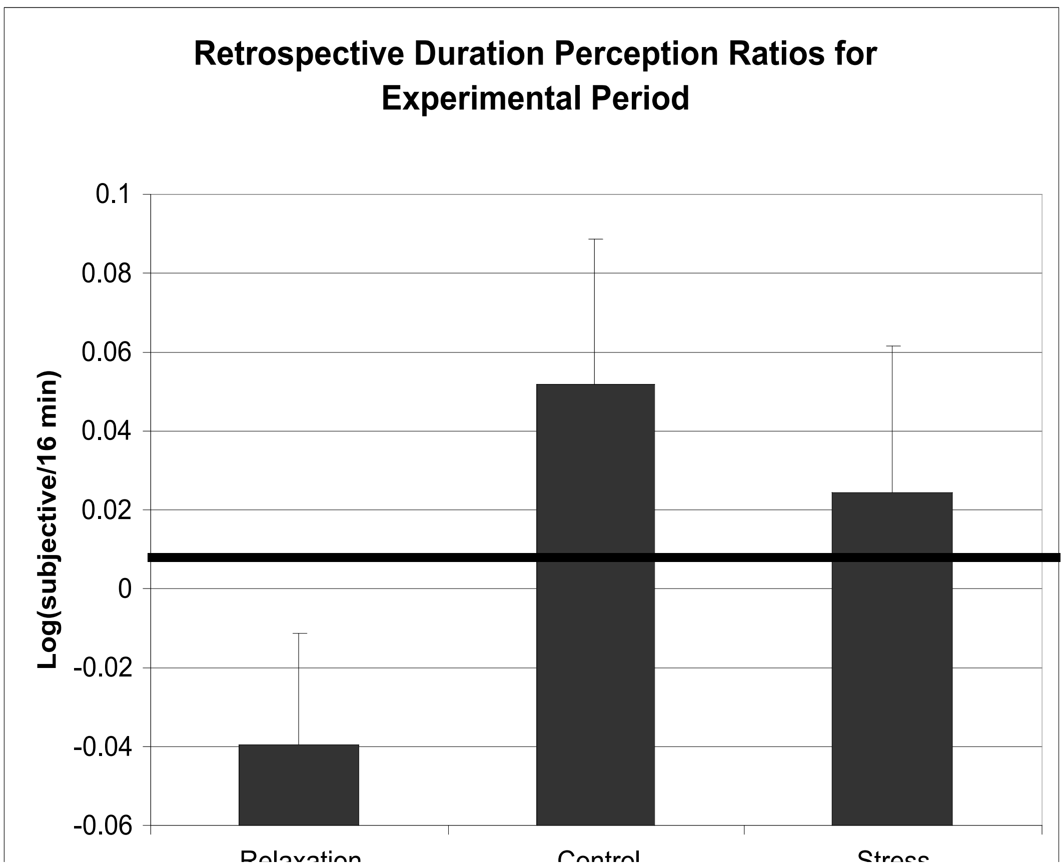

Figure 15: Retrospective Duration Perception Ratio for the experimental period.

The ratio of the experimental phase estimates to the headphone time estimate was close to 3 to 1 for the control and stress conditions (3.03 and 3.00, respectively) but was close to 2 to 1 (2.15) for the relaxation condition. Time spent in relaxation appears to be remembered as shorter than does time spent under stress or control conditions. Figures

15 and 16 display duration perception ratios for the 16-minute experimental period and for the 6-minute baseline period, respectively. The dark line at zero represents an accurate subjective estimate of the objective time.

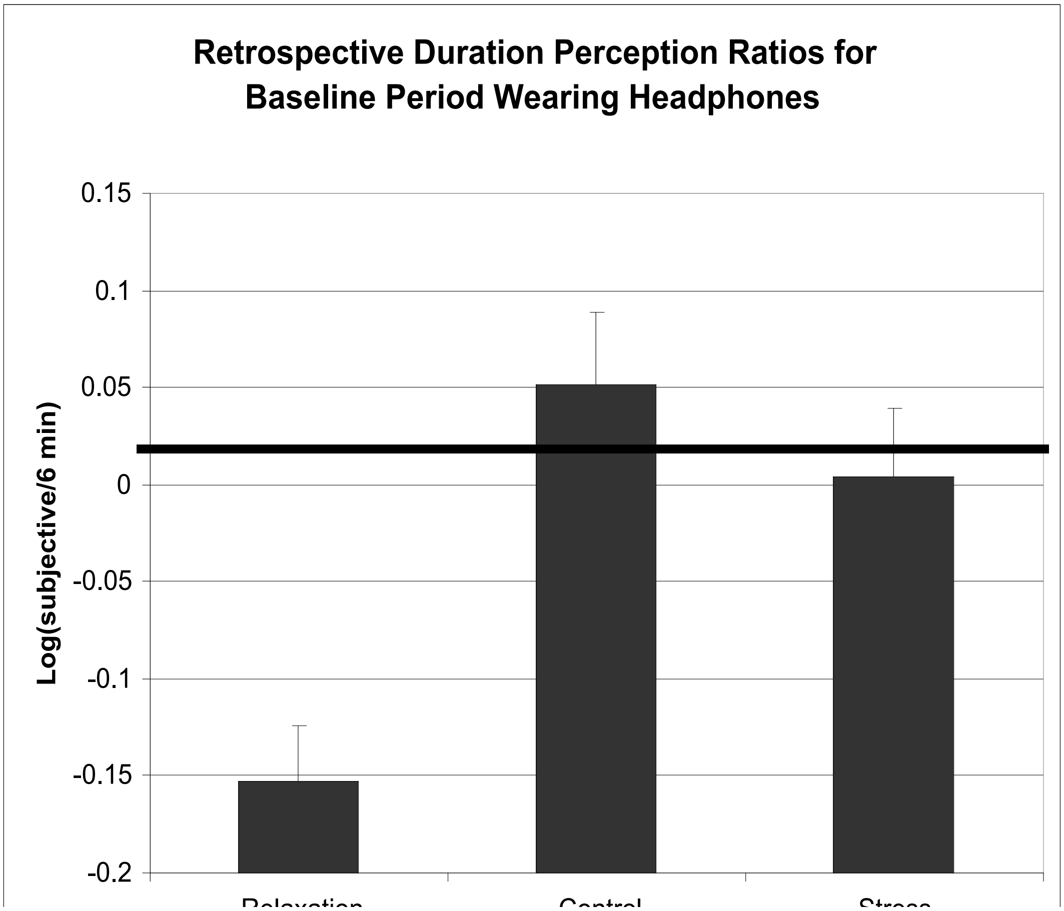

Figure 16: Retrospective Duration Perception Ratio (RT) for the 6-minute baseline.

Saliva Sample Duration Ratings

A non-parametric measure of retrospective time perception was included in the debrief questionnaire. Participants had collected three saliva samples up to that point in the session (two during baseline and one in the post-manipulation period). Each time, the participants were asked to put the cotton in their mouths and after 2 minutes were told to spit the cotton into the collection tube. Therefore, all collection periods were the same objective duration. Two questions asked about the relative subjective duration of time the cotton was in the mouth in each sampling by asking which of the three times was the "longest" and which was the "shortest." Because each sampling period was, in fact, the

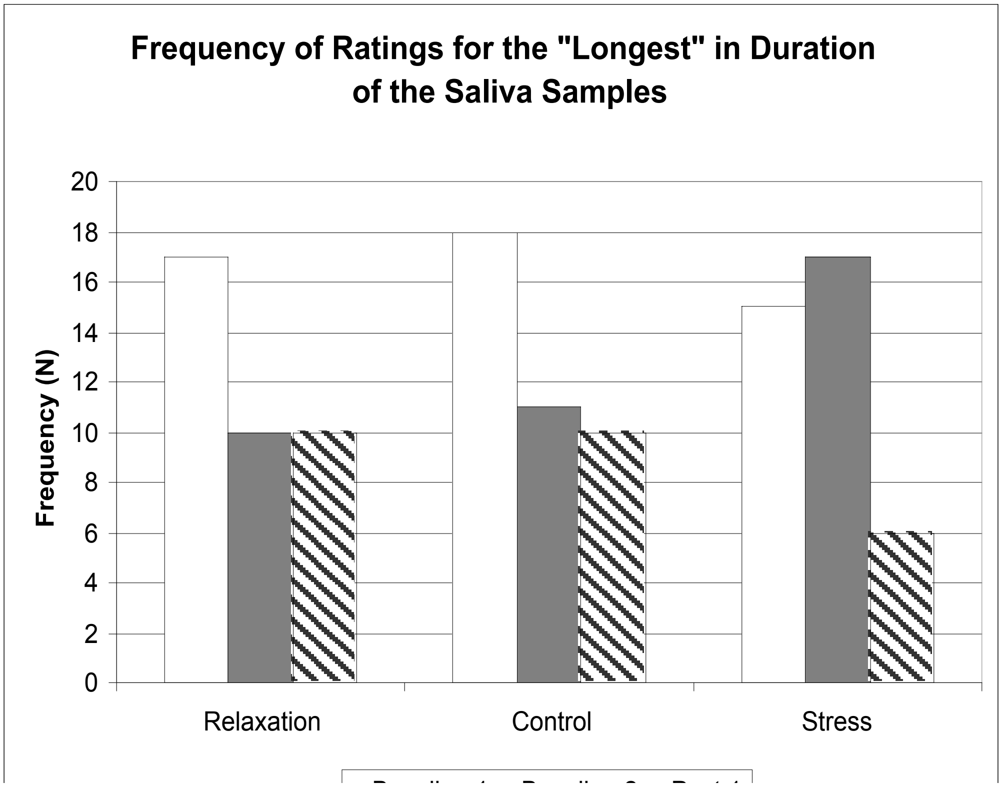

Figure 17: Frequency of Ratings for the "Longest" in Duration of the Saliva Samples.

experimental phase experiences.

Figures 17 and 18 display the frequency of ratings for each of the three collection periods in each condition for longest and shortest. Most participants in the control and relaxation conditions remembered the first collection period as the longest but, in the stress condition, the first and second samplings were remembered as longest at similar frequencies. On ratings of the shortest sampling period, there were clear differences among conditions with relaxation group participants rating the second baseline and first post collection periods as shortest with similar frequencies and greater frequency of control and stress participants rating the post collection period as shortest. Chi square

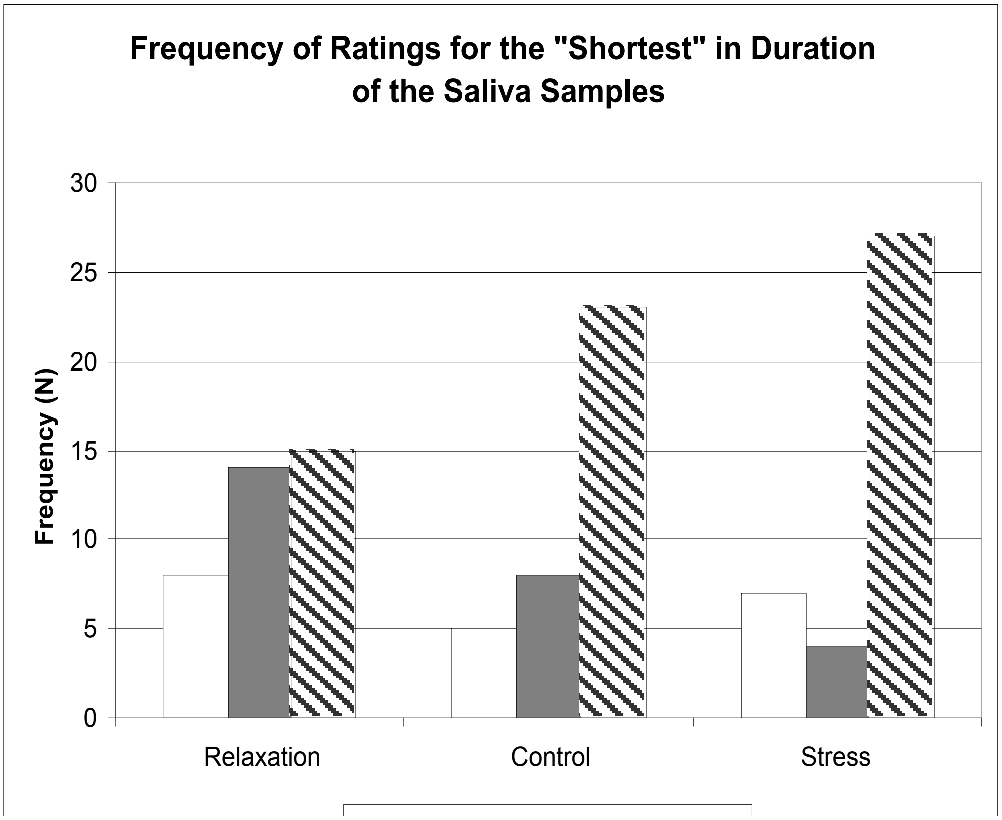

Figure 18: Frequency of Ratings for the "Shortest" in Duration of the Saliva Samples.

same, differences between conditions can be attributed to effects of the different analyses revealed a significant difference among the conditions for the shortest rating ($\chi^2(4) = 9.85, p<.05$). It appears that the sampling period experienced after stress seemed comparatively shorter than the sampling periods experienced before stress, whereas the sampling period following relaxation was comparable to the sampling period before relaxation.

<u>Attention-Related Repeated measures</u>

Measures related to attention included the Non-Verbal Cancellation Task (NVCT) given baseline and post-manipulation, Visual Analogue Scales of Bored-Interested and Distracted-Focused given baseline and post-manipulation, and Domain Attention (distribution of thought in percentages to past, present, and future) asked at baseline for usual thought and asked post-manipulation for thought during the experimental phase.

Non-Verbal Cancellation Task

The Non-Verbal Cancellation task was administered in the baseline and post phases. Throughput scores were computed as the number of target cancellations minus the number of non-target cancellations divided by completion time. Tables O-1 and O-2 in Appendix O display the values and results for the NVCT measure. Repeated-measures Analysis of Variance found no differences among conditions for this measure, suggesting no obvious or dramatic change in general attention as a result of the experimental phase experiences.

VAS Scales of Interest and Focus

In addition to the behavioral measure of attention, the participants also provided self-report ratings of focus and interest. There were no differences at baseline among conditions for the VAS ratings for Bored-Interested or Distracted-Focused, but there were significant differences among conditions for the ratings of interest ($F(2,109) = 3.08$, $p=.05$) and focus ($F(2,109) = 6.79$, $p<.01$) given immediately after the experimental phase referencing the experimental phase. Tables O-4 and O-5 in Appendix O display the values and results of the VAS for interest and focus. For the VAS Bored-Interested there were no significant differences in post hoc analyses, but there was a trend ($F(2,112=3.08$, $p=.05$) for the stress group to report greater interest than the relaxation and control groups. Participants in the control condition reported significantly less focus in the experimental phase than the participants in the stress and relaxation conditions ($F(2,112)=6.79$, $p<.01$). Overall, participants reported greater attention while preparing and delivering speeches than while listening to a biography on tape and these differences may have influenced time perception.

Incidental Memory / Attention to Environmental Sounds

Three random times during the experimental phase, a brief beeping sound was made by means of an electronic stopwatch. Immediately after the experimental phase, participants were asked if they noticed any beeping sounds during the experimental phase. Figure 19 displays the frequency of reports for each condition. Most participants reported not noticing any of the sounds, but there was a trend ($\chi 2(2)=4.1$, $p=.13$) for stress > control > relaxation for number of participants who reported noticing the sounds. The trend suggests that individuals may be more likely to notice and/or remember environmental noise in conditions of stress than they are when relaxed and is consistent with the VAS reports of greater focus and interest in the stress condition.

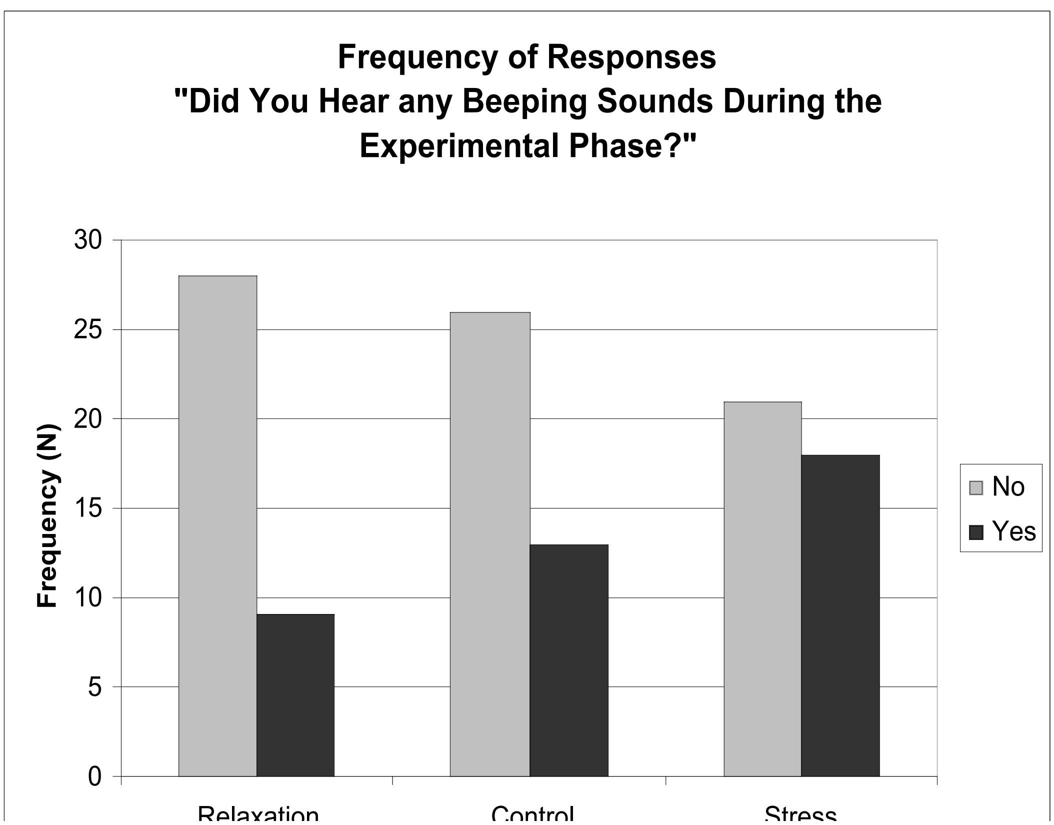

Figure 19: Frequency of reports of hearing beeping sounds by condition.

Domain Attention

There were significant differences in this measure at baseline with the relaxation group reporting more usual attention to the future than the other groups ($F(2,112) = 3.57$, $p<.05$). All groups reported less attention to the past (and future) and more attention to the present during the experimental phase than usual. The changes in attention from usual were significant for all conditions. Table O-7 in Appendix O displays the values and results for domain attention measures.

Correlations

There was a pattern of correlations among time perspective, stress, and time perception measures at baseline. Although these correlations do not reveal cause and effect relationships, they do suggest a linkage in these measures. Tables N-11 and N-12 in Appendix N present the correlations between measures.

The positive correlations among Perceived Stress (PSS), symptom reporting (BSI), and POMS subscales of Tension and Depression were expected because each of these indices taps some aspect of the experience of stress. That these stress-related measures correlated negatively with the POMS scale of Vigor was also expected. Feelings about the present and past (on a 5-point scale from very bad to very good) correlated negatively with PSS and BSI and positively with Vigor, as might be expected.

Several of the findings for the temporal perspective variables are interesting. Age was positively correlated with attention to the present, negatively correlated with attention to the future, and positively correlated with the ratio of subjective to objective duration (θ). Also, attention to the past was correlated with perceived stress, BSI, and all of the POMS scales except vigor. Attention to the present was negatively correlated with perceived stress, symptom reporting, and the POMS scales (except vigor). So, people who devote the most attention to the past are the most distressed in general and the people who devote the most attention to the present are least distressed. Symptom reporting is negatively correlated with usual rate of time passage (time does not fly when you are distressed). Also, continuing to think about a stressful event after it has happened (stress extension) is correlated with perceived stress and symptoms of distress.

