

Technical Report 1035

An Exploration of Psychological and Psychophysiological Measures as Predictors of Successful Performance Under Stress

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14. ABSTRACT (Maximum 200 words): Based on a review of the literature and the development of a new psychophysiological model to account for individual coping responses to stress, two investigations were conducted. The first investigation developed and validated a new Occupational Stress Assessment Inventory that better examined stress in an occupational context with measures of active coping and ability to deal with stress built into the same instrument. In the second investigation this new inventory as well as other personality measures were employed in a psychophysiological stress paradigm to directly assess the predictive power of personality and psychophysiological measures with respect to predicting performance under stress. The second investigation showed that several psychophysiological variables, such as heart rate, vagal tone, and mean arterial and diastolic blood pressures, predicted performance on both simple and more complex tasks with correlations as high as .67. These results demonstrated that there are marked individual differences in psychophysiological responses under stress that reliably predict performance. In terms of personality measures, the data indicated that those individuals who perceived themselves as having more of an ability to cope with stress and who more actively cope with stressful situations indeed are more successful performers. These investigations support the contention that selection and classification for stressful occupations can be improved by the integration of specific personality and psychophysiological measures. It was recommended that a full field evaluation of these methods be conducted to assess the validity of these findings in specific populations of interest and to evaluate their practical feasibility.					
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An Exploration of Psychological and Psychophysiological Measures as Predictors of Successful Performance Under Stress

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FOREWORD

U.S. Army activities, including Special Forces, Rangers, Airborne personnel, emergency personnel, and peacekeepers, involve a high degree of physical and mental stress. Indeed, all military occupations have the potential for requiring high levels of performance under marked elevations in stress since military personnel are increasingly asked to serve in peacekeeping as well as combat situations. In peacekeeping situations, military personnel are required to maximize restraint during periods of conflict escalation to maintain peace. Thus, the need for a better understanding of stress and coping in real-world situations is perhaps even more clear today than before. The requirement to select personnel for high-stress occupations or select personnel who will perform well in high-stress environments has never been more paramount.

In a previous report, the current authors conducted an interdisciplinary review, evaluation, and synthesis of the feasibility of using personality and psychophysiological measures to improve the selection and classification of personnel for stressful occupations. The present report summarizes the current theoretical approach and reports on two investigations designed to examine the potential importance of personality and psychophysiological measures with respect to predicting successful performance under stress. The results demonstrated that there are marked individual differences in personality and psychophysiological responses under stress that reliably predict performance. In terms of personality measures, the data indicated that those individuals who perceived themselves as having more of an ability to cope with stress and who more actively cope with stressful situations indeed are more successful performers. Together, these investigations support the contention that selection and classification methods can be improved by the integration of specific personality and psychophysiological measures. It was recommended that a full field evaluation of these methods be conducted to assess the validity of these findings as well as their practical feasibility.

This effort was part of the "Specialized MOS Classifications and Army-Wide Selection Methods" task conducted by university researchers through the U.S. Army Research Office and Battelle under the Selection and Assignment Research Unit of the Manpower and Personnel Research Division.

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AN EXPLORATION OF PSYCHOLOGICAL AND PSYCHOPHYSIOLOGICAL MEASURES AS PREDICTORS OF SUCCESSFUL PERFORMANCE UNDER STRESS

EXECUTIVE SUMMARY

Research Requirement:

Since stress tends to have negative consequences on performance and the Army is composed of a number of occupations that can be viewed as inherently stressful (such as Special Forces, Rangers, Airborne personnel, emergency personnel, and peace-keepers), it is important to discover whether the selection and classification of personnel for stressful occupations can be improved. Based on this need for better selection and classification of individuals for performance under high stress, the U.S. Army Research Institute for the Behavioral and Social Sciences identified a requirement to conduct an investigation into the feasibility of using personality and psychophysiological measures to improve the selection and classification of personnel into stressful occupations. This report examines the potential of both personality and psychophysiological measures as predictors of successful performance under stress.

Procedure:

In an earlier report the authors concluded that stress was best characterized as the dynamic relationship between situational demands, the cognitive appraisal of those demands, and an individual's response to those demands. Effective coping occurs when there is a balance between environmental demands and the individual's perceived available resources. Based on the literature, a personality profile emerged that successful copers tended to be more introverted, task-oriented, and self-confident. From the psychophysiological perspective, a new psychophysiological model was developed to explain the findings in the literature. This model proposed that when personnel are faced with potentially threatening or dangerous environments but optimal performance is required, successful copers engage a task-oriented coping process and actively suppress or inhibit arousal normally caused by exogenous (environmental) and endogenous (fear or anxiety) stimuli. It was concluded that cardiovascular measures, such as heart rate and vagal tone, were potentially sensitive discriminators and predictors of successful performance in stressful occupations and should be explored further. Based on these conclusions, two investigations were conducted. The first investigation developed a new Occupational Stress Assessment Inventory that better examined stress in an occupational context with measures of active coping and self-confidence built into the same instrument. In the second investigation, this new inventory as well as other personality measures were employed in a psychophysiological stress paradigm to directly assess the predictive power of personality and psychophysiological measures with respect to predicting performance under stress.