Summary of Results

Figures 20 to 23 provide a graphical summary of key results.

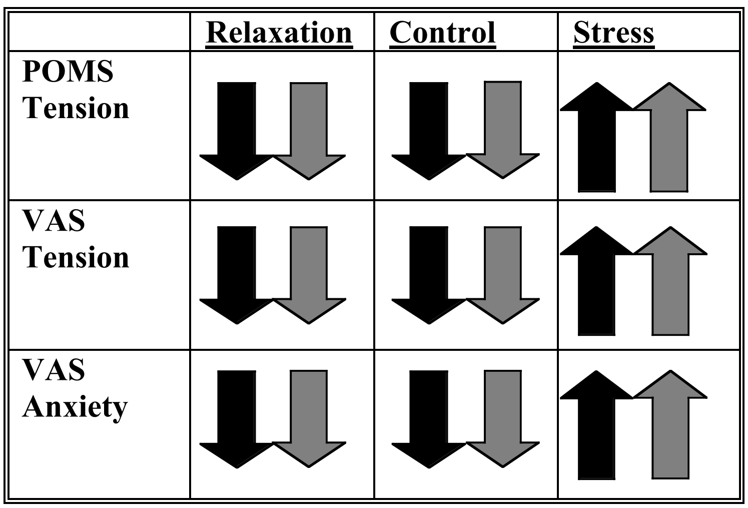

Figure 20: Direction of Change from Baseline to Post for Self Reported Stress
Black arrows indicate women and grey arrows indicate men.

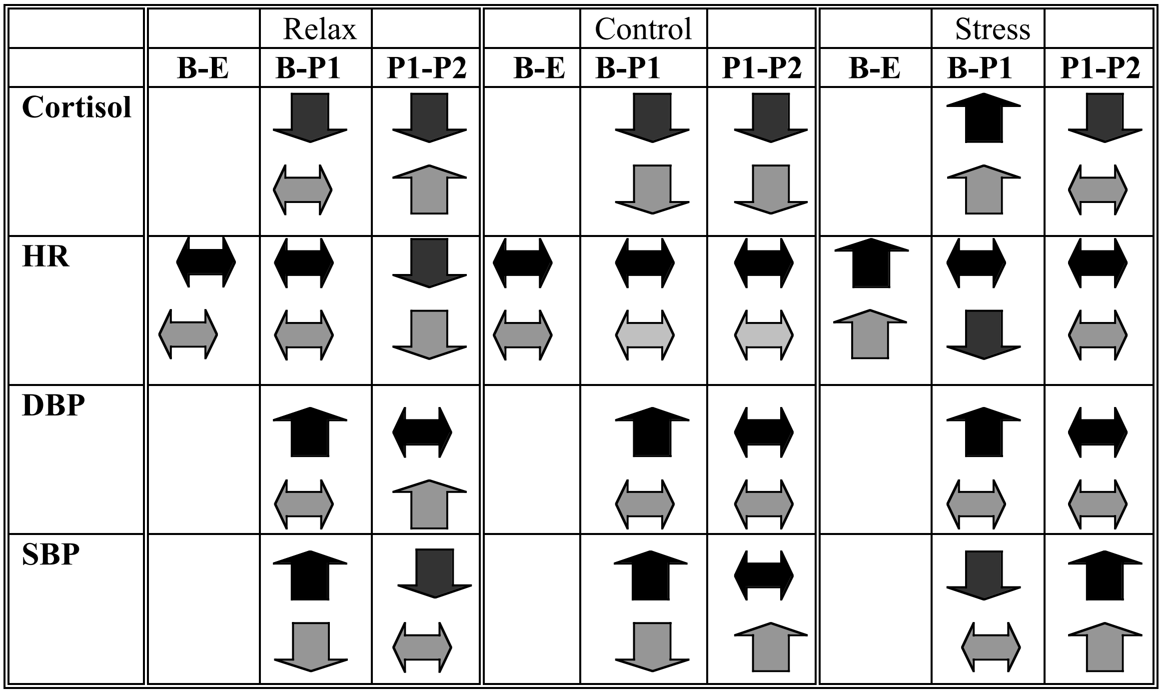

Figure 21: Direction of Change from Baseline to Post for Physiological and Chemical Measures. B-E is Baseline to Experimental, B-P1 is Baseline to Post 1, P1-P2 is Post 1 measure to Post 2. Black arrows indicate women and grey arrows indicate men.

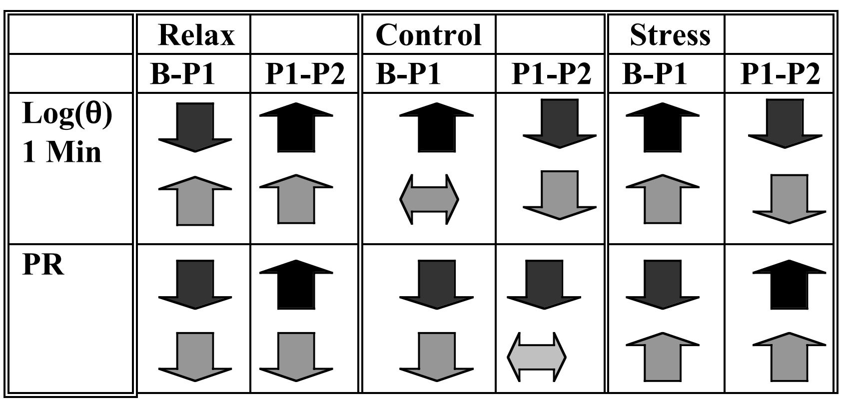

Figure 22: Direction of Change from Baseline to Post for Time Perception Measures. B-P1 is Baseline to Post 1, P1-P2 is Post 1 measure to Post 2. Black arrows indicate women and grey arrows indicate men.

Confirmation of Hypotheses

1. **Acute stress increases perceived duration.**

    a. θ stress > θ baseline.

    Confirmed. Repeated measure's t-test for the values of log(θ) for the 1-minute production from the second baseline to the first post-manipulation measures indicates a significant increase ($t(37) = 2.35$, $p<.05$).

    b. Δθ stress > Δθ control

    Not confirmed. Although there is a difference in the predicted direction, it is statistically indistinguishable from chance ($t(75)= -0.50$, $p=.62$).

2. **Relaxation changes perceived duration.**

    a. θ relaxation > θ baseline

    Not confirmed. There is an increase for women and a decrease for men. Neither change approaches statistical significance.

    b. Δθ relaxation > Δθ control

    Not confirmed. There is a difference opposite to the predicted direction that is statistically indistinguishable from chance.

3. **Acute stress decreases perceived rate** (time seems to pass more slowly).

    a. PR stress < PR usual

    Not confirmed. Time is reported to pass more slowly during the stress manipulation period than usual ($t(38) = 3.68$, $p=.001$), however the slowing is not unique to stress. Time is reported to pass slower than usual in all of the conditions, and the difference from PR at baseline to PR during the stress period is not significant.

b. ΔPR stress < ΔPR control.

Not Confirmed. There is a greater decrease in the control period relative to usual than in the stress period. The change is not significant. Compared to baseline, the control group also reports time to pass more slowly during the experimental phase than does the stress group although only approaching statistical significance ($t(75) = -1.79$, $p=.077$)

4. **Relaxation decreases perceived rate** (time seems to pass more slowly)

a. PR relaxation < PR usual

Confirmed: Time is reported to pass more slowly during the relaxation period than usual ($t(34)=5.37$, $p<.01$). It is also reported to pass more slowly during relaxation than baseline ($t(34)=2.51$, $p<.05$).

b. ΔPR relaxation < ΔPR control

Not confirmed. A difference in the predicted direction is statistically indistinguishable from chance.

5. **Perceived stress relates to PR usual in a quadratic function such that higher perceived stress corresponds to very low and very high values of PR**.

Not Confirmed. There is not a quadratic relationship between perceived rate and stress in this sample.

DISCUSSION

Time seems to pass differently from usual when under stress or when relaxed – a phenomenon well known in human experience. Prior to the present study, this common observation and belief had scant empirical support because of prior conceptual and methodological limitations. The available information was mainly from qualitative reports, experiments on time perception, and theoretical models. People have reported altered time perception in states of stress and relaxation according to clinical case reports and interview studies (Flaherty, 1999; Fraisse, 1963; Terr, 1979, 1983). Experimental studies of time perception in which psychobiological state was probably altered, have generally reported changes in time perception in the direction of an increase in the ratio of subjective to objective duration (θ). Several current theoretical models of time perception include an arousal component and predict changes in time perception with stress and relaxation (e.g., Block, 1996; Flaherty, 1999; Gibbon & Church, 1984; Glicksohn, 2001).

The purpose of this study was to determine how time perception is affected by experimental manipulations designed to invoke states of mild stress and relaxation as compared to an attention control. Several different aspects of time perception were measured using multiple methods. Types of time perception measured were prospective duration perception (perceived time), retrospective duration perception (remembered time), and perceived rate of the passage of time. The experimental manipulation of psychobiological state (the independent variable) was accomplished through a commonly used speech preparation and delivery task in the stress condition, a progressive muscle relaxation task in the relaxation condition, and listening to a passage of a biography on tape in the control condition. Alterations of psychobiological state were verified using self-report, physiological, and biochemical indices.

Interpretation of Results

Hypotheses confirmed and unconfirmed.

Two primary hypotheses were confirmed by the data. Stress increased the ratio of subjective to objective time, consistent with both theoretical predictions and prior empirical findings. Relaxation slowed the rate at which time was perceived to pass consistent with Flaherty (1999) model of stimulus complexity and perceived rate. Stress decreased perceived rate also consistent with Flaherty (1999) but to a lesser extent than did the control condition. The effect was not strong enough to be clearly measured in this study. The secondary hypotheses which were formulated without the benefit of substantial prior experimental evidence, and where theories conflicted on predictions, were not confirmed. Relaxation did not substantially change the ratio of subjective to objective time (taken prospectively) in this study overall because of considerable variance. The variance in response to relaxation might be accounted for by some individual differences and is worth exploring in future studies. The relationship between perceived stress at baseline and how quickly time seems to usually pass was a quadratic function in previous research using a young, relatively demographically-homogenous college sample (Yatko, 2001). The quadratic relationship did not exist in this broad age-group, demographically-diverse sample of community volunteers.

θ as an individual perceptual characteristic

Despite changes in time perception during the course of the experiment, individuals were remarkably consistent in the ratio of time subjectively perceived to time on the clock. The duration perception ratios (θ) were correlated to a large extent across different measurement methods over time. Factor analyses of the multiple measures of θ revealed that a single factor accounted for 65% of the variance in θ overall. This tendency in individuals toward a characteristic θ is similar to the tendency toward a characteristic blood pressure. For example, factor analyses of the systolic and diastolic blood pressures over the course of the study found that one factor accounted for 69% of the variance in the measures even though there were some significant changes in blood pressure during the experiment. The θ factor does not account for appreciable variance in remembered time (RT) or perceived rate (PR) suggesting that the individual characteristic that provides relative stability in prospective duration judgment may be different from what individuals use to gauge remembered time and perceived rate. The relative stability of θ has two important implications. First, it provides strong impetus for within-subjects designs in time perception research because differences in time perception from one person to the next tend to be greater than changes in an individual's time perception. Second, perceived θ may be a useful measure to include in clinical and research settings because it reveals an important aspect of individual perception and may be an indicator of changes in states of stress or relaxation.

Stress effects

Lab session patterns. Time perception did change with stress. This relationship was revealed in two parts of the experiment. First, θ's were high during the introduction to the laboratory conditions (i.e., first baseline set) and decreased after participants had become somewhat accustomed to the setting (i.e., second baseline set). Participants (many of whom had never participated in a research study before) might have found the laboratory setting (i.e., going through security checks, being brought into a small soundproof room without windows, being attached to physiological monitoring equipment, and asked to answer questionnaires about themselves) to be initially stressful. The presumption that the novelty of the setting may have been a stress experiences that reduced with familiarity is supported by the measures of stress indices. There was reduction from the first baseline measure to second baseline measure for cortisol concentration in saliva, diastolic blood pressure, and systolic blood pressure. In the introductory period, individuals reported time to be passing much slower than it does for them usually. Perceived θ was highest at the first measurement point and, like the stress indices, dropped significantly to the second baseline measure.

Stress phase patterns. Time perception changed in the stress group during and following the speech stress phase. The participants in the stress condition had a significant increase in θ measured immediately following the speech stressor as compared to the second baseline measure. Women generally reported that time seemed to pass slowly (decreased PR) during the speech phase and men reported little change in how time passed during the speech, but both men and women reported that time passed somewhat more quickly after the speech phase than during baseline. That time was reported to speed up after stress is consistent with the retrospective comparisons of the saliva sampling times. Stress participants reported that, in retrospect, the time seemed comparatively shortest during the saliva sample collection after the stress phase as compared to the two identical collections taken during baseline (which were rated the longest with equal frequency). Summarizing, stress caused an increase in θ, consistent with previous research and the first experimental hypothesis. Removal of stress seemed to speed time up and an activity after stress was experienced as shorter than objectively identical activities before stress. Interestingly, stress did not affect the accuracy of the retrospective report of time spent in the stress period – the stress group was more accurate in the estimate than either the control group (that overestimated the period of the experimental phase) or the relaxation group (that underestimated). Overall, under stress there is a sense that the clock is slowing only to be followed by a rebounding in speed after the stress is removed as if perceived time were somehow conserved as evidenced by an increase in the ratio of subjective time to clock time immediately following stress and a later decrease along with self report of time seeming to pass faster following stress.

Relaxation effects

Relaxation affected time perception somewhat differently. More so than stress, relaxation decreased perceived rate (PR) (particularly for men) such that time was reported to pass much slower during the relaxation phase as compared to baseline. Time passed even more slowly following relaxation according to men, but speeded up again for women. Men and women responded differently in θ following relaxation but there was not a clear pattern. There was a slight increase in θ at the final measurement point compared to the immediate post-relaxation measure. In contrast to the report that time was passing slowly during relaxation (low PR), the retrospective estimate of the time spent in the relaxation phase (remembered time: RT) was significantly shorter than in the control or stress phases. So, although time felt like it passed slowly, in memory it seemed as if less time was spent in relaxation than actually was spent. This finding is consistent with cognitive theories that RT is a function of amount of information and contextual changes stored in memory from the period (Block 1985; Ornstein, 1969). The relaxation period would be expected to generate fewer memory cues than would the control period spent listening to a series of historical facts or the stress period spent preparing and giving two speeches. The finding of shorter RT in relaxation is consistent with the old adage that "time flies" (in retrospect) when relaxed and may shed light on the typical student's Monday morning protest that "the weekend was too short."

Control condition effects.

The control condition served its purpose as a neutral control because there were no significant changes in self-reported tension and anxiety or changes in stress indices that would indicate that the control condition was stressful or relaxing. However, some changes in time perception also occurred in the control condition. RT in the control phase was significantly longer than RT in relaxation - a finding consistent with storage size models for remembered time because information was presented in the control condition during the entire experimental phase whereas information was presented only briefly during the relaxation condition with intermittent time for participants to do the relaxation exercises directed on the tape. As with relaxation, the control group reported time to pass much more slowly during the control phase than at baseline (particularly for women) and PR was reported to be even slower immediately after the control phase. It is not clear whether to attribute the control condition effect to the laboratory setting, to directed attention to the taped passage, or to the passive nature of the task. In listening to a passage, the participant has little control over the time whereas the more actively tasks of preparing and presented speeches or tensing and relaxing muscles may have allowed more perceived control of the time. θ showed no clear pattern immediately after the control phase but had decreased by the final measurement point.

Gender and age effects

Gender. Although there were no hypotheses related to gender or age, additional analyses revealed that there are important relationships between gender and time perception and, within gender, between age and time perception. When the θ calculated from the time production measures were compared, women's θ were significantly larger than were men's. When the θ from the method of estimation were compared, the gender differences were not significant, largely because of the tendency of both men and women to estimate time in rounded numbers. Women and men reported different changes in PR with women reporting slowing during stress and men reporting quickening. Men tended to report the greatest slowing of PR in the relaxation condition, wereas women reported the slowest PR in the control condition. Women also had greater RT but the effect was only significant for the estimate of time spent in the stress phase. Women estimated the stress phase to be longer than clock time and men estimated it to be shorter. That women remembered a minor psychological stress period to be of longer duration than did men is consistent with the finding from Yatko (2001), which was replicated in this study, that women report continuing to think about a minor psychological stressor longer than do men. The general gender differences in this study are consistent with the findings of gender differences in retrospective duration (and to a lesser extent prospective duration) reported in a recent meta-analysis on the topic (Block, Hancock, & Zakay, 2000).

Age. Age makes a difference in perceived time (θ), and age differences in time perception may be related to plasma levels of steroidal hormones. Although variable, the general trend in this study was for both θ and salivary cortisol to be highest in the men aged 40-50. For women there was a direct correlation between age and θ with age accounting for between 10 and 25% of the variance on all measures of θ except those taken immediately post-manipulation. A recent study of women with normal menstrual cycles suggests that θ in women may be related to two different hormones, cortisol and estrogen, that appear to have opposite relations with θ increasing with cortisol and decreasing with estrogen (Morofushi, Shinohara, & Kimura, 2001). As women age, there is a reduction in estrogen levels and an increase in cortisol levels, both of which would be associated with an increase in θ. Although age differences in this study are consistent with a steroidal hormone relationship with time perception, future research explicitly examining the relationship between various hormones and time perception is needed to determine if this is the case.

Dynamic measures summary

To summarize the results of the dynamic measures of time perception, individuals have a relatively stable characteristic set-point for prospective θ about which changes occur in different experiences. The set-point for θ partially depends upon gender and age, and the differences may be related to plasma levels of steroid hormones. People report subjective changes in the rate time passes in different states. Psychological experience state also may affect remembered time consistent with an effect on memory whereby experiences with more new information or more salient memory cues are remembered as longer than less memorable periods of experience. The perceived duration (θ) results are discussed relative to the theoretical models and potential mechanism following a discussion of the temporal perspective relationships.

Temporal perspective

The more static or trait-like aspects of temporal perspective relate to some measures of more enduring psychological states. The pattern of correlations among the temporal perspective factors and self-reported stress, mood, and symptoms of distress suggest a relationship between temporal perspective and psychological health, although the cause of the relationship cannot be inferred from the correlational data. Specifically, attention to the past was associated with greater perceived stress, negative mood, and symptoms of distress, whereas attention to the present was associated with lower perceived stress, less symptom reporting, and less negative mood. Also, continuing to think about a stressful event after it has happened (stress extension) was associated with greater perceived stress and symptoms of distress. Usual rate of time passage was negatively correlated with symptom reporting (time does not fly when you are distressed). So, people dwelling in the past are more distressed in general than people living in the moment. All of the experimental conditions resulted in shift of usual attention from the past to the present and all groups reported some degree of slowing of perceived rate (PR) during the experimental condition. Perhaps, focus on the present results in a relative slowing of time because of greater awareness of each moment. Focus on the past may lead to a sense that time is passing slowly because the mental scenery is not changing but is a re-run of memories.

Attention

Measures related to attention were included in the experiment to help determine whether any changes in time perception were linked to changes in attention. Attention is a key component of cognitive models of prospective duration perception including the Attention Gating Model (Block, 1996; see figure B-3 in Appendix B) and the Multiplicative Model (Glicksohn, 2001; see figure B-4 in Appendix B). There were no significant differences between groups pre to post manipulation in performance on an attention-dependent task (NVCT), suggesting that participants' capacity for attention to a single task was not altered appreciably as a result of the experimental manipulations at those measurement points. There were some differences in the Visual Analogue Scales related to interest and focus during the experimental phase with the stress group more interested and the control group more distracted. The measure of incidental awareness to environmental sounds (three soft beeps at random times during the experimental phase) was different among the groups with participants in the stress condition most likely to have noticed the sounds and those in relaxation least likely to report noticing the sounds. It is not clear if the difference on the beep measure indicates a difference in capacity to attend, relative focus to task, or memory for extraneous stimuli. Changes in attention and environmental awareness with different experiences cannot be ruled out as a mechanism by which different experiences effect time perception and should be examined in future research.

However, the changes in θ immediately after the experimental phase (when the task and empty time was the same in each condition) and lack of measurable differences among conditions in attention to task following the experimental phase suggest that attention alone cannot account for all of the time perception effects and that arousal may have attention-independent effects on time perception. The finding that θ was increased briefly following stress is consistent with many of the theoretical models of time perception. Stress increases general arousal and would then increase the number of subjective time units in the Scalar Timing Model (Gibbon & Church, 1984), the Attention Gating Model (Block, 1996) and the Multiplicative Function Model (Glicksohn, 2001). Empty time tasks were used to prevent confounding task demands with psychobiological arousal, but the findings do not rule out the possibility that time perception changed following stress because of an increase in attention to time.

Implications

Clinical

The results have several important implications to clinical work in mental health. First, changes in time perception may reflect acute changes in experiences such as stress and as such may be an important indicator of mental status to be evaluated along with changes of sleep, appetite, concentration, etc. Clinical interventions that focus on the present moment would be useful for reducing acute distress. Additionally, differences in time perception set-point may be important to consider in relationship counseling. For example, if a wife has a 30-second subjective minute and a husband has a 120-second subjective minute, disagreements centering on impatience and timeliness may be easier to understand in the context of different time perception.

Military

The findings of this work have implications to military training and readiness. In experiences of novel stressors, individuals are unreliable judges of time, so external time keeping devices are essential when precision timing is needed. Also, commanders may well influence the moral and distress of their troops by emphasizing a particular time domain. When attention is placed on past training, debriefs after an incident, and the past in general, members are likely to be more distressed. When attention is placed on the present moment, the immediate task at hand, and the present in general, members are likely to be less distressed. Finally, additional research should explore the possibility of training personnel in relaxation or other techniques to manipulate perceived rate of time and memory of time for experiences of extended periods of stress, such as prisoner of war experiences.

Limitations

Manipulation Limitations

There are several important limitations of this study. The relaxation condition did not result in reliable reduction in physiological arousal, the control condition was not uniformly neutral in that individuals reacted with a range of interest and boredom, and perceived duration was not measured during the experimental manipulation phase itself (to avoid confounding task demands). The progressive muscle relaxation procedure used in the relaxation condition involved successively tensing and relaxing various muscle groups. Although participants consistently reported increases in relaxation and decreases in anxiety following the relaxation phase, the physiological changes were variable, partially depending on participants' relative efforts in the tensing of muscle groups.

Therefore, variability in physiological arousal following relaxation may have contributed to increased variance in time perception and lack of a clear finding with regard to how relaxation affects time perception. It is unclear also whether the changes in time perception in the control condition reflect non-specific changes with time in the laboratory setting or if the task itself altered time perception. Although not statistically significant, there was a pattern for men to like the control task more and to find it more interesting than did women. There also was a trend in prospective θ immediately following the control condition for an increase for women and a decrease for men.

Measurement Limitations

Another limitation is that prospective θ was not measured during the experimental phase - a design intended to avoid confounding effects of the task demands with effects of psychobiological state. However, the finding of an unexpected rebound in time perception measures from immediate post-manipulation to the final measurement point suggests that it is important to recognize that different experiences may result in a pattern of changes in time perception during and following the experience. Specifically, a change in time perception in one direction during and immediately after the experience may be followed by a rebound or change in the opposite direction at a later point following the experience. Given that biological and psychological effects of stress (and relaxation) follow different time courses, this pattern of different changes at different points during and after an experience is perhaps not surprising after all. It is, therefore, unclear from the present studies whether or not the changes immediately post-manipulation were a result of a brief continuation of the psychobiological state (i.e., individuals continue to feel stressed or relaxed for some time after the phase ended). If that is the case, then the effect of the manipulation on time perception would be in the same direction, but smaller than if it had been if measured during the experimental phase. Alternatively, the effects could be unique to the post-manipulation period, reflecting a cognitive comparison or contrast with the immediately preceding state in the determination of duration.

Generalizability Limitations

The study involved minor manipulations of stress and relaxation in a laboratory. The magnitude and duration of stress and relaxation experiences in day-to-day life, and particularly in extreme or traumatic events, may result in changes in time perception with similar direction but greater magnitude, but might instead result in changes that are qualitatively different. The study sample included men and women from a relatively broad range of age and demographic backgrounds, consistent with the population of the Washington, D.C., region. The breadth of the sample likely increased the baseline variability in time perception, making it more difficult to detect changes caused by stress or relaxation. Despite its relative breadth, the sample was restricted to individuals not suffering from major physical or mental health problems, so results may not generalize to clinical populations.

Future Directions

Laboratory Studies

Future laboratory studies should use stronger and more varied manipulations of stress and relaxation, use more focused measures of time perception, and be designed to determine the pattern of time perception effects during and following the stress or relaxation experiences. For example, stress manipulations might include other common induction techniques such as mental arithmetic and watching stressful movie scenes. Alternate relaxation manipulations might include listening to music and completing a guided imagery relaxation induction. Time perception measures should include productions of several different intervals with the complete set repeated at each measurement point. The method of production is superior to verbal estimation in this type of study because the tendency to estimate in round units confounds the measure. The method of comparisons (i.e., how does the presented duration compare to a previously presented standard) also would be appropriate in future studies of this type. Measures of θ and perceived rate should be taken during the experimental manipulation, immediately afterward, and at several time points following the manipulation to determine the time course of effects.

Field and Clinical Studies

Other types of studies important for future time perception research include field studies and studies in clinical settings. Field studies should be designed to measure time perception and indices of stress over the course of periods of changing stress such as military training or deployment, entering college, and during the aftermath of disaster. Clinical studies should compare different diagnostic populations on time perception measures. It would be particularly interesting to study populations suffering from post-traumatic stress, depression, and anxiety disorders. Clinical studies also should evaluate any changes in time perception occurring over the course of treatment, particularly treatment that involves relaxation and stress management.

Conclusion

It appears that stress and relaxation do have an effect on time perception. Time feels slower when relaxed but is remembered as shorter (consistent with William James 1890 observation). Time perception is relative. The results suggest that people have a baseline subjective time keeper that is influenced by individual differences such as gender and age. In the absence of any external clock, people judge time to stretch or shrink from their own baseline by comparing their current experience with recent experiences. In this experiment the speed of time did not change remarkably during mild stress but the ratio of subjective to clock time increased immediately following stress and time seemed to pass faster. An event following stress seems shorter than a comparison event that immediately preceded the stress. People who experience mild stress may feel that their post-stress time passes more quickly partly because they experience more subjective time per clock unit when stressed. More chronic stress was related to relative attention to the past and present.

Subjective time increased slightly immediately following stress and later decreased. The findings imply that, in high stress operations, such as military missions, in which timing is important, use of reliable external time-keeping devices (e.g. “synchronize your watches”) may be imperative because individual time perception may be altered. Training should be as realistic as possible in invoking stress states similar to actual performance environments to minimize the impact of such alterations. In clinical settings, time perception measures may be a simple and cost-effective (and relatively non-threatening) addition to the repertoire of measures to assess and monitor an individual’s state at repeated times. Individual differences in perceived duration set-point may be valuable to consider in treatment planning and in such areas as couples counseling to, for example, enhance understanding of differences and impatience when the wife's minute is 30 seconds long and the husband's minute is 90 seconds long. Clinical interventions designed to shift the focus of a patient's attention from the past to the present, or increase capacity to maintain attention to the present (rather than escaping from the present through memories, worries, or chemically altered states) may be used to treat conditions of chronic distress. Alteration of temporal perspective may be one of the ways through which mindfulness based therapies (e.g., Linehan, 1993) achieve their results.

As observed by the philosophers of time throughout history, time perception is linked to human experience. The findings from this study suggest that experiences of mild stress and relaxation, similar to common experiences of daily life, lead to changes in time perception, and individuals appear to have a characteristic set point for perceived duration about which these experiential changes occur. There are several different aspects of how people perceive time that may provide information about the immediate experience as well as an individual's aggregate style of experience over longer periods of time. Time perception merits future study because understanding human experience is central to the aims and benefits of the science and practice of psychology.

APPENDIX A: GLOSSARY OF TERMS AND SYMBOLS

GLOSSARY OF TERMS AND SYMBOLS

Domain attention - relative attention to past, present, and future

Duration - the "length" of the segment of time between two momentary events or of a prolonged event (the start and end of the event then serves as the two momentary events)

Duration judgment ratio - is the ratio of subjective duration to clock duration and is indicated in this paper by the Greek letter **theta** (**θ**) for prospective measures and by **RT** for retrospective measures

Method of discrimination – person tells which of several presented stimulus intervals is longest

Method of production (time production) - person produces an interval given by the experimenter in conventional units (e.g., one minute)

Method of reproduction - person produces an interval of the same duration as a given stimulus interval

Method of verbal estimation (time estimation) - person gives a numerical estimate (usually in conventional time units of seconds or minutes) of the duration of a given interval period

Orientation to time - awareness of the clock time and date

Pace - sense of urgency and quantity of activity per time period

Perceived rate (**PR)**- subjective impression of how quickly or slowly time passes

Relaxation - a process in which directed awareness of internal or external events (**relaxors**) augment an organism's existence and well-being, and relaxation responses occur that are directed toward enhancing and preserving the organism's psychobiological resources

Simultaneity -events occurring together or at the same time

Stress - a process in which internal or external events (**stressors**) threaten or challenge an organism's existence and well-being, and stress responses occur that are directed toward reducing the event's impact

Succession -events occur one before another at different times

Temporal horizon -how far into the past or future a person thinks

Temporal orientation -attitude toward past, present, and future

APPENDIX B: THEORETICAL MODELS OF TIME PERCEPTION

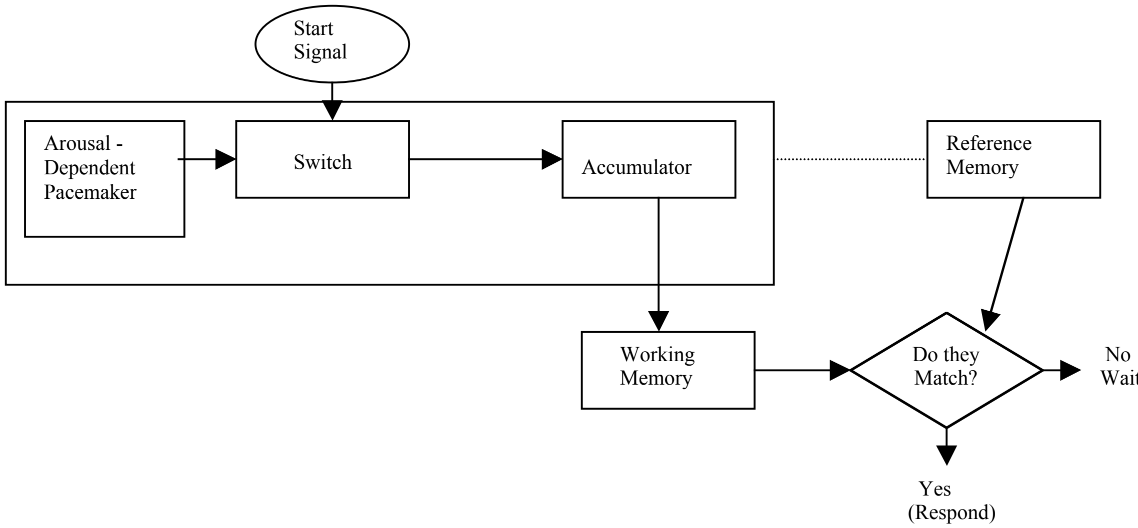

Figure B-1. Scalar Timing Model (based on Church, 1984 and Gibbon, 1984)

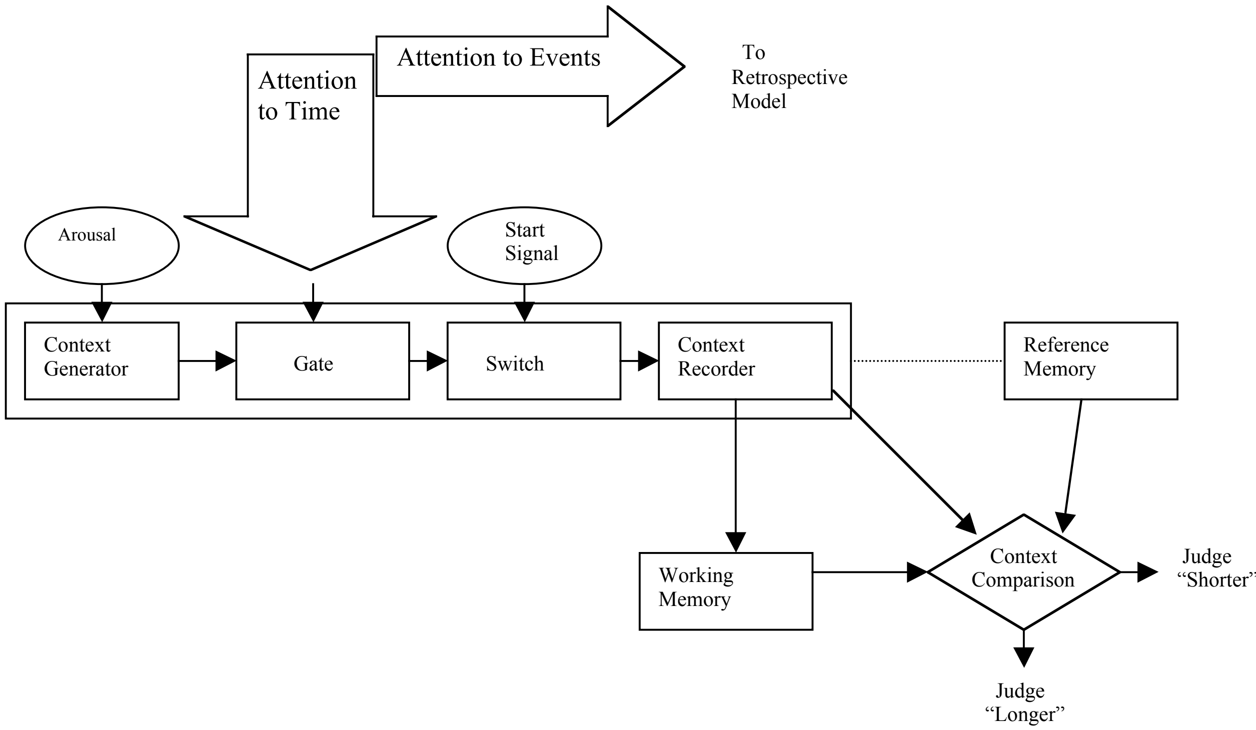

Figure B-2. Contextual Change Model (based on Block, 1992).

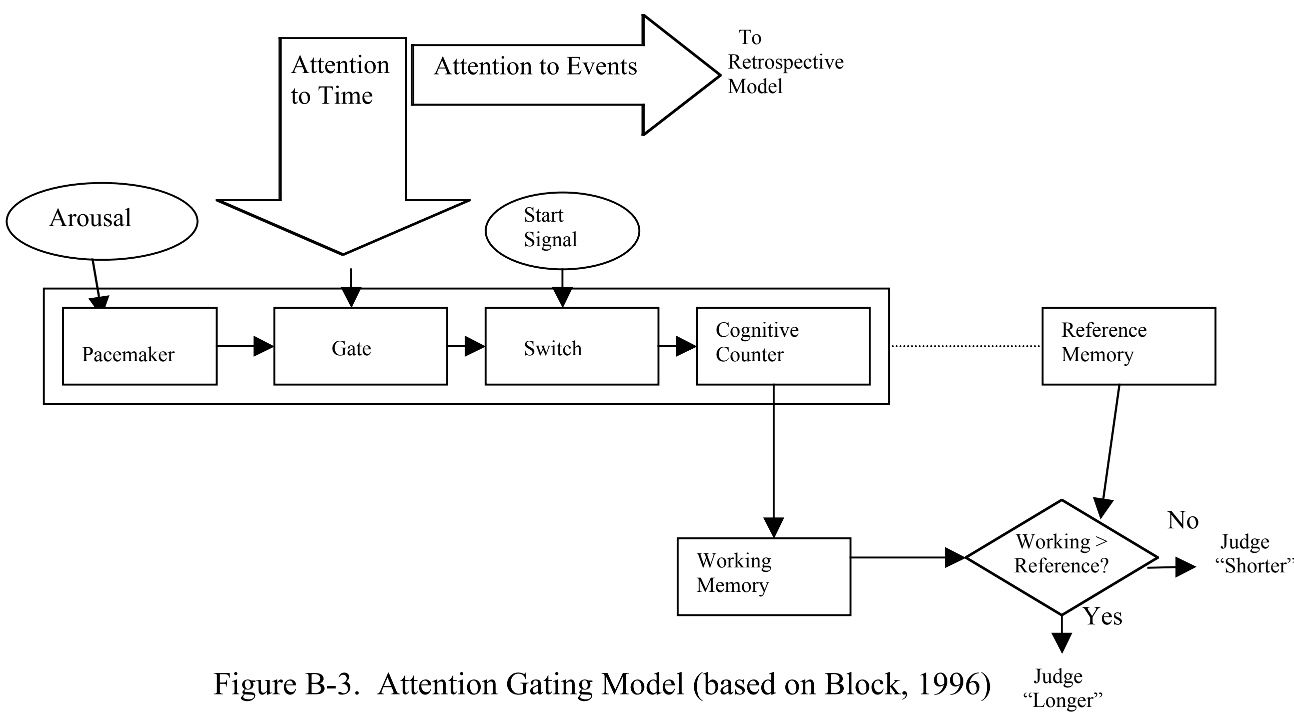

Figure B-3. Attention Gating Model (based on Block, 1996)

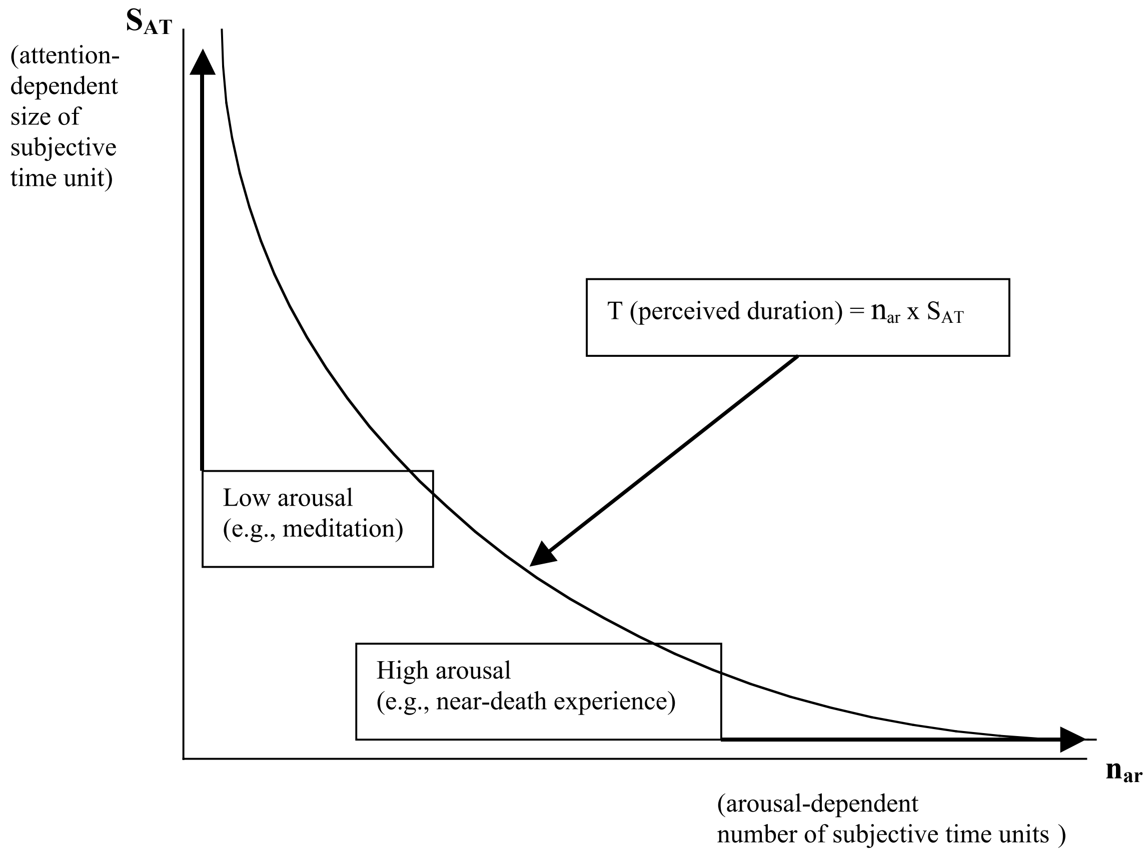

Figure B-4. Multiplicity Model (based on Glicksohn, 2001).

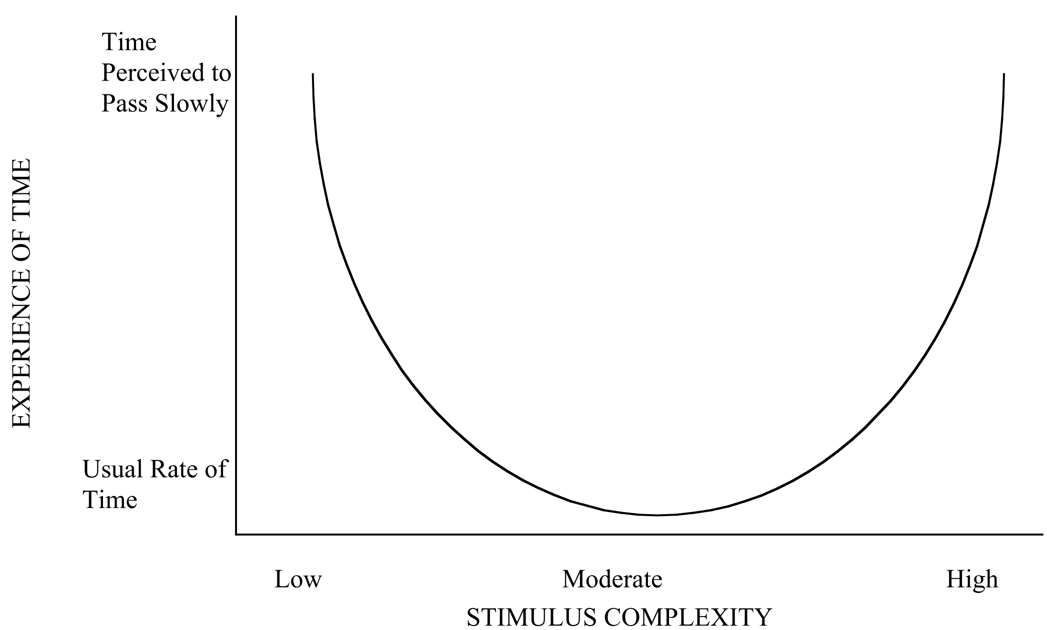

Figure B-5. Stimulus Complexity Model (based on Flaherty, 1999).

APPENDIX C: ADVERTISEMENTS

Research Volunteers Needed

If you are a man or woman between the ages of 18 and 80, you may be eligible to participate in a study of perception.

The study takes 2 hours to complete and you will receive $30 as compensation for your time.

This is a Uniformed Services University of the Health Sciences study and will take place at the USUHS campus in Bethesda, MD. (Medical Center Stop on Metro Red Line)

Contact 301 295-TBD to determine your eligibility for participation.

Contact: Bonnie Yatko 301 295-TBD

Sample Newspaper Advertisement

"MEN and WOMEN: **EARN $30** – Participate in a Research Study on perception at a local University. Call (301) 295-TBD to volunteer."

APPENDIX D: PHONE SCREEN AND INTERVIEW SCRIPT

September 22, 2001

TELEPHONE SCRIPT FOR STARS
(Study of Time After Relaxation or Stress)

"Hello, this is _______________ calling from the Uniformed Services University. I am calling regarding your interest in an ongoing research study concerning how people perceive and react to different experiences. Do you have about 10 minutes for me to tell you about the study?"

Yes- continue
No. "OK. Is there a better time that I may call you to tell you more about the study?"
Yes. → Write down Time and Date on Telephone Log Sheet
No. "Thank you for your time."

"The purpose of this study is to assess individual's perception and physiology during various experiences. We are interested in this topic to better understand perceptual processes that may be related to health and performance. The study involves one laboratory session that will take about 2 hours. If you agree to participate you will be asked to come to the Medical Psychology Laboratory at the USUHS / Navy Medical complex campus."

"The study consists of filling out some questionnaires and completing some tape-recorded exercises. We'll measure your heart rate, muscle responses, and blood pressure at various times during the study and also ask you to give saliva samples. You will also be asked to listen to some sounds and give ratings of different odors and textures. The lab session will be videotaped."

"Do you have any questions?"

"You will receive $30 for your time in the research."
"Do you think that you would like to participate in this study?"

No. "OK. Thank you for your time."
YES- "OK, I have some questions I need to ask you to determine your eligibility to participate in this study."

1. "What is your birth date?" _______________(18 = Must be before date 1983)

   If birthday AFTER Date 1983 – "You must be at least 18 years of age to participate in this study. Thank you for your time."

   If birthday BEFORE Date 1983 → continue.

2. "Is English your primary language?"
   Yes → continue.
   No –"Do you anticipate any difficulties reading questionnaires and listening to taped instructions in English?"

Yes. "Because the questionnaires and tapes are in English, you need to be able to read and understand spoken English well in order to participate so this study would not be appropriate for you. Thank you for your time."
No. Continue.

3. "Do you have any difficulties or disabilities that interfere with reading, speaking or hearing?"
No → continue.
Yes –"What are those difficulties?"______________________________

If not easily resolved "This study is would not be appropriate for you. Thank you for your interest and time."
If easily resolved (e.g. allowing a magnifier for reading). Continue.

4. "Are you active duty military?"
No-> Continue
Yes -> "No payment is possible for military personnel and you must use TDY or liberty time to participate. Are you still interested in the study?"
No – "Thank you for your time."
Yes -> Continue

5. "Are you currently taking any medication on a regular basis?
No -> Continue
Yes -> "What medication do you take?"____
If medication is a psychotropic drug or opiate (anxiolytic, antidepressant, mood stabilizer, antipsychotic, methodone, opiate pain killers) – "You do not meet the requirements for participation in this study, but thank you for your time and interest."

6. "Have you ever been diagnosed with any of the following health problems?"

__ Diabetes	__Flashbacks/PTSD
__Heart Disease	__Panic Attack
__High/Low Blood Pressure	__Schizophrenia
__Anxiety/ Depression	__Substance Abuse

__Any other health problems?
____

(Note: Screening question from Scheufele, 1999)

No health problems-> Continue
Yes to any-> "Are you currently under treatment for this diagnosis or health problem?"
Yes -> "You do not meet the requirements for participation in this study, but thank you for your time and interest."
No -> Continue

7. “Have you ever participated as a subject in a research project at the Uniformed Services University of the Health Sciences?”

No - > Continue

Yes -> “Was this study conducted by the Department of Medical Psychology?”
“Did you participate in a study at USUHS within the last six months?”
“What did the study involve?”________________________________

If study involved stress manipulation or relaxation or took place in the last six months -> “You do not meet the requirements to participate in the study at this time. Thank you for your time and interest.”

8. “Do your work responsibilities or your activities require frequent public speaking?”

No -> Continue

Yes -> “You do not meet the requirements for participation in this study, but thank you for your time and interest.”

9. “Do you have any allergies?”

No -> Continue

Yes-> What_________________________________

“OK, now I need to schedule a time for you to come to the lab. We have sessions available at 1:30 and 3:30. The study will be running all days of the week beginning in December. Is there a particular day that works well for you?”

“The lab is located in _______________. <GIVE DIRECTIONS> We can also send you a copy of directions by email or mail – which do you prefer? <Make a note on log sheet>

“I want to make sure I have information to be able to contact you and provide a reminder for your appointment.”

Name:____________________________________

Mailing Address:____

____

Phone numbers: Home_______________ Work______________ Cell/Pager____________

Email:___________________________

Best way to reach_____________ best time of day to call____________________

Because of increased security on the campus, I need to have your social security number and drivers license number so the guard at the gate will let you in.

SSN_________________________________ DLN________________________

“Because of our research schedule, it is important that you arrive at the lab on time. Please call us at _________ if you anticipate any problems with keeping your appointment. Thank you and we look forward to seeing you on _______ (date) at _______ (time). Be sure not to eat or brush your teeth for at least 90 minutes before the session because gum irritation can interfere with the saliva measures.”

APPENDIX E: INFORMED CONSENT DOCUMENT

UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES
4301 JONES BRIDGE ROAD
BETHESDA, MARYLAND 20814-4799

**INFORMED CONSENT DOCUMENT
FOR A RESEARCH STUDY ON
PERCEPTION AND PHYSIOLOGY WITH DIFFERENT EXPERIENCES**

I. INTRODUCTION

You are being asked to take part in a research study. Before you decide to be part of this study, you need to understand its risks and benefits so that you can make an informed decision. This is known as ***informed consent***.

This consent form provides information about the research study that has been explained to you. Once you understand the study and the tasks it requires, you will be asked to sign this form if you want to take part in this study. Your decision to take part is voluntary. This means you are free to choose if you want to take part in this study.

II. DESCRIPTION OF PURPOSE AND PROCEDURES

The Department of Medical and Clinical Psychology of the Uniformed Services University of the Health Sciences (USUHS) is conducting a study to examine how people perceive different experiences along with the physiological components of these experiences. We are interested in this topic to better understand perceptual processes that may be related to health and performance. You will be asked to complete some questionnaires about yourself. Your heart rate, muscle responses, and blood pressure will be measured. During the study, we will sometimes ask you to hold a wad of cotton in your mouth to get a sample of your saliva to measure a body chemical called cortisol that provides a biological measure of stress. If you are a woman, then we will ask you to spit into a tube to provide another saliva sample to measure the body chemical estrogen. During the study you will be asked to listen to an audiotape and complete some exercises as directed on the tape. You also will be asked to listen to some sounds and to make ratings of some odors and textures. The experimental session will be videotaped. The entire session will take approximately two hours to complete.

USUHS IRB APPROVED
RWK Jones #1
Expires: 15 OCTOBER 2002

 Initials_____

III. OVERVIEW OF THE STUDY

This study involves filling out questionnaires, getting blood pressure, heart-rate, and electromyographic (EMG) measures and providing saliva samples periodically before during and after completing directed exercises from an audio-tape. These exercises may include asking you to listen to different sounds or stories, to speak about different topics, and to tense and relax different muscles. You will be asked to do a task in which you circle symbols on a page, and you will be asked to touch different objects and smell different scents and give your opinions.

IV. STUDY PROCEDURES

A. QUESTIONNAIRES

You will be asked to complete questionnaires that ask some background information and gather information about your mood, sensations, your psychological status and your experiences of the study. The questionnaires are standard instruments used in research studies like this one. You select your answer by marking the response that best describes you or by filling in a response on a black line. The information gathered by these questionnaires is for research purposes only and will not be used to exclude any individual from participation in the study.

B. SALIVA SAMPLES

Several times during your participation in the study, we will ask you to hold a cotton roll in your mouth for a short period of time to get a sample of your saliva to measure a body chemical called cortisol. Cortisol provides a biological measure of stress. For women, you will be asked to spit through a straw into a tube to get a sample of saliva to measure a body chemical called Estradiol that varies with the menstrual cycle.

C. PHYSIOLOGICAL MEASURES

During the study a blood pressure cuff will be placed on your arm to occasionally measure your blood pressure throughout the study. You may feel some slight pressure on your arm when the cuff inflates. Electrical leads will be placed on your collarbone, ribcage, arms, fingers and leg to measure heart rate and physiological responses throughout the study. These leads should present no discomfort. During the study you will be asked to put on headphones and listen to a brief series of abrupt noise bursts. The brief duration of these noise pulses presents no risk to hearing.

D. TAPED EXERCISES

During the study you will be randomly assigned to listen to one of three taped exercises. You will be asked to follow the instructions on the tape. None of the exercises requires physical exertion or involves any anticipated risks. They are similar to activities you might encounter in everyday life.

 Initials

E. CANCELLATION TASK
You will be asked to perform a short task in which you circle symbols on a page.

F. SENSORY RATINGS
You will be asked to touch different objects and smell different scents and give your ratings. These are objects or scents you may encounter in everyday life and there are no anticipated risks or discomforts associated with his activity.

G. VIDEOTAPING
The lab session will be videotaped for quality assurance purposes and in order to record your non-written responses.

V. POTENTIAL BENEFITS TO YOU

Active duty military cannot receive financial compensation for participation in this study. If you are not active duty, then you will receive $30 in return for your participation. Additionally, the information that you provide may contribute to knowledge of perception, health, and performance and you may find the study interesting.

VI. POSSIBLE RISKS

This study involves minimal risk; that is, no risks to your physical or mental health beyond those encountered in the normal course of everyday life.

VII. RIGHT TO WITHDRAW FROM THE STUDY

This study does not entail any physical or mental risk beyond those described above. The investigators do not expect any complications to occur, but if, for any reason, you feel that continuing this study would constitute a hardship for you, the investigators will immediately end your participation in the study. In this case, you will receive $30 as compensation for your time. **You may decide to stop taking part in the study at any time.** Your relations with personnel at the Uniformed Services University of the Health Sciences will not be changed in any way if you decide to end your participation in the study.

USUHS IRB APPROVED 30 NOV 01
Expires: 15 OCTOBER 2002

VIII. RECOURSE IN THE EVENT OF INJURY

This study should not entail any physical or mental risk. We do not expect complications to occur, but if, for any reason, you feel that continuing this study would constitute a hardship for you, we will end your participation in the study. DoD will provide medical care at government facilities for any DoD eligibles (active duty) for injury or illness resulting from participation in this research. If you are not DoD eligible, medical care is available in the event of an injury resulting from research but neither financial compensation nor free medical treatment is provided. Understand that you are not waiving any rights that you might have against the University for injury resulting from negligence of the University or investigators. You can contact the Director of Research

Initials_____

Programs in the Office of Research at the Uniformed Services University of the Health Sciences at (301) 295-3303 if you have additional questions concerning your rights as a participant.

If at any time you believe that you have suffered an injury or illness as a result of participating in this research project, you should contact the Office of Research at the Uniformed Services University of the Health Sciences, Bethesda, MD 20814 at (301) 295-3303. This office can review the matter with you, can provide information about your rights as a subject, and may be able to identify resources available to you. Information about judicial avenues of compensation is available form the University's General Counsel at (301) 295-3028.

IX. PRIVACY AND CONFIDENTIALITY

All information you provide as part of this study will be confidential and will be protected to the fullest extent provided by law. Information that you provide and other records related to this study will be kept private, accessible only to those persons directly involved in conducting this study and members of the Uniformed Services University of the Health Sciences Institutional Review Board (IRB), who provides oversight for protection of human research volunteers. All questionnaires, forms, and video-tapes will be kept in a restricted access, locked cabinet while not in use. However, please be advised that under Federal Law, a military member's confidentiality cannot be strictly guaranteed. To enhance the privacy of the answers you provide, data from questionnaires will be entered into a database in which individual responses are not identified. After verification of the database information, paper copies of the questionnaires containing identifiers will be shredded. Video tapes will be destroyed at the completion of the study.

QUESTIONS

If you have any questions about this research study, you should contact the principal investigator, Bonnie R. Yatko (301-305-9445) or Neil E. Grunberg, Ph.D. (301-295-9673), in the Department of Medical and Clinical Psychology, Uniformed Services University of the Health Sciences. If you have any questions about your rights as a research subject, you should call the Director of Research Programs in the Office of Research at the Uniformed Services University of the Health Sciences at (301) 295-3303. This person is your representative and has no connection to the personnel conducting this study.

USUHS IRB APPROVED
RUX 30 NOV 01
Expires: 15 OCTOBER 2002

Initials____

SIGNATURES

By signing this consent form you are agreeing that this study has been explained to you, you understand this study, you understand that the study is designed for research purposes and not to be of direct benefit to you, and that you may withdraw your consent to participate at any time. You are signing that you agree to take part in this study. You will be given a copy of this consent form.

SIGNATURE OF VOLUNTEER:______________________________________

PRINTED NAME OF VOLUNTEER:___________________________________

DATE:_______________

SIGNATURE OF WITNESS:____

DATE:_______________

INVESTIGATOR STATEMENT

I certify that the research study has been explained to the above individual, by me or members of the research team, and that the individual understands the nature and purpose, the possible risks and benefits associated with taking part in this research study. Any questions that have been raised have been answered.

INVESTIGATOR SIGNATURE:______________________DATE:_____________

Initials_____

APPENDIX F: SELF-REPORT MEASURES

6639243250

QUESTIONNAIRE SET 1

Background Questionnaire

Subject Number ☐☐☐☐☐

Enter today's date (month/day/year) ☐☐ / ☐☐ / ☐☐☐☐

Enter your birth date (month/day/year) ☐☐ / ☐☐ / ☐☐☐☐

GENDER ☐ Male ☐ Female

What race and ethnic background do you identify yourself with? (mark one or more)

☐ American Indian or Alaskan Native
☐ Asian
☐ Black or African American
☐ Hispanic or Latino
☐ Native Hawaiian or Other Pacific Islander
☐ White

What is the highest education level you have attained?

☐ Some High School ☐ HS/GED Diploma ☐ Tech School ☐ Some College
☐ BA or BS degree ☐ Master's Degree ☐ Doctoral/Law Degree

About how many beverages containing caffeine do you consume a day?

☐ None ☐ 1-2 ☐ 3-4 ☐ 5-6 ☐ 7-8 ☐ 9 or more

Do you use tobacco products (such as cigarettes, pipe tobacco, chewing tobacco) on a daily basis? ☐ Yes ☐ No

(For women) Are you currently taking oral contraceptives? ☐ Yes ☐ No

---

VAS

Place an 'X' or mark at the point on the following four lines that best describe yourself at this moment.

Extremely relaxed ________________________ Extremely tense

Extremely calm ________________________ Extremely anxious

Extremely bored ________________________ Extremely interested

Extremely distracted ________________________ Extremely focused

7386243250

SEQ

Subject Number

People sometimes experience their senses differently. The following questions ask about your common experiences with your senses. There are no right or wrong answers for any questions. For each of the following questions, please mark the response that best describes you. The word *sensitive* in these questions means *more likely to notice*.

1. Are you sensitive to the temperature of food?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
2. Are you sensitive to the temperature of water (like in a bath)?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
3. Are you very sensitive to pain?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
4. Are you very insensitive to pain?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
5. Do you dislike being touched?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
6. Do you dislike the feel of certain clothes?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
7. Do you dislike the feel of tags or seams in shirts, pants, or socks?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
8. Do you dislike being spun around?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
9. Do you get sick from movement?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
10. Do you respond negatively to unexpected or to loud noises?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
11. Do common sounds or noises (like vacuum cleaners, kitchen appliances, or sirens) bother you?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
12. Do almost unnoticeable sounds distract you (like refrigerators, fans, or heaters)?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
13. Are you very sensitive to light?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
14. Do you like to watch objects spin?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
15. Do you like to watch blinking lights?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
16. Do you cover your eyes often?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
17. Are you very sensitive to certain smells?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
18. Do certain smells distract you?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
19. Do certain smells bother you?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
20. Are you very sensitive to certain tastes?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
21. Do you prefer spicy foods?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
22. Do you prefer sour foods?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
23. Do you prefer sweet foods?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always
24. Do you chew on non food items (like fingernails, pencils, or paper)?	☐ Never	☐ Rarely	☐ Sometimes	☐ Usually	☐ Always

6909243250

TS

Subject Number ☐☐☐☐☐

1. Which do you usually think about? (Mark one)

☐ Past ☐ Present ☐ Future

2. When you think about the past, how far back are you most often thinking? (Mark one)

☐ minutes ☐ hours ☐ days ☐ weeks ☐ months ☐ years ☐ decades

3. When you think about the present, what time frame do you think about? (Mark one)

☐ within seconds ☐ within minutes ☐ this hour ☐ this day ☐ this week

4. When you think about the future, how far into the future are you most often thinking? (Mark one)

☐ minutes ☐ hours ☐ days ☐ weeks ☐ months ☐ years ☐ decades

5. Please indicate the percentage of time that you usually think about the:

Past ______ % Present ______ % Future ______ % (total should = 100%)

6. Please rate how you feel about your: (Mark one box for each time)

a. Past	☐ Very bad	☐ Bad	☐ Neutral	☐ Good	☐ Very Good
b. Present	☐ Very bad	☐ Bad	☐ Neutral	☐ Good	☐ Very Good
c. Future	☐ Very bad	☐ Bad	☐ Neutral	☐ Good	☐ Very Good

7. How long would you think about a minor physical stressor (e.g., a stubbed toe, paper cut, or minor scrape) after it had happened and assuming no permanent consequences?

☐ Seconds ☐ Minutes ☐ Hours ☐ Days ☐ Weeks ☐ Months ☐ Years

8. How long would you think about a major physical stressor (e.g., broken bones, pneumonia) after it had happened and assuming no permanent consequences?

☐ Seconds ☐ Minutes ☐ Hours ☐ Days ☐ Weeks ☐ Months ☐ Years

9. How long would you think about a minor psychological stressor (e.g., minor disagreement with a friend) after it had happened and assuming no permanent consequences?

☐ Seconds ☐ Minutes ☐ Hours ☐ Days ☐ Weeks ☐ Months ☐ Years

10. How long would you think about a major psychological stressor (e.g.,major argument with a significant other) after it had happened and assuming no permanent consequences?

☐ Seconds ☐ Minutes ☐ Hours ☐ Days ☐ Weeks ☐ Months ☐ Years

Place an 'X' or mark on the line below to indicate how quickly or slowly time usually passes.

Extremely slowly ____ Extremely quickly

Place an 'X' or mark on the line below to indicate how quickly or slowly time is passing right now.

Extremely slowly ____ Extremely quickly

3090243258

PSS

Subject Number

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, please indicate with a check how often you felt or thought a certain way.

1. In the last month, how often have you been upset because of something that happened unexpectedly?

☐ never ☐ almost never ☐ sometimes ☐ fairly often ☐ very often

2. In the last month, how often have you felt that you were unable to control the important things in your life?

☐ never ☐ almost never ☐ sometimes ☐ fairly often ☐ very often

3. In the last month, how often have you felt nervous and "stressed"?

☐ never ☐ almost never ☐ sometimes ☐ fairly often ☐ very often

4. In the last month, how often have you felt confident about your ability to handle your personal problems?

☐ never ☐ almost never ☐ sometimes ☐ fairly often ☐ very often

5. In the last month, how often have you felt that things were going your way?

☐ never ☐ almost never ☐ sometimes ☐ fairly often ☐ very often

6. In the last month, how often have you found that you could not cope with all the things that you had to do?

☐ never ☐ almost never ☐ sometimes ☐ fairly often ☐ very often

7. In the last month, how often have you been able to control the irritations in your life?

☐ never ☐ almost never ☐ sometimes ☐ fairly often ☐ very often

8. In the last month, how often have you felt that you were on top of things?

☐ never ☐ almost never ☐ sometimes ☐ fairly often ☐ very often

9. In the last month, how often have you been angered because of things that were outside of your control?

☐ never ☐ almost never ☐ sometimes ☐ fairly often ☐ very often

10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

☐ never ☐ almost never ☐ sometimes ☐ fairly often ☐ very often

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QUESTIONNAIRE SET 2

Subject Number [| | | |]

Place an 'X' or mark at the point on the following four lines that best describe yourself at this moment.

Extremely relaxed ________________________________ Extremely tense

Extremely calm ________________________________ Extremely anxious

Extremely bored ________________________________ Extremely interested

Extremely distracted ________________________________ Extremely focused

Place an 'X' or mark on the line below to indicate how quickly or slowly time passed during *Phase 2* of the experiment (while you were following the taped instructions).

Extremely slowly ________________________________ Extremely quickly

Place an 'X' or mark on the line below to indicate how quickly or slowly time is passing right now.

Extremely slowly ________________________________ Extremely quickly

Please estimate how long *(in minutes)* you spent in Phase 2 of the experiment (while you were following the taped instructions) :

[|] minutes

Please estimate how long (in minutes) you were sitting still and quiet while heart rate and blood pressure readings were first taken today:

[|] minutes

Please indicate the percentage of time that you thought about *the past, present* and future during Phase 2 of the experiment (while you were following the taped instructions) :

Past ______ % Present ______ % Future ______ % *(total should = 100%)*

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QUESTIONNAIRE SET 3

Subject Number

Below are words that describe feelings and moods people have. Please read EVERY word carefully. Select the answer which best describes how you feel AT THIS MOMENT by placing a check or X in the appropriate box.

FEELING/MOOD	Not at all	A little bit	Moderately	Quite a bit	Extremely
Tense	☐	☐	☐	☐	☐
Confused	☐	☐	☐	☐	☐
Lively	☐	☐	☐	☐	☐
Sad	☐	☐	☐	☐	☐
On edge	☐	☐	☐	☐	☐
Unable to concentrate	☐	☐	☐	☐	☐
Active	☐	☐	☐	☐	☐
Blue	☐	☐	☐	☐	☐
Uneasy	☐	☐	☐	☐	☐
Bewildered	☐	☐	☐	☐	☐
Energetic	☐	☐	☐	☐	☐
Hopeless	☐	☐	☐	☐	☐
Restless	☐	☐	☐	☐	☐
Forgetful	☐	☐	☐	☐	☐
Cheerful	☐	☐	☐	☐	☐
Discouraged	☐	☐	☐	☐	☐
Nervous	☐	☐	☐	☐	☐
Uncertain about things	☐	☐	☐	☐	☐
Full of pep	☐	☐	☐	☐	☐
Miserable	☐	☐	☐	☐	☐
Anxious	☐	☐	☐	☐	☐
Vigorous	☐	☐	☐	☐	☐
Helpless	☐	☐	☐	☐	☐
Worthless	☐	☐	☐	☐	☐
Unhappy	☐	☐	☐	☐	☐

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Debrief Questionnaire

Subject Number | | | | | |

So far during this experiment, you have been asked three different times to place cotton in your mouth to collect a saliva sample.

1. Please indicate which collection (1st, 2nd, or 3rd) you had to keep the cotton in your mouth:

For the longest time ? ☐ 1st ☐ 2nd ☐ 3rd

For the shortest time? ☐ 1st ☐ 2nd ☐ 3rd

2. Did you notice any beeping sounds during Phase 2 of the experiment (while you were following the taped instructions)?

☐ Yes ☐ No If so, how many did you notice? ___

3. Please explain any previous experience you have had with activities that you did today during Phase 2 of the experiment (such as relaxation training, giving speeches, or listening to books on tape).

4. Please explain how you went about making the time estimates in this experiment.

5. Would you recommend participation in this study or a similar study to someone you know?

☐ Definitely not ☐ Probably not ☐ Maybe ☐ Probably ☐ Definitely yes

6. What did you think of this study (mark all that apply)?

☐ Upsetting ☐ Learned something ☐ Boring ☐ Worthwhile ☐ Interesting ☐ Disliked ☐ Liked

7. Hav e vou nersonallv exnerienced a traumatic event? Please exnlain the tvne of event and how lone ago it was.

8. Please comment on anything you would like the experimenter to know about your experience today?

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Sensory Ratings Touch

Subject Number ☐☐☐☐☐

Instructions: Please feel each object and rate it on the following two scales by placing an "X" in the box by one number in response to each question.

1.	Rough	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Smooth
	Pleasant	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Unpleasant
2.	Rough	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Smooth
	Pleasant	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Unpleasant
3.	Rough	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Smooth
	Pleasant	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Unpleasant
4.	Rough	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Smooth
	Pleasant	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Unpleasant
5.	Rough	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Smooth
	Pleasant	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Unpleasant
6.	Rough	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Smooth
	Pleasant	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Unpleasant

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Sensory Ratings Smell

Subject Number

Instructions: Please smell each object and rate it on the following two scales by placing an "X" in the box by one number in response to each question.

1. Odorless ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 Strong Odor

Pleasant ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 Unpleasant

2. Odorless ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 Strong Odor

Pleasant ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 Unpleasant

3. Odorless ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 Strong Odor

Pleasant ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 Unpleasant

4. Odorless ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 Strong Odor

Pleasant ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 Unpleasant

5. Odorless ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 Strong Odor

Pleasant ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 Unpleasant

6. Odorless ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 Strong Odor

Pleasant ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 Unpleasant

APPENDIX G: ASSAY PROTOCOLS

SALIMETRICS LLC

HS-CORTISOL HIGH SENSITIVITY

SALIVARY CORTISOL ENZYME IMMUNOASSAY KIT

Catalog No. 1-0102/1-0112 96-Well Kit Updated: 1/15/03

For Research Use Only. Not For Diagnostic Use

Intended Use

Salimetrics HS-Cortisol kit is a competitive immunoassay specifically designed for the quantitative measurement of salivary cortisol. It is not intended for use with serum/plasma or for diagnostic use. It is intended only for research use with saliva. Please read the complete kit insert before performing this assay. For further information about this kit, its application, or the procedures in this insert, please contact the technical service team at Salimetrics by phone at (800) 790-2258, Fax (814) 234-1608, or online at www.salimetrics.com.

Introduction

At Salimetrics, we know that the current market approach to the application of immunoassay techniques in the measurement of biomarkers in saliva is problematic. This assay kit has been designed to specifically address the following three problems. First, the majority of available immunoassays for saliva cortisol are modifications of protocols developed for the use with serum/plasma. The calibrators used in those assay kits are suspended in a human serum matrix. Given that the composition of serum is markedly different from saliva, these calibrators are likely to produce results that are influenced by matrix differences. To ensure the most accurate results, this salivary immunoassay is designed using a matrix that matches saliva. Second, the level of cortisol in saliva is significantly lower than levels in the general circulation. The use of a standard curve developed to capture the range of values expected in serum/plasma samples is often not sensitive enough to capture the complete range of individual differences in the level expected in saliva. This assay is designed to capture the full range of salivary cortisol levels while using only 25 µL of saliva per test. Third, the pH of saliva is easily lowered or raised by the consumption of food or drink. Performance of immunoassays becomes compromised as the pH of samples to be tested drops below 4 (1). This results in artificially inflated levels. This assay system is designed to be very sensitive to the effects of interference caused by collection techniques that affect pH. In addition, a built-in pH indicator warns the user of acidic or basic samples.

Test Principle

A microtitre plate is coated with rabbit antibodies to cortisol. Cortisol in standards and unknowns compete with cortisol linked to horseradish peroxidase for the antibody binding sites. After incubation, unbound components are washed away. Bound cortisol peroxidase is measured by the reaction of the peroxidase enzyme on the substrate tetramethylbenzidine (TMB). This reaction produces a blue color. A yellow color is formed after stopping the reaction with sulfuric acid. Optical Density is read on a standard plate reader at 450 nm. The amount of cortisol peroxidase detected is inversely proportional to the amount of cortisol present (2).

Special Feature

A pH indicator in the assay diluent alerts the user to samples with high or low pH values. Acidic samples will turn the diluent yellow. Alkaline samples will turn the diluent purple. Dark yellow or purple wells indicate that a pH value for that sample should be obtained using pH strips. Cortisol values from samples with a pH $\leq$ 3.5 or $\geq$ 9.0 may be artificially inflated or lowered (1).

Precautions

1. Stop Solution is a solution of sulfuric acid. This solution is caustic; use with care.
2. This kit uses break-apart microtitre strips. Unused wells must be stored at 4°C in the sealed foil pouch and used in the frame provided.
3. Do not mix components from different lots of kits.
4. When using a multichannel pipette, reagents should be added to duplicate wells at the same time. Follow the same sequence when adding additional reagents so that incubation time with reagents is the same for all wells.
5. See Material Safety Data at the end of procedure.
6. As for all quantitative assays for salivary analytes, we highly recommend that samples be screened for possible blood contamination. This can be efficiently and economically accomplished using Salimetrics Blood Protein EIA Kit (Cat No: 1-1302/1-1312). For a description of this assay or an assay kit insert see www.salimetrics.com.
7. Routine calibration of pipettes is critical for the best possible assay performance.
8. Pipetting of samples and reagents must be done as quickly as possible (without interruption) across the plate.
9. When running multiple plates, or multiple sets of strips, a standard curve should be run with each individual plate and/or strips.

Storage All components of this kit are stable at 2-8°C until the kit's expiration date.

Reagents and Reagent Preparation

1. **Anti-Cortisol Coated Plate**: A ready to use microtitre plate pre-coated with antibodies in a resealable foil pouch.
2. **Cortisol Standard**: Cortisol, at a concentration of 1.8 µg/dL.
3. **Wash Buffer**: A 10X phosphate buffered solution containing detergents and a non-mercury preservative. Dilute the wash buffer concentrate 10 fold with room temperature deionized water (100 ml of 10X wash buffer to 900 ml of deionized H_2O). (**If precipitate has formed in the concentrated wash buffer, it may be heated to 60°C for 15 minutes. Cool to room temperature before use in assay.)*
4. **Assay Diluent**: A phosphate buffered solution containing a pH indicator and a non-mercury preservative.
5. **Enzyme Conjugate**: A solution of cortisol labeled with horseradish peroxidase.
6. **Tetramethylbenzidine (TMB)**: A non-toxic ready to use solution.
7. **Stop Solution**: A solution of sulfuric acid in distilled water. (USA customers only). Stop solution is provided in powdered form to customers outside the USA. Reconstitute the powdered stop solution with 12.5 mL of deionized water. Let sit for 20 minutes before use.
8. **Non-specific Binding Wells**: These wells do not contain anti-cortisol antibody. In order to support multiple-use, a strip of NSB wells is included. They are located in the foil pouch. Wells may be broken off and inserted where needed.

Note: The quantity of reagent provided with break-apart kits is sufficient for three individual runs. The volume of diluent and conjugate used for assays using less than a full plate should be scaled down accordingly, keeping the same dilution ratio.

Materials Needed But Not Supplied

- Precision pipette to deliver 25 µL, 50 µL, and 100 µL and 24 mL.
- Precision multichannel pipette to deliver 50 µl, and 200 µl.
- Vortex
- Plate rotator (if unavailable, tap to mix)
- Plate reader with a 450 nm filter
- Log-linear graph paper or computer software for data reduction
- Deionized water
- Reagent reservoirs
- One disposable tube capable of holding 24 mL
- Five small disposable tubes
- Pipette tips
- Serological pipette

Specimen Collection

The preferred saliva collection method (3,4) is to use plain (non-citric acid) cotton Salivettes (Sarstedt). Freeze all saliva samples prior to assay in order to precipitate mucins. Thaw completely, vortex, and centrifuge at 1500 x g (@3000 rpm) for 15 minutes. Pipette clear sample into appropriate wells.

Procedure

Bring all reagents to room temperature.

Step 1: Determine your plate layout. Here is a suggested layout.

	1	2	3	4	5	6	7	8	9	10	11	12
A	1.80 Std	1.80 Std	Control H	Control H								
B	.600 Std.	.600 Std	Control L	Control L								
C	.200 Std	.200 Std	Sample 1	Sample 1								
D	.067 Std	.067 Std	Sample 2	Sample 2								
E	.022 Std	.022 Std	Sample 3	Sample 3								
F	.007 Std	.007 Std	Sample 4	Sample 4								
G	Zero	Zero	Sample 5	Sample 5								
H	Nsb	Nsb	Sample 6	Sample 6								

Step 2: Keep the desired number of strips in the strip holder and place the remaining strips back in the foil pouch. If you choose to place non-specific binding wells in H-1, 2, remove strips 1 and 2 from the strip holder and break off the bottom wells. Place the strips back into the strip holder leaving H-1, 2 blank. Break off 2 NSB wells from the strip of NSBs included in the foil pouch. Place in H-1, 2. Alternatively, NSBs may be placed wherever you choose on the plate. Reseal the zip-lock and refrigerate the pouch at 4°C.
Caution: Extra NSB wells should not be used for determination of calibrators or unknowns.

Step 3:

- Label five microcentrifuge tubes or other small tubes 2 through 6.
- Pipette 100 µL of assay diluent in tubes 2 through 6.
- Serially dilute the standard 3X by adding 50 µL of the 1.80 µg/dL standard (tube 1) to tube 2. Mix well. After changing pipette tips, remove 50 µL from tube 2 to tube 3. Mix well. Continue for tubes 4, 5, and 6. The final concentrations of standards for tubes 1 through 6 respectively are 1.800 µg/dL, 0.600 µg/dL, 0.200 µg/dL, 0.067 µg/dL, 0.022 µg/dL, and 0.007 µg/dL.
  (Values in nmol/L are 49.66, 16.55, 5.52, 1.84, 0.61, and 0.20 nmol/L respectively.)
- Pipette 24 mLs of assay diluent into a disposable tube. Set aside for Step 5.

Step 4:

- Pipette 25 µL of standards and unknowns into appropriate wells. Standards and samples should be assayed in duplicate.
- Pipette 25 µL of assay diluent into 2 wells to serve as the zero.
- Pipette 25 µL of assay diluent into each NSB well.

Step 5: Make a 1:1,600 dilution of the conjugate, by adding 15 µL of the conjugate to the 24 mL of assay diluent prepared in Step 3, (full plate only). Immediately mix the diluted conjugate solution and pipette 200 µL into each well using a multichannel pipette.

Step 6: Mix plate on rotator for 5 minutes at 500 rpm (or tap to mix) and incubate at room temperature for an additional 55 minutes.

Step 7: Wash the plate 4 times with 1X wash buffer. A plate washer is recommended. However, washing may be done by gently squirting wash buffer into each well with a squirt bottle or by pipetting 300µL of wash buffer into each well, and then discarding the liquid by inverting the plate over a sink. After each wash, the plate should be thoroughly blotted on paper towels before being turned upright. *If using a plate washer, blotting is still recommended after the last wash.*

Step 8: Add 200 µL of TMB solution to each well with a multichannel pipette.

Step 9: Mix on a plate rotator for 5 minutes at 500 rpm (or tap to mix) and incubate the plate in the dark at room temperature for an additional 25 minutes.

Step 10: Add 50 µL of stop solution with a multichannel pipette.

Step 11:

- Mix on a plate rotator for 3 minutes at 500 rpm (or tap to mix). **Caution:** *DO NOT mix at speeds over 600 rpms. Wells are very full!*
- Wipe off bottom of plate with a water-moistened lint-free cloth and wipe dry.
- Read in a plate reader at 450 nm. Read plate within 10 minutes of adding stop solution (correction at 492 to 620 is desirable).

Calculations

1. Compute the average Optical Density (OD) for all duplicate wells.
2. Subtract the average OD for the NSB wells from the average OD of the zero, standards, and unknowns.
3. Calculate the percent bound (B/BO) for each standard by dividing the average OD (B) by the average OD for the zero (BO).
4. If calculating the results by hand, plot B/BO on the vertical axis against the log of the concentration on the horizontal axis for each calibrator and draw a straight line through the points. Determine the concentrations of the unknowns by interpolation.
5. If using software capable of logistics, use a 4 parameter sigmoid minus curve fit. Otherwise, use log-linear regression.

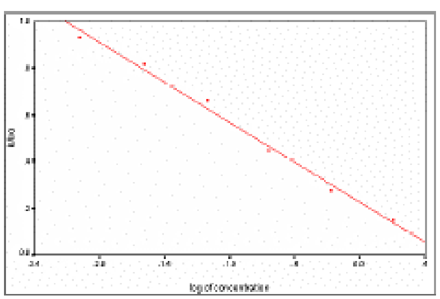
Typical Results

The following charts and graphs are for illustration only and SHOULD NOT be used to calculate results from another assay.

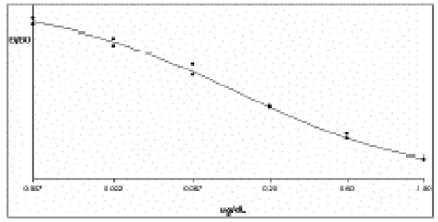
Well	Sample	Average OD	B	B/Bo	Cortisol ug/dL
A1,A2	S1	0.229	0.205	0.1207	1.613
B1,B2	S2	0.419	0.395	0.2326	0.757
C1,C2	S3	0.737	0.713	0.4199	0.214
D1,D2	S4	1.090	1.066	0.6278	0.052
E1,E2	S5	1.330	1.306	0.7691	0.020
F1,F2	S6	1.561	1.537	0.9052	0.008
G1,G2	B0	1.722	1.698	NA	
H1,H2	NSB	0.024	NA	NA	

Example: Standard Curves

Log-Linear Regression



4-Parameter Sigmoid Minus Curve Fit



Material Safety Data*

Hazardous Ingredients

Stop Solution is a solution of sulfuric acid. This solution is caustic; use with care. We recommend the procedures listed below for all kit reagents.

Handling

Follow good laboratory procedures when handling kit reagents. Laboratory coats, gloves, and safety goggles are recommended. Wipe up spills using standard absorbent materials while wearing protective clothing. Follow local regulations for disposal.

Emergency Exposure Measures

In case of contact, immediately wash skin or flush eyes with water for 15 minutes. Remove contaminated clothing. If inhaled, remove individual to fresh air. If individual experiences difficulty breathing, give oxygen and call a physician.

*The above information is believed to be accurate but is not all-inclusive. This information should only be used as a guide. Salimetrics shall not be liable for accidents or damage resulting from contact with reagents.

References

1. Schwartz, E.B., Granger, D.A., Susman, E.J., Gunnar, M.R., & Laird, B. (1998). Assessing Salivary Cortisol in Studies of Child Development. Child Development, 69, 1503-1513.
2. Chard, T. (1990). An Introduction to Radioimmunoassay and Related Techniques. Elsevier, Amsterdam.
3. Clements, A.D., & Parker, C.R. (1998). The Relationship Between Salivary Cortisol Concentrations in Frozen Versus Mailed Samples. Psychoneuroendocrinology, 23, 613-616.
4. Kirschbaum, C., Read, G.F., & Hellhammer, D.H. (1992). Assessment of Hormones and Drugs in Saliva in Biobehavioral Research. Kirkland, WA: Hogefe & Huber Publishers.

HS Cortisol EIA Assay Performance Characteristics

Recovery: Two saliva samples containing different levels of endogenous cortisol were spiked with known quantities of cortisol and assayed.

Sample	Endogenous (ug/dL)	Added (ug/dL)	Expected (ug/dL)	Observed (ug/dL)	Recovery (%)
1	0.41	0.54	0.95	0.825	86.8%
		0.04	0.450	0.390	86.7%
2	0.111	0.54	0.651	0.614	94.3%
		0.04	0.151	0.136	90.1%

Precision:

1. The intra-assay precision was determined from the mean of 10 replicates each.

Sample	N	Mean (ug/dL)	Standard Deviation (ug/dL)	Coefficient of Variation (%)
H	10	0.897	0.01	3.88
M	10	0.51	0.03	6.22
L	10	0.14	0.01	7.12

2. The inter-assay precision was determined from the mean of average duplicates for ten separate runs.

Sample	N	Mean (ug/dL)	Standard Deviation (ug/dL)	Coefficient of Variation (%)
H	10	0.538	0.04	6.69
L	10	0.129	0.01	6.88

Linearity of Dilution: Three saliva samples were diluted with PBS and assayed.

Sample	Dilution Factor	Expected (ug/dL)	Observed (ug/dL)	Recovery (%)
1			0.513	
	1:2	0.256	0.271	105.8%
	1:4	0.128	0.134	104.7%
	1:8	0.064	0.057	89%
	1:16	0.032	0.036	112.5%
	1:32	0.016	0.015	93.8%
2			0.141	
	1:2	0.071	0.068	95.8%
	1:4	0.035	0.035	100%
	1:8	0.018	0.020	111.1%
3			0.387	
	1:2	0.193	0.199	103.1%
	1:4	0.097	0.100	103.1%
	1:8	0.048	0.054	112.5%
	1:16	0.024	0.023	95.8%
	1:32	0.012	0.011	91.7%

Sensitivity: The lower limit of sensitivity was determined by interpolating the mean minus 2SD for 10 sets of duplicates at 0 ug/dL standard. The minimal concentration of cortisol that can be distinguished from 0 is <.007 ug/dL.

Correlation with Serum: The correlation between serum and saliva cortisol was determined by assaying 19 matched samples using the Diagnostic Products Corporation serum Coat-a-Count Cortisol RIA and the Salimetrics HS Salivary Cortisol EIA.

The correlation between saliva and serum was highly significant, $r(17) = 0.960$, $p < 0.0001$.

Seller's Limited Warranty

"Seller warrants that all goods sold hereunder will be free from defects in material and workmanship. Upon prompt notice by Buyer of any claimed defect, which notice must be sent within thirty (30) days from date such defect is first discovered and within six months from the date of shipment, Seller shall, at its option, either repair or replace the product that is proved to Seller's satisfaction to be defective. This warranty does not cover any damage due to accident, misuse, negligence, or abnormal use.

It is expressly agreed that this limited warranty shall be in lieu of all warranties of fitness and in lieu of the warranty of merchantability. Seller shall not be liable for any incidental or consequential damages that arise out of the installation, use or operation of Seller's product or out of the breach of any express or implied warranties."

APPENDIX H: LABORATORY INSTRUCTIONS

STARS (Study of Time After Relaxation or Stress) Script
Principle Investigator: Bonnie R. Yatko, M. S.
Laboratory of Neil E. Grunberg, Ph.D.
Uniformed Services University of the Health Sciences

PHASE I

Meet participant at building entrance / security desk.

Hello. Are you here to participate in a perception study? Are you (name)? My name is Bonnie Yatko, and I'll be working with you today. Our room is __________.
(Go to room and talk with participant during the trip about directions, parking, USUHS.)

Before we get started, would you like to use the restroom?

Wait, if necessary. Then, escort the participant to the human laboratory.

This is the room where the study will take place. Please have a seat in the large chair and make yourself comfortable. May I hang up your coat for you?

First, thank you for coming today. We greatly appreciate your participation.

As we discussed on the phone, this study is concerned with how people perceive different experiences along with the physiological components of these experiences.

We are interested in this topic to better understand perceptual processes that may be related to health and performance.

The study consists of filling out some questionnaires and completing some tape-recorded exercises. We'll measure your heart rate, muscular responses and blood pressure at various times during the study and also ask you to give saliva samples. The saliva samples will be used to measure the level of cortisol, a chemical in your body associated with stress. For women, one of the saliva samples will be used to measure estradiol, a chemical that fluctuates with the menstrual cycle. The entire session will be videotaped for quality assurance purposes and in order to record your non-written responses.

Please rinse out your mouth with water from the sports bottle on the table.

Start video recording.

Before we go any farther, please read over this consent form. (***Hand participant two copies of consent form).***

Essentially, what the consent form says is:

- Each person participating in a study must read and sign a consent form to indicate their understanding and willingness to take part.

- The next section reviews the purpose and procedures of the study as I just described it to you, and indicates that the experiment should last no more than 2 hours for which you will receive $30.00 for participating.

- The next sections say that the study involves no risk, and should not result in any discomfort, however, you are free to discontinue at any time.

- The next section is required in consent forms, and says that the government may provide compensation through judicial avenues to non active-duty participants if they are injured.

- The next section says that information that is gathered during the study is protected to fullest extent of the law, and any information about the study that is disclosed will be done so in a manner that does not reveal your identity.

- The last sections say that if you have any questions about the study, you can call Dr. Neil Grunberg at the number listed on the consent form, and that you agree to take part in the study by signing the consent form.

- You also need to initial where there is a blank provided at the bottom of the first two pages, to indicate that you have read them. When you are finished reading the consent form, please fill out the last page with your name, today's date, and your signature for each copy of the form. One of the copies is for you to take home at the end of the study.

- Do you have any questions at this time?

Answer questions. Start Video Recording

Throughout the study, we'll be measuring your heart rate and blood pressure because we are interested in physiological as well as perceptual responses during different experiences. For this reason, I am attaching this blood pressure cuff to your arm, and request that you do not move it while it is attached during today's study. (***Attach blood pressure cuff.***) I am attaching leads to your arms and leg to measure heart rate and muscular responses. To make sure the equipment functions properly, please remove any watches, pagers or cellular phones and place them in this box. These will be locked in a safe place and returned to you at the end of the study. (***Place consent forms in the box and take box out of the experimental room. Attach leads.)***

Also, try to keep your arm still as much as possible. The blood pressure cuff will inflate from time to time throughout the study. Just ignore it and continue with the directed task.

Open the blue folder on the table next to you. It contains a questionnaire packet that asks about some of your background and experiences. Again, all information you provide is confidential. Please read the instructions on each page of the questionnaire packet in the folder. You may use either pencil or pen provided on the table, but please print clearly or place your x in the box as appropriate. If you make a mistake, then just mark through it neatly and then mark your new response. When you finish, please make sure you have answered each page, place the packet back in the blue folder, and wait for further instructions. Begin answering the questionnaire packet now.

Now, I would like to collect the first saliva sample.

Open the plastic tube labeled 1 but do not touch the inside of the tube or the cotton wad with your hands.

When you hear the direction "start" put the cotton in your mouth and roll it around on your tongue until you hear the direction "stop." Do not let the cotton get under your tongue or between your cheek and gum. Do you have any questions?

Answer questions.

Ready, start. (***Wait time 2 minutes)***

Stop. Now spit the cotton into the larger collection tube and place the cap on firmly.

Place the collection tube in the ice bucket.

From here on, your instructions will be given by audio-tape so that it is just the same for each participant. Please do your best to follow all of the instructions carefully. The experimenter will remain in the room in case you need her during the course of the study.

START TAPE

Please rinse out your mouth with water from the sports bottle on the table.

When I tell you to start, please let me know when you think 1 minute has gone by. Try not to count. Just estimate when 1 minute has elapsed. When I say start, you will begin and you will say, "stop" in a loud, clear voice when the time has passed. Ready. Start.
(Stop Tape until after the "stop" then restart tape.)

Now, when I tell you to start, please let me know when $2^1/_4$ minutes have gone by. Try not to count. Just estimate when $2^1/_4$ minutes have elapsed. When I say start, you will begin and you will say, "stop" in a loud, clear voice when the time has passed. Ready. Start.
(Stop Tape until after the "stop" then restart tape.)
In a moment I will say, "START" and after a period of time **I will say** "STOP". When I say stop, please say how much time you feel went by from start to stop. Try not to count,

just say in a loud, clear voice how much time it felt like in seconds. Ready. Start. (47s) Stop. Now say how long in seconds it felt like from start to stop.

Nonverbal Cancellation Test. This is the target symbol. When I tell you to start, I want you to circle all of the target symbols on this page as quickly and as accurately as you can. When you finish turn your paper over. Ready. Start.

Acoustic Startle. I am going to place a pair of earphones on you. You will hear a series of loud and abrupt bursts of static over the headphones. Ignore the noises and sit still and quiet until given further instructions. (10 minutes)

At this time, please collect the second saliva sample.

Open the plastic tube labeled 2 but do not touch the inside of the tube or the cotton wad with your hands.

When you hear the direction "start" put the cotton in your mouth and roll it around on your tongue until you hear the direction "stop." Do not let the cotton get under your tongue or between your cheek and gum.

Ready, start.

Stop. Now spit the cotton into the larger collection tube and place the cap on firmly.

Place the collection tube in the ice bucket.

Time production. When I tell you to start, please let me know when you think that 1-minute has gone by. Try not to count. Just estimate when 1-minute has elapsed. When I say start, you will begin and you will say, "stop" in a loud, clear voice when the time has passed. Ready. Start.

(Stop Tape until after the "stop" then restart tape.)

Time estimation. The experimenter will stop the tape after the direction "start" and will restart the tape after the participant has said, "stop." The tape will give the instructions for the 18-second prospective verbal time estimation.

In a moment I will say, "START" and after a period of time I will say "STOP." When I say stop, please say how much time you feel went by from start to stop. Try not to count, just say in a loud, clear voice how much time it felt like in seconds. Ready. Start. (18s) Stop. Now say how long in seconds it felt like from start to stop.

Phase II of this experiment will begin shortly. Continue to follow the instructions on the tape.

PHASE II

Control Condition: You will hear a taped passage from a biography of a famous person. After the passage you will be asked a few questions about the passage and what you thought of it.

Adams biography passage. (15 minutes, Questions 1 minute)

Now please answer these questions in a loud, clear voice. (0.5 minutes)
Who was the passage about?
On a scale of 1 to 10, with 1 being disliking it very much and 10 being liking it very much, how would you rate this passage?
On a scale of 1 to 10, with 1 being very boring and 10 being extremely interesting, how would you rate this passage?

Relaxation Condition: You are about to hear a relaxation exercise. The directions for this exercise will be read to you by a voice on this tape. Please listen to the directions on the tape, and follow along with the exercise as explained on the tape. (16 minutes)

Stress Condition: You are now to prepare a speech concerning your personal faults or undesirable habits; those aspects of your behavior or personality with which you are not happy. Please do not divulge information on any illegal activities. The speech will be video-taped, and will be evaluated by a panel of psychologists for the quality of the speech, the style of presentation, and the content of the speech. Try to make the speech as organized as possible because the quality, content, and style will be evaluated. Begin preparing your speech now. Do not begin giving your speech until instructed to do so (4 minutes).

Ok, your planning time is over and it is time to begin. Remember to speak for the entire time until I say stop, continuing to speak to the psychologists watching the video tape. Remain seated and look toward the video-camera. Start speaking now (4 minutes). STOP speaking now.

We would like you to give another speech. Again the speech will be video-taped, and a panel of psychologists will listen to what you say in your speech, as well as how well you say it. I'm going to read you a hypothetical situation where you're accused of shoplifting, Then I'll ask you to prepare and deliver a speech in defense of yourself as if you were appearing before a judge. After I describe the situation to you, you will have some time to plan your story. Do not begin giving your speech until instructed to do so. You must speak for the entire time allowed until I say STOP.

You are shopping in a mall in a department store and you pick up a pair of sunglasses to look at them. All of a sudden you feel a hand grab you on the shoulder, turn you around, and a voice say, "okay, I saw you steal those sunglasses." You then realize that you are being accused by a department store security guard of stealing store merchandise, which, of course, you didn't do. You are brought back to the department st ore security office where you are formally charged with shoplifting. Your attempts to explain the situation are ignored. Describe what you will say to the judge in your own defense and include the following:

4. What you think should happen to the security guard for his error.
5. What you think should happen to the department store for hiring the security guard.

6. How you should be compensated.

There is a sheet of paper on the table with these points listed on it. You'll need to speak for the full time until you are directed to STOP. If you run out of things to say, repeat the point you made. Begin preparation now (2 minutes).

Ok, your planning time is over and it is time to begin. Remember to speak for the entire time, continuing to talk to the psychologists watching the video-tape as if we were the store manager and security personnel. START speaking now (2.5 minutes). STOP speaking now.

This concludes Phase II of the experiment.

PHASE III

Please rinse your mouth with water from the sports bottle on the table.

Open the yellow folder and answer the questions on the page inside (questionnaire VAS stress, VAS rate, retrospective Phase II, domain attention). When you are done, return the page to the folder and wait for additional instructions.

When I tell you to start, please let me know when you think a minute has gone by. Try not to count. Just estimate when a minute has elapsed. When I say start, you will begin and you will say, "stop" in a loud, clear voice when the time has passed. Ready. START.
(Stop Tape until after the "stop" then restart tape.)

Now, when I tell you to start, please let me know when two and a quarter minutes have gone by. Try not to count. Just estimate when two and a quarter minutes have elapsed. When I say start, you will begin and you will say, "stop" in a loud, clear voice when the time has passed. Ready. START.
(Stop Tape until after the "stop" then restart tape.)

In a moment I will say, "START" and after a period of time I will say "STOP". When I say stop, please say how much time you feel went by from start to stop. Try not to count, just say in a loud, clear voice how much time it felt like in seconds. Ready. START. (47s) STOP. Now say how long in seconds it felt like from start to stop.

At this time, please collect the third saliva sample.

Open the plastic tube labeled 3 but do not touch the inside of the tube or the cotton wad with your hands.

When you hear the direction "start" put the cotton in your mouth and roll it around on your tongue until you hear the direction "stop." Do not let the cotton get under your tongue or between your cheek and gum.

Ready, start.

Stop. Now spit the cotton into the larger collection tube and place the cap on firmly.

Place the collection tube in the ice bucket.

Please rinse your mouth with water from the sports bottle on the table.

Nonverbal Cancellation Test. This is the target symbol. When I tell you to start, I want you to circle all of the target symbols on this page as quickly and as accurately as you can. When you finish turn your paper over. Ready. Start.

Acoustic Startle. I am going to place a pair of earphones on you. You will hear a series of loud and abrupt bursts of static over the headphones. Ignore the noises and sit still and quiet until given further instructions. (10 minutes)

Time production. When I tell you to start, please let me know when you think that 1-minute has gone by. Try not to count. Just estimate when 1-minute has elapsed. When I say start, you will begin and you will say, "stop" in a loud, clear voice when the time has passed. Ready. Start.
(Stop Tape until after the "stop" then restart tape.)

Time estimation. The experimenter will stop the tape after the direction "start" and will restart the tape after the participant has said, "stop." The tape will give the instructions for the 18-second prospective verbal time estimation.

In a moment I will say, "START" and after a period of time I will say "STOP." When I say stop, please say how much time you feel went by from start to stop. Try not to count, just say in a loud, clear voice how much time it felt like in seconds. Ready. Start. (18s) Stop. Now say how long in seconds it felt like from start to stop.

I have some final questionnaires that I would like you to complete and then get one last saliva sample and a few ratings. After that, I'll be glad to answer any questions you might have regarding the study. Open the green folder, and take out the questionnaire. Read the instructions on each page carefully. When you are finished, return the questionnaire to the green folder. Begin answering the questions now. (POMSsf and Debrief Questionnaire)

At this time we will ask for the fourth saliva sample.

Open the plastic tube labeled 4 but do not touch the inside of the tube or the cotton wad with your hands.

When you hear the direction "start" put the cotton in your mouth and roll it around on your tongue until you hear the direction "stop." Do not let the cotton get under your tongue or between your cheek and gum.

Ready, start.

Stop. Now spit the cotton into the larger collection tube and place the cap on firmly.

Place the collection tube in the ice bucket.

(For women only). Now pick up the tube labeled "E" and the straw on the table. Please spit through the straw into the tube until you have filled it to the black line. This sample will be used to measure Estradiol. Now place the cap firmly on the collection tube and place the tube in the ice bucket.

Sensory Ratings. You will be handed six boxes one at a time. Just reach in and feel the object and then rate it on the 2 scales on the paper. ***Administer the 6 objects.*** Now you will be handed six vials one at a time. Please smell the contents and rate each smell on the two scales on the paper. ***Administer the 6 vials.***

Debrief. Participants will be given the following debrief monologue:

We appreciate the time that you have taken to participate in our study. We will take your responses, along with about 100 other people, to better understand people's perceptions and physiological reactions in different experiences of everyday life. There are different groups with different lab experiences.

Relaxation: The group you were in was designed to determine how relaxation effects perception and particularly how you perceive time.

Control: The group you were in was designed to see how paying attention to something neutral affects perception and particularly how you perceive time.

Stress: The group you were in was designed to see how the stress response affects perception and particularly how you perceive time. For that reason, you were asked to speak for the camera because most people find this stressful. No panel of psychologists will rate your speeches. The tape will be used to time your responses and to make sure the experiment is conducted the same way each time. I apologize if this caused you any discomfort.

Now that you are finished with these questionnaires, I'll be happy to answer any questions you have regarding the study or hear any comments you have about the study experience. ***Answer Questions***.

Debrief Psychopathology Assessment and Referral. ***If participant indicated recent thoughts of suicide on the BSI or high endorsement of many of the symptoms on the BSI along with a pattern of distress on the PSS and POMS then go to the Debrief Counseling and Referral Protocol (Appendix I).***

If that is it, then I will return your things.
Return consent form copy, watch, and cell phone or pager.
You should receive the $30 check for your participation today in the mail within 30 days. If your mailing address changes or for some reason you do not receive your check, then please call us at the number on your copy of the consent document. Please do not talk about this study with other people. We are still

recruiting and running volunteers. Knowledge about the study before people come in could change the results. Thank you very much for taking the time to come in and help us with our study. (***escort to exit)***

We appreciate the time that you have taken to participate in our study. We will take your responses, along with about 100 other people, to better understand people's perceptions and physiological reactions in different experiences of everyday life. There are different groups with different lab experiences.

Relaxation: The group you were in was designed to determine how relaxation effects perception and particularly how you perceive time.

Control: The group you were in was designed to see how paying attention to something neutral affects perception and particularly how you perceive time.

Stress: The group you were in was designed to see how the stress response affects perception and particularly how you perceive time. For that reason, you were asked to speak for the camera because most people find this stressful. No panel of psychologists will rate your speeches. The tape will be used to time your responses and to make sure the experiment is conducted the same way each time. I apologize if this caused you any discomfort.

Now that you are finished with these questionnaires, I'll be happy to answer any questions you have regarding the study or hear any comments you have about the study experience. ***Answer Questions***.

Return consent form copy, watch, and cell phone or pager.

You should receive the $30 check for your participation today in the mail within 30 days. If your mailing address changes or for some reason you do not receive your check, then please call us at the number on your copy of the consent document. Please do not talk about this study with other people. We are still recruiting and running volunteers. Knowledge about the study before people come in could change the results. Thank you very much for taking the time to come in and help us with our study. (***escort to exit)***

APPENDIX I: RELAXATION EXERCISE SCRIPT

Script for Relaxation Condition

At this time you be listening to a series of instructions that are designed to help you relax. Please follow the instructions as they are read.
Time will be provided for you to complete each portion of this exercise.
If the instructions are unclear or you begin to feel confused continue listening and try to relax as best as you can. Be patient with yourself. The exercise will begin in a moment.

(please move your chair away from any furniture nearby in order to clear space for yourself to relax)

Now settle comfortable into the chair.
Uncross your arms or legs and loosen any tight clothing.
Close your eyes and sit quietly for a moment.
Take a few deep breaths and release any surface tension each time you exhale.
Put all worries and concerns aside and allow yourself to become completely immersed in the experience of relaxation.

Now, we will begin the exercise called progressive muscle relaxation.
To begin, guide your awareness down the body to your feet. Begin to build up tension in your lower legs by flexing your feet and pulling your toes up toward your knees and pressing down toward your heels.
Feel the tension as it spreads through your feet your ankle your shin and your calf muscle. Feel the tension spreading around the back of the leg into the foot, under the foot and around the toes.
Focus on the tension.

Now, gradually release the leg tension. Allow your feet to relax onto the floor. Notice the difference in your legs. Focus on the feeling of relaxation.

Now, guide your awareness to the knees and upper thighs. Begin to build up tension in the upper legs by squeezing your upper legs together. Focus on the tightness through the upper legs. Feel the pulling sensations from the hip down and notice the tension in the legs.
Focus on the tension.

Now, gradually release the tension and allow your legs to sink heavily into the chair.
Notice the difference in your legs.
Allow the tension to disappear.
Keep your thighs straight and feet flat on the floor with a 90 degree angle at the knees.
Focus on the feeling of relaxation.

Now, guide your awareness to your abdomen. Begin to build up tension in your abdomen by pulling your navel in towards the spine very tightly. Feel the tension. Feel the tightness and focus on that part of your body.

Now, gradually let the abdomen go - letting it go further and further. Allow the back of your abdomen to rest comfortably in the chair. Feel a sense of warmth circulating across your abdomen. Focus on the feeling of warmth and relaxation.

Now, guide your awareness to your chest. Begin to build up tension around your chest by taking in a deep breath and holding it. Expand your chest stretching the muscles and feeling the tension around the front and back of your chest. Continue to hold the breath.

Now, gradually release the breath … and resume normal breathing.
Allow the breath to flow in and out smoothly, easily.
Allow your spine to rest comfortably in the chair. Relax your upper chest. Focus on the feeling of relaxation.

Now, guide your awareness to you shoulders. Begin to build up tension in your shoulders and upper back by shrugging your shoulders up and squeezing your shoulder blades together toward the midline of the body. Feel the tension around your shoulders and upper back. Focus on that part of your body.
Focus on the tension.

Now, gradually release your shoulder blades and let your shoulders droop down. Allow them to droop further and further. Keep the shoulder blades touching the back of the chair. Allow them to be relaxed.
Focus on the feeling of relaxation.

Now, guide your awareness to your arms and your hands. Turn the palms up and begin to build up tension in your arms by making a fist in each hand. Then, bend the elbows bringing the fists up to the shoulders and pressing the arms in toward your sides. Feel the tension in your upper and lower arms, the fingers and hands. Focus on the tension. Notice the sensations of pulling, of discomfort, of tightness

Now gradually release the tension by lowering your arms and opening the palms of your hands. Allow your arms and hands to rest on your thighs and your hands to lightly curl. Focus on the sensations in your hands and arms. Feel the release from tension as the muscles relax. Your arms may feel heavy, warm, relaxed. Focus on the feeling of relaxation.

Now, guide your awareness to your neck and chin. Begin to build up tension around your neck and chin by pulling your chin down and pressing it into your chest and then pressing the back of your neck towards the chair.
Feel the tension around the front and back of your neck spreading up into your head. Focus on the tension.

Now, gradually release the tension allowing your head to rest in a comfortable, upright position. Keep your head upright and motionless with the nose in midline with the rest of the body.
Allow your throat to relax to be quiet and smooth. Focus on the feeling of relaxation.

Now, guide your awareness to your teeth and facial muscles. Begin to build up tension around your mouth and jaw by clenching the teeth together and forcing the corners of your mouth up into a tight smile. Scrunch the bridge of your nose and squeeze the eyes tightly shut.
Tense all the facial muscles in toward the center of the face. Hold the tension focus on it.

Now, gradually release the tension allowing your lower jaw to drop down and the muscles around the throat and jaw to relax.
Allow your mouth to open slightly and your tongue to drop away from the roof of your mouth. Relax the muscles around your eyes. Keep your eyes closed and smooth. Focus on the feeling of relaxation.

Now guide your awareness to your eyebrows and forehead. Begin to build up tension in your eyelids and forehead by raising your eyebrows up and tensing the muscles across the forehead and over the scalp.
Feel the tension in your forehead and focus on the tension.

Now, gradually release the tension by allowing your eyebrows to rest and the tension in the forehead to melt away. Soften the face and allow the mind to relax.
Focus on the feeling of relaxation.

Now your whole body may be feeling relaxed and comfortable.
As you spend a few minutes in this relaxed state, continue focusing on your breathing.
Feel the cool air as you breath in and the warm air as you breathe out.
Allow the abdomen to gently rise and fall with each breath.
If you find yourself distracted bring your awareness back to your breath, allowing it to be slow and regular.

Now we will begin to conclude this exercise.

As I count backwards from 5 to 1 gradually feel yourself becoming more alert, ready to return to your daily activities

5 bring your awareness to the surface of your body
4 coming out of relaxation
3 feeling more alert
2 opening your eyes
1 slowly flex your hands and turn your head to the left and right and then back to center

Reorient yourself to your environment.

This concludes an exercise in relaxation.

APPENDIX J: DEBRIEF COUNSELING AND REFERRAL

Debrief Counseling and Assessment Procedure

If subject answers anything other than "Not at All" on question 17 of the BSI "Thoughts of ending your life" then say:

"We routinely screen a few of the questions to evaluate your health and safety. I noticed that you indicated a number of symptoms of depression (or anxiety). You also indicated that you would like to kill yourself.

1. Many people sometimes think about dying when they are depressed. How long have you felt that you wanted to die?

2. How often do you think about dying?

3. Have these been passing thoughts or something you have thought about seriously?

4. Have you ever tried to kill yourself?

5. Do you have a plan?

If **yes** then get details of plan and ask

6. Do you have the means to carry out your plan?

It's very common for people who are depressed to believe that nothing can help them , but there are a lot of things available to help you get through this and feel better. I am going to give you some numbers you may call to talk to someone who can help you. Would you like to use the phone and call right now or have me call for you?

If **yes** then provide the phone or make the call

If **no** then ask

8.Can you promise me that you will call these numbers or 911 if you feel like you might kill yourself?

If **no** then **do not leave the person**, call ____________________

If the person **does not** answer "Thoughts of ending my life" on question 17, but their BDI score is 30 or over (look also at PSS and POMS for elevation)
say:

We routinely screen a few of the questions to evaluate your health. Like many people you endorsed a number of symptoms of depression (or anxiety).

A. Many people sometimes think about dying when they are depressed (or anxious). Have you felt that you wanted to die?

   If **yes** then go to 2.
   If **no** then

B. There are a lot of things available to help you get through this and feel better. I am going to give you some numbers you may call for counseling. Would you like to use the phone and call right now or have me call for you?

   If **yes** then provide the phone or call.
   If **no** then

C. Put these numbers in a safe place so you will have these numbers if you decide you want to call later.

Compensate participant for their time in the study and encourage them to make the telephone call.

APPENDIX K: TABLES OF BASELINE DEMOGRAPHICS

Tables of Baseline Demographics

Table K-1: Frequency Table of Sample Demographics

	Relax		**Control**		**Stress**		**Total**	
	F	**M**	**F**	**M**	**F**	**M**	**F**	**M**
Asian	0	1	3	1	1	2	**4**	**4**
Black	7	2	2	2	4	4	**13**	**8**
Hispanic	2	0	2	1	0	2	**4**	**3**
White	10	15	12	16	15	9	**37**	**40**
Other	0	1	0	0	0	2	**0**	**3**
Total	**19**	**19**	**19**	**20**	**20**	**19**	**58**	**58**

Table K-2: Kruskal-Wallis Test for Demographic Differences Among Conditions

	χ^2	df	p
Asian	1.785	2	.410
Black / African American	2.549	2	.280
Hispanic / Latino	.283	2	.868
White	.529	2	.768

Table K-3: Frequency Table of Educational Background
(χ^2 (2) = .529 p = .412)

Education	Relaxation	Control	Stress	Total
Some High School	1	1	0	**2**
HS/GED Diploma	2	1	5	**8**
Tech School	1	1	0	**2**
Some College	7	10	12	**29**
BA or BS Degree	15	19	14	**48**
Master's Degree	9	3	5	**17**
Doctoral/Law	3	4	3	**10**

Table K-4: Frequency Table of Tobacco Use
(χ^2 (2) = .519 p = .771)

Tobacco	Relaxation	Control	Stress	Total
Yes	6	4	5	15
No	32	35	34	101

Table K-5: Frequency Table of Oral Contraceptive Use in Women
(χ^2 (2) = .519 p = .771)

OC	Relaxation	Control	Stress	Total
Yes	6	5	4	15
No	13	14	16	33

Table K-6: Frequency Table of Caffeine Consumption
(χ^2 (2) = .668 p = .716)

BEVERAGES	RELAXATION	CONTROL	STRESS	TOTAL
None	8	8	8	24
1-2	20	23	25	68
3-4	5	8	4	17
5-6	0	0	1	1
7-8	3	0	0	3
9 or more	2	0	1	3

Table K-7: Sample Age in Years (F(2,113) = 0.05, p = .51)

	Relaxation	Control	Stress
Mean (Standard Deviation)	37.9 (15.9)	38.7 (14.8)	39.0 (15.9)
Minimum - Maximum	18.1 – 75.2	22.3 – 70.8	18.6 – 79.7

Table K-8: Means Table of Perception of Time and the Senses Survey Scales and Items

	Relaxation	Control	Stress	ANOVA	p
% of Thought to Past	19.9 (11.7)	25.9 (13.1)	27.0 (16.7)	F(2,112) = 2.27	.108
% of Thought to Present	43.5 (22.0)	44.1 (16.8)	47.6 (21.9)	F(2,112) = 0.46	.630
% of Thought to Future	36.1 (20.6)	31.8 (15.5)	25.4 (15.4)	F(2,112) = 3.57	.031*
Feelings about Past	4.0 (0.9)	3.4 (1.1)	3.6 (1.0)	F(2,113) = 3.76	.026*
Feelings about Present	4.0 (0.7)	3.8 (0.9)	4.1 (0.9)	F(2,112) = 1.35	.265
Feelings about Future	4.2 (0.7)	4.3 (0.7)	4.3 (0.8)	F(2,112) = 0.13	.881
Temporal Extension	13.9 (2.8)	13.8 (2.9)	14.2 (2.9)	F(2,112) = 0.20	.823
Stress Extension	12.8 (3.2)	13.2 (2.9)	13.7 (3.1)	F(2,113) = 1.01	.367

APPENDIX L: TABLES OF SELF REPORT MEASURES OF STRESS AND RELAXATION

Tables of Measures of Stress and Relaxation Self Report

Table L-1: Means Table and MANOVA for Stress-Related Self-Report Scales at Baseline

	Relaxation	Control	Stress	MANOVA	p
VAS Relaxed - Tense	26.9 (2.8)	31.7 (2.7)	26.3 (2.6)	F(2,104) = 1.22	.300
VAS Calm - Anxious	25.8 (2.8)	30.2 (2.7)	28.9 (2.6)	F(2,104) = 0.66	.521
Perceived Stress Scale (PSS)	13.7 (1.1)	15.7 (1.0)	14.8 (1.0)	F(2,104) = 0.94	.395
Brief Symptom Inventory (BSI)	24.8 (1.1)	25.9 (1.0)	24.7 (1.0)	F(2,104) = 0.45	.637
POMS Tension Subscale	8.5 (0.5)	9.0 (0.4)	8.9 (0.4)	F(1,104) = 0.30	.739

Table L-2: Means Table and MANOVA for Stress-Related Self-Report Scales Post

	Relaxation	Control	Stress	MANOVA	p
VAS Relaxed - Tense	15.5 (13.6)	27.0 (16.7)	49.2 (25.1)	F(2,108) = 29.1	<.0001**
VAS Calm - Anxious	15.8 (13.5)	26.2 (17.5)	46.8 (25.2)	F(2,108) = 24.0	<.0001**
POMS Tension Subscale	7.6 (1.8)	8.2 (2.2)	9.9 (4.3)	F(1,108) = 54.3	.004**

Table L-3: Means Table of POMS Subscales at Baseline and Post Experimental Phase

	Relaxation	Control	Stress
Tension Base	8.41 (2.2)	9.47 (3.5)	8.85 (2.7)
Tension Post	7.51 (1.8)	8.42 (2.3)	9.95 (4.3)
Vigor Base	14.68 (6.2)	15.21 (5.4)	15.10 (6.2)
Vigor Post	13.70 (6.4)	12.32 (4.7)	13.59 (6.7)
Confusion Base	6.24 (1.9)	7.11 (3.0)	6.64 (2.3)
Confusion Post	5.86 (1.3)	6.84 (2.3)	6.87 (2.0)
Depression Base	9.00 (2.4)	9.71 (3.5)	8.54 (1.5)
Depression Post	8.41 (1.1)	8.79 (2.0)	8.59 (1.0)

Table L-4: Within-Subject Contrasts for
POMS Tension Subscale Baseline and Post by Condition

Source	POMST	Type III Sum of Squares	df	Mean Square	F	Sig.
POMT	Linear	4.49	1	4.49	1.31	.26
POMT * COND	Linear	55.53	2	27.76	8.08	.0005**
Error(POMT)	Linear	381.53	111	3.44		

Table L-5: Within-Subject Contrasts for
POMS Vigor Subscale Baseline and Post by Condition

Source	CA	Type III Sum of Squares	df	Mean Square	F	Sig.
POMV	Linear	183.27	1	183.27	21.99	<.0001**
POMV * COND	Linear	37.03	2	18.52	2.22	.11
Error(POMV)	Linear	925.15	111	8.33		

Table L-6: Within-Subject Contrasts for
POMS Confusion Subscale Baseline and Post by Condition

Source	RT	Type III Sum of Squares	df	Mean Square	F	Sig.
POMC	Linear	1.07	1	1.07	0.73	.4
POMC * COND	Linear	4.02	2	2.01	1.36	.26
Error(POMC)	Linear	163.50	111	1.47		

Table L-7: Within-Subject Contrasts for
POMS Depression Subscale Baseline and Post by Condition

Source	CA	Type III Sum of Squares	df	Mean Square	F	Sig.
POMD	Linear	13.57	1	13.57	9.86	.002**
POMD * COND	Linear	9.44	2	4.72	3.43	.04*
Error(POMD)	Linear	152.79	111	1.38		

Table L-8:Means Table of VAS of Tension and Anxiety Baseline
and Experimental Phase

	Relaxation	Control	Stress
Relaxed-Tense Base	27.3 (2.9)	30.8 (2.7)	26.1 (2.5)
Relaxed-Tense Exp	15.4 (2.3)	27 (2.7)	49.2 (4.0)
Calm – Anxious Base	26.6 (2.8)	29.3 (2.5)	28.5 (2.8)
Calm – Anxious Exp	15.7 (2.3)	26.2 (2.8)	46.8 (4.0)

Table L-9: Within-Subject Contrasts for
VAS Relaxed-Tense Baseline and Experimental Phase by Condition

Source	RT	Type III Sum of Squares	df	Mean Square	F	Sig.
RT	Linear	337.42	1	337.42	1.50	.22
RT * COND	Linear	12682.38	2	6341.19	28.18	<.0001**
Error(RT)	Linear	24527.08	109	225.02		

Table L-10: Within-Subject Contrasts for
VAS Calm-Anxious Baseline and Experimental Phase by Condition

Source	CA	Type III Sum of Squares	df	Mean Square	F	Sig.
CA	Linear	115.70	1	115.70	0.57	.45
CA * COND	Linear	8586.42	2	4293.21	20.97	<.0001**
Error(RT)	Linear	22319.71	109	204.77		

APPENDIX M: TABLES OF PHYSIOLOGICAL AND CHEMICAL MEASURES

Tables of Physiological and Chemical Measures

Table M-1: Means Table and MANOVA for Physiological Measures at Time Set 1

	Relaxation	Control	Stress	MANOVA	p
Systolic Blood Pressure	119.4 (16.8)	116.3 (14.7)	118.5 (15.8)	F(1,108) = 0.37	.691
Diastolic Blood Pressure	69.6 (8.7)	69.5 (6.7)	70.6 (9.2)	F(2,108) = 0.18	.833
Heart Rate (Dinamap)	69.3 (11.3)	68.3 (9.1)	73.2 (11.9)	F(2,108) = 2.16	.120
Heart Rate (Biopac)	71.9 (11.0)	73.7 (9.9)	78.1 (12.1)	F(2,108) = 3.07	.050*

Table M-2: Means Table and MANOVA for Physiological Measures at Time Set 2

	Relaxation	Control	Stress	MANOVA	p
Systolic Blood Pressure	113.2 (13.5)	110.1 (12.8)	113.1 (13.0)	F(2,108) = 0.66	.519
Diastolic Blood Pressure	67.3 (7.2)	68.1 (6.3)	69.2 (9.2)	F(2,108) = 0.57	.569
Heart Rate (Dinamap)	69.4 (10.8)	68.9 (8.9)	72.9 (12.0)	F(2,108) = 1.62	.203
Heart Rate (Biopac)	72.2 (11.8)	72.3 (9.0)	76.9 (11.9)	F(2,108) = 2.20	.116

Table M-3: Means Table and MANOVA for Physiological Measures at Time Set 3

	Relaxation	Control	Stress	MANOVA	p
Systolic Blood Pressure	113.9 (16.7)	111.5 (15.8)	112.6 (13.9)	F(2,108) = 0.23	.797
Diastolic Blood Pressure	68.8 (8.9)	69.6 (8.5)	69.8 (8.3)	F(2,108) = 0.15	.858
Heart Rate (Dinamap)	71.9 (11.0)	72.6 (9.3)	75.2 (11.4)	F(2,110) = 1.01	.368
Heart Rate (Biopac)	68.0 (10.7)	68.6 (9.4)	71.0 (11.4)	F(2,108) = 0.86	.428

Table M-4: Means Table and MANOVA for Physiological Measures at Time Set 4

	Relaxation	Control	Stress	MANOVA	p
Systolic Blood Pressure	114.1 (16.3)	113.6 (14.4)	116.0 (16.0)	F(2,108) = .23	.775
Diastolic Blood Pressure	70.6 (9.3)	70.7 (8.1)	69.2 (9.2)	F(2,108) = 0.002	.998
Heart Rate (Dinamap)	68.1 (10.5)	67.6 (9.7)	72.9 (12.0)	F(2,108) = 1.67	.194
Heart Rate (Biopac)	70.7 (10.5)	73.1 (11.2)	74.6 (11.8)	F(2,108) = 1.18	..310

Table M-5: Means Table of Cortisol Concentrations μg/dL

Time Point	**Relaxation**	**Control**	**Stress**	**ANOVA**	**p**
1	0.131 (.056)	0.128 (.062)	0.118 (.039)	F (2,33) = 0.189	.829
2	0.125 (.056)	0.120 (.059)	0.108 (.037)	F (2,33) = 0.333	.719
3	0.128 (.068)	0.096 (.051)	0.118 (.056)	F (2,33) = 1.074	.353
4	0.108 (.050)	0.088 (.043)	0.113 (.056)	F (2,33) = 0.817	.450

Repeated Measures Analyses

Table M-6: Means Table of Heart Rate Measured Continuously by Biopac

	Relaxation	**Control**	**Stress**
Baseline 1	71.94 (11.0)	74.22 (10.3)	78.07 (12.1)
Baseline 2	72.43 (11.7)	72.96 (9.7)	76.88 (11.9)
Experimental	73.66 (11.5)	73.28 (9.5)	84.21 (11.4)
Post 1	71.89 (11.0)	72.59 (9.3)	75.18 (11.4)
Post 2	70.70 (10.5)	73.12 (11.2)	74.64 (11.8)

Table M-7: Within-Subject Contrasts for
Biopac Heart Rate over Time by Condition with Baseline 1 Measure as Covariate

Source	**HR4**	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
HR4	Linear	0.17	1	0.17	0.01	0.91
	Quadratic	38.95	1	38.95	3.00	0.09
	Cubic	13.10	1	13.10	0.89	0.35
HR4 * AHR_1	Linear	5.29	1	5.29	0.37	0.54
	Quadratic	13.51	1	13.51	1.04	0.31
	Cubic	0.01	1	0.01	0.00	0.98
HR4 * COND	Linear	197.13	2	98.57	6.95	0.001
	Quadratic	329.24	2	164.62	12.68	<.0001
	Cubic	581.19	2	290.60	19.80	<.0001
Error(HR4)	Linear	1530.99	108	14.18		
	Quadratic	1402.53	108	12.99		
	Cubic	1584.74	108	14.67		

Table M-8: Within-Subject Contrasts for
Diastolic Blood Pressure over Time by Condition with Baseline 1 Measure as Covariate

Source	DBP3	Type III Sum of Squares	df	Mean Square	F	Sig.
DBP3	Linear	4.94	1	4.94	0.57	0.45
	Quadratic	25.66	1	25.66	3.42	0.07
DBP3 * AVDBP_1	Linear	0.15	1	0.15	0.02	0.90
	Quadratic	29.81	1	29.81	3.97	.05*
DBP3 * COND	Linear	13.56	2	6.78	0.78	0.46
	Quadratic	1.56	2	0.78	0.10	0.90
Error(DBP3)	Linear	968.43	112	8.65		
	Quadratic	841.47	112	7.51		

Table M-9: Within-Subject Contrasts for
Systolic Blood Pressure over Time by Condition with Baseline 1 Measure as Covariate

Source	SPB33	Type III Sum of Squares	df	Mean Square	F	Sig.
SPB33	Linear	1.25	1	1.25	0.04	0.85
	Quadratic	28.68	1	28.68	0.92	0.34
SPB33 * AVSBP_1	Linear	0.15	1	0.15	0.00	0.95
	Quadratic	46.23	1	46.23	1.49	0.23
SPB33 * COND	Linear	86.68	2	43.34	1.29	0.28
	Quadratic	31.48	2	15.74	0.51	0.6
Error(SPB33)	Linear	3774.13	112	33.70		
	Quadratic	3485.38	112	31.12		

APPENDIX N: TABLES OF TIME PERCEPTION MEASURES

Tables of Time Perception Measures

Table N-1: Means Table of Log(θ) at Time Point 1

	Relaxation	Control	Stress	MANOVA	p
Log(θ) production 60s 1	0.13 (.17)	0.09 (.19)	0.09 (.18)	F (2,109) = 0.634	.532
Log(θ) production 135s 1	0.09 (.14)	0.08 (.16)	0.06 (.16)	F (2,109) = 0.391	.677
Log(θ) estimation 47s 1	0.18 (.16)	0.11 (.18)	0.10 (.18)	F (2,109) = 2.208	.155

Table N-2: Means Table of Log(θ) at Time Point 2

	Relaxation	Control	Stress	MANOVA	p
Log(θ) production 60s 2	0.072 (.15)	0.016 (.18)	0.015 (.15)	F (2,109) = 1.526	.222
Log(θ) estimation 18s 1	0.12 (.19)	0.11 (.21)	0.10 (.16)	F (2,109) = 0.188	.829

Table N-3: Means Table of Log(θ) at Time Point 3

	Relaxation	Control	Stress	MANOVA	p
Log(θ) production 60s 1	0.06 (.15)	0.03 (.17)	0.02 (.16)	F (2,109) = .616	.542
Log(θ) production 135s 1	0.17 (.16)	0.13 (.18)	0.07 (.16)	F (2,109) = 3.399	.037*
Log(θ) estimation 47s 1	0.09 (.16)	0.05 (.20)	0.02 (.20)	F (2,109) = 1.536	.220

Table N-4: Means Table of Log(θ) at Time Point 4

	Relaxation	Control	Stress	MANOVA	p
Log(θ) production 60s 2	.07 (.15)	0.04 (.17)	0.005 (.18)	F (2,109) = 1.333	.268
Log(θ) estimation 18s 1	0.07 (.26)	0.08 (.18)	0.02 (.23)	F (2,109) = 0.752	.474

Table N-5: Table of Means for Retrospective Time Estimates (Log (θ))

	Relaxation	Control	Stress	ANOVA	p
Experimental Phase (16 min)	-0.153 (.17)	0.051 (.24)	0.004 (.21)	F(2,108) = 9.88	<.0001**
Headphone Period (6 min)	-0.040 (.17)	0.052 (.23)	-0.024 (.23)	F(2,111) = 1.81	.169

Table N-6: Means Table of VAS of Perceived Rate

	Relaxation	Control	Stress	ANOVA	p
Time Rate Usual	65.7 (17.8)	65.3 (19.9)	67.5 (23.6)	F(2,109) = 0.13	.883
Time Rate Baseline	52.3 (17.0)	56.1 (17.9)	51.8 (22.7)	F(2,109) = 0.55	.581
Time Rate Exp	40.1 (20.2)	44.4 (20.3)	52.0 (28.1)		
Time Rate Post	52.2 (13.4)	52.0 (14.5)	57.9 (23.4)		

Table N-7: Means Table and T-Test for Gender Differences in Time Production

	Gender	N	Mean	Std. Dev.	t	df	Sig. (2-tailed)
log(θ) 1_1	Male	57	0.07	0.15	-2.15	100.10	.03*
	Female	54	0.14	0.20			
log(θ) 1_2	Male	57	0.01	0.16	-1.82	109.60	0.07
	Female	56	0.06	0.17			
log(θ) 1_3	Male	56	0.02	0.14	-1.83	102.52	0.07
	Female	54	0.07	0.17			
log(θ) 1_4	Male	55	0.00	0.16	-2.25	107.58	.03*
	Female	55	0.07	0.17			
log(θ) 2.25_1	Male	57	0.09	0.17	-2.51	109.87	.01*
	Female	56	0.18	0.19			
log(θ) 2.25_2	Male	57	0.09	0.16	-2.69	108.48	.01*

Table N-8: Frequency Table of Saliva Sample Rated as Shortest ($\chi^2(4) = 9.845$ p<.05).

	Relaxation	Control	Stress	Total
Baseline 1	8	5	7	20
Baseline 2	14	8	4	26
Post 1	15	23	27	65

Table N-9: Frequency Table of Saliva Sample Rated as Longest ($\chi 2(2) = 0.01$ p=.99)

	Relaxation	Control	Stress	Total
Baseline 1	17	18	15	50
Baseline 2	10	11	17	38
Post 1	10	10	6	26

Table N-10: Correlation Table of Duration Perception Measures log(θ)

		log(θ) 1_2	log(θ) 1_3	log(θ) 1_4	log(θ) e47_1	log(θ) e47_2	log(θ) e18_1	log(θ) e18_2	log(θ) 2.25_1	log(θ) 2.25_2
log(θ) 1_1	**r**	0.74	0.71	0.59	0.60	0.48	0.50	0.51	0.78	0.58
	p	**	**	**	**	**	**	**	**	**
	N	113	111	111	112	113	110	112	113	113
log(θ) 1_2	**r**		0.84	0.75	0.64	0.59	0.66	0.47	0.71	0.74
	p		**	**	**	**	**	**	**	**
	N		112	112	114	114	112	113	115	114
log(θ) 1_3	**r**			0.79	0.71	0.63	0.59	0.47	0.73	0.78
	p			**	**	**	**	**	**	**
	N			110	112	112	110	111	113	112
log(θ) 1_4	**r**				0.59	0.55	0.55	0.51	0.63	0.76
	p				**	**	**	**	**	**
	N				112	113	110	112	113	113
log(θ) e47_1	**r**					0.65	0.59	0.47	0.62	0.59
	p					**	**	**	**	**
	N					114	112	113	115	114
log(θ) e47_2	**r**						0.63	0.63	0.43	0.60
	p						**	**	**	**
	N						112	114	115	115
log(θ) e18_1	**r**							0.57	0.52	0.62
	p							**	**	**
	N							111	113	112
log(θ) e18_2	**r**								0.31	0.45
	p								**	**
	N								114	114
log(θ) 2.25_1	**r**									0.75
	p									**
	N									115

** indicates significant at the .001 level, r is the Pearson Correlation Coefficient, p is 2-tailed significance.
1_1 is 1 minute production, first measure: 1_2 is 1 minute production, second measure, etc.
2.25_1 is 2.25 minute production, first measure: 2.25_2 is 2.25 minute production, second measure.
e47_1 is 47 second time estimation, first measure: e47_2 is 47 second time estimation, second measure.
e18_1 is 18 second time estimation, first measure: e18_2 is 18 second time estimation, second measure.

Table N-11: Table of Correlations Among Temporal Perspective Scales, Time Perception, and Age

		PR Usual	% Past	% Present	% Future	Feel Past	Feel Present	Feel Future	Temp Ext.	Stress Ext	Ave log(θ)
Age	r	0.18	-.02	0.25	-0.25	-0.08	0.01	-0.16	-0.13	-0.16	0.31
	p	.06	.83	.01*	.01*	.40	.92	.08	.18	.08	**
	N	113	116	116	116	116	115	115	115	116	112
PR Usual	r		-.29	0.22	0.03	0.09	0.13	0.14	0.17	0.03	0.09
	p		**	.02*	.76	.34	.18	.15	.07	.76	.33
	N		113	113	113	113	112	112	112	113	110
% Past	r			-0.52	-0.28	-0.20	-0.19	-0.15	-0.12	0.15	-0.04
	p			**	**	.03*	.05*	.10	.19	.10	.66
	N			116	116	116	115	115	115	116	112
% Pres	r				-0.65	0.03	0.02	0.00	-0.16	-0.19	0.07
	p				**	.73	.87	.97	.09	.04*	.48
	N				116	116	115	115	115	116	112
% Future	r					0.09	0.06	0.08	0.30	0.08	-0.01
	p					.35	.54	.42	**	.38	.92
	N					116	115	115	115	116	112
Feel Past	r						0.33	0.32	0.01	-0.24	0.02
	p						**	**	.95	.01*	.83
	N						115	115	115	116	112
Feel Pres	r							0.43	-0.13	-0.28	-0.19
	p							**	.17	**	.05*
	N							115	114	115	111
Feel Fut	r								0.03	-0.18	-0.16
	p								.76	.05*	.09
	N								114	115	111
Temp Ext	r									0.21	-0.13
	p									.02*	.16
	N									115	111
Stress Ext	r										-0.13
	p										.18
	N										112

** indicates significant at the .001 level, r is the Pearson Correlation Coefficient, p is 2-tailed significance

Table N-12: Table of Correlations Among Temporal Measures and State Self Report

		PSS	BSI	POMS Tension	POMS Vigor	POMS Confuse	POMS Depress
Age	**r**	-0.03	-0.27	-0.33	0.29	-0.22	0.04
	p	.76	**	**	**	.02*	.71
	N	114	114	115	115	116	116
PR Usual	**r**	-0.12	-0.19	-0.15	-0.01	-0.06	-0.14
	p	.22	.04*	.11	.88	.55	.13
	N	111	111	112	112	113	113
% Past	**r**	0.35	0.34	0.21	0.07	0.22	0.29
	p	**	**	.02*	.48	.02*	**
	N	114	114	115	115	116	116
% Present	**r**	-0.21	-0.21	-0.23	-0.12	-0.21	-0.19
	p	.02*	.03*	.01*	.20	.03*	.04*
	N	114	114	115	115	116	116
% Future	**r**	-0.08	-0.07	0.05	0.09	0.07	-0.03
	p	.42	.47	.63	.36	.46	.74
	N	114	114	115	115	116	116
Feel Past	**r**	-0.36	-0.31	-0.10	0.05	-0.17	-0.10
	p	**	**	.29	.62	.07	.28
	N	114	114	115	115	116	116
Feel Pres	**r**	-0.50	-0.33	-0.02	0.25	-0.10	-0.24
	p	**	**	.81	.01*	.30	.01*
	N	113	113	114	114	115	115
Feel Fut	**r**	-0.37	-0.10	0.09	0.31	0.02	-0.11
	p	**	.31	.35	**	.85	.26
	N	113	113	114	114	115	115
Temp Ext	**r**	0.09	0.09	-0.12	-0.04	-0.15	-0.11
	p	.32	.34	.19	.71	.12	.23
	N	114	113	114	114	115	115
Stress Ext	**r**	0.41	0.31	0.04	-0.16	0.03	0.07
	p	**	**	.65	.09	.79	.47
	N	114	114	115	115	116	116
Ave log(q)	**r**	-0.03	-0.16	0.06	0.05	0.16	0.21
	p	.79	0.10	.54	.61	.09	.03*
	N	110	110	111	111	112	112

** indicates significant at the .001 level, r is the Pearson Correlation Coefficient, p is 2-tailed significance

APPENDIX O: TABLES OF MEASURES OF ATTENTION AND MEMORY

Tables of Measures of Attention and Memory

Table O-1: Means Table of Non Verbal Cancellation Task at Baseline

	Relaxation	Control	Stress	ANOVA	p
Completion Time	44.8 (14.0)	42.6 (11.2)	43.8 (16.3)	F(2,113) = 0.23	.793
Errors of Omission	0.4 (0.8)	0.9 (2.0)	0.7 (1.2)	F(2,113) = 1.07	.346
Errors of Commission	0.03 (0.16)	0.05 (0.22)	0.03 (0.16)	F(2,113) = 0.24	.784
Throughput	0.71 (0.19)	0.73 (0.23)	0.77 (0.31)	F(2,113) = .48	.621

Table O-2: Means Table of Non Verbal Cancellation Task Post

	Relaxation	Control	Stress	ANOVA	p
Completion Time	37.7 (8.5)	38.6 (11.3)	40.5 (14.4)	F(2,113) = 0.60	.548
Errors of Omission	0.4 (0.8)	0.9 (2.0)	0.7 (1.2)	F(2,113) = 1.07	.346
Errors of Commission	0.03 (0.16)	0.03 (0.16)	0.03 (0.16)	F(2,113) = 0.00	1.0
Throughput	0.82 (0.19)	0.82 (0.25)	0.83 (0.31)	F(2,113) = .92	.45

Table O-3: Means Table of VAS of Interest and Focus at Baseline and Experimental Phase

	Relaxation	Control	Stress	ANOVA	p
Bored – Interested Base	64.7 (18.9)	69.6 (15.9)	73.4 (16.7)	F(2,109) = 2.37	.098
Bored – Interested Exp	55.6 (21.7)	54.0 (20.1)	65.2 (22.5)	F(2,109) = 3.08	.05*
Distracted - Focused Base	68.7 (16.1)	67.1 (18.8)	72.7 (21.7)	F(2,109) = 0.87	.422
Distracted – Focused Exp	73.7 (14.8)	59.11 (21.0)	73.0 (21.2)	F(2,109) = 6.79	.002

Table O-4: Within-Subject Contrasts for
VAS for Bored-Interested at Baseline and Experimental Phase by Condition

Source	BI	Type III Sum of Squares	df	Mean Square	F	Sig.
BI	Linear	6721.21	1	6721.21	32.59	<.0001**
BI * COND	Linear	613.85	2	306.92	1.49	.23
Error(RT)	Linear	22477.65	109	206.22		

Table O-5: Within-Subject Contrasts for
VAS Distracted-Focused Baseline and Experimental Phase by Condition

Source	DF	Type III Sum of Squares	df	Mean Square	F	Sig.
DF	Linear	43.98	1	43.98	0.17	.68
DF * COND	Linear	1613.35	2	806.67	3.19	.04*
Error(RT)	Linear	27548.58	109	252.74		

Table O-6: Frequency Table of Hearing Beeps During Experimental Phase
($\chi 2(2) = 4.1$ $p=.13$)

	Relaxation	Control	Stress	Total
No	28	26	21	75
Yes	9	13	18	40

Table O-7: Table of Means for Percentage of Thought in Each Time Domain Usual and in the Experimental Phase

	Relaxation		Control		Stress	
	% Usual	**% Exp**	**% Usual**	**% Exp**	**% Usual**	**% Exp**
Past	19.9 (11.7)	7.2 (14.2)	25.9 (17.7)	21.3 (25.4)	27.0 (16.7)	19.0 (24.5)
Present	43.5 (22.0)	76.2 (30.3)	44.1 (16.8)	62.8 (31.9)	47.6 (21.9)	69.1 (31.3)
Future	36.1 (20.6)	15.7 (26.5)	31.0 (16.1)	15.3 (20.4)	25.4 (15.7)	12.4 (17.8)

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