Findings:

The first investigation developed a more appropriate measure of occupational stress and coping. In a psychometric examination of this new instrument, the new inventory showed reasonably good convergent validity with other measures and good internal consistency. It was found that individuals who rated situations as less stressful tended to rate their ability to change the situations as high and that those individuals who perceived their abilities to change stressful situations engaged in more problem-focused coping strategies as planning, suppressing competing activities, restraint coping, and reinterpretation and growth.

The second investigation included this new inventory and other personality measures in a psychophysiological stress paradigm to directly assess the predictive power of personality and psychophysiological measures to predict performance under stress. The results of the second investigation showed that the absolute levels of heart rate, vagal tone, and mean arterial and diastolic blood pressures, as well as reactivity-based change measures of vagal tone (and to a lesser extent heart rate), predict performance on simple and more complex cognitive tasks. Not only do these measures predict performance levels but they also predict different performance levels under different stressors. Specifically, individuals with better performance under stress showed higher heart rates and blood pressures under stress as well as lower vagal tone and greater suppression of vagal tone from baseline levels. Given the low statistical power associated with this pilot investigation of only 20 subjects and the usually high variability associated with performance abilities and psychophysiological responses to stress, these psychophysiological measures demonstrated unexpectedly impressive predictive power with respect to predicting performance under stress with significant correlations ranging from .43 to .67. Personality predictor variables were less consistent than the psychophysiological predictor variables but nevertheless showed some consistent patterns of response. The data suggested that those individuals who perceived themselves as having more ability to cope with stress and those individuals who more actively cope with stressful situations indeed are more successful performers when they encounter the need to perform under stress. These successful copers also tended to be more introverted.

Utilization of Findings:

The present findings appear to indicate that psychophysiological measures (especially vagal tone and blood pressure measures) can be an extremely valuable addition to the selection and classification process to better select those individuals who will perform better under stress. While these data are impressive and encouraging, it is recommended that these findings be validated in more real-world settings such as recruitment centers and training environments against more realistic performance under stress. It is also recommended that the protocol used in the present investigation be used as a method of manipulating stress in such settings to examine each individual's response to stress in a controlled setting. It is further recommended that some preliminary data be collected that will further assess these measures in realistic selection settings for a specific population of interest. If the results are similar to those found in the laboratory investigation, a more thorough and extensive effort to validate these findings under realistic occupational stress settings would be warranted.

AN EXPLORATION OF PSYCHOLOGICAL AND PSYCHOPHYSIOLOGICAL MEASURES AS PREDICTORS OF SUCCESSFUL PERFORMANCE UNDER STRESS

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AN EXPLORATION OF PSYCHOLOGICAL AND PSYCHO-PHYSIOLOGICAL MEASURES AS PREDICTORS OF SUCCESSFUL PERFORMANCE UNDER STRESS

INTRODUCTION

Many military occupations can be characterized by the old aviation adage that their occupation is defined by "hours and hours of total boredom punctuated by moments of sheer terror." While this is true for some civilian (e.g., nuclear power operators, air-traffic controllers) and military (e.g., Special Forces, Rangers, Airborne personnel, helicopter and fighter pilots, bomb disposal experts, emergency personnel) occupations, the present state of the world situation makes sustained operations in high stress environments much more likely and increasingly more frequent for military personnel. While all military occupations have the potential for a marked elevation in stress, increasingly military personnel are asked to serve in not only combat situations but also situations of peace-keeping. Unfortunately, at present, peace-keeping is more often than not defined by keeping the peace in a war zone where the opposing parties have little desire for peace. In these situations, military personnel are required to maximize restraint during periods of conflict escalation. It is clear from previous literature cited in our earlier report (Heslegrave & Colvin, 1993) that while such an environment is inherently stressful, this peace-keeping situation is made even more stressful by removing many of the active coping mechanisms normally available to personnel. Thus, the need for a better understanding of stress and coping in real-world situations is perhaps even more clear today than it was in the earlier report. The requirement to select personnel for high stress occupations or select personnel who will perform well in high stress environments has never been more paramount.

GOALS OF THE PRESENT REPORT

The present report has two purposes. The first purpose is to explore the development of a novel and potentially useful psychological instrument designed to measure reactivity to stressful situations. This instrument was developed and assessed with the explicit purpose of creating a simple tool that might provide a reasonable yet simple and efficient method to select personnel for high stress environments. The second purpose was to empirically examine the psychophysiological model proposed in the initial report (Heslegrave & Colvin, 1993). This model will be reviewed in this report but essentially this new "psychophysiological coping model" proposed that when personnel are faced with potentially threatening or dangerous environments but optimal performance is required, successful copers engage in a task-oriented coping process and actively suppress or inhibit arousal responses that are usually caused by exogenous (environmental demands) and endogenous (psychological demands such as fear or anxiety) stimuli. It was proposed that those psychophysiological measures that best reflect inhibitory processes, such as heart rate and heart rate variability, may be the most sensitive predictors of successful performance in stressful occupations. The empirical assessment of this new psychophysiological

model in this report also provided a laboratory platform on which to assess the newly developed "situational stress-reactivity" instrument.

In order to provide an appropriate context for this report, it is necessary to briefly examine the recommendations of the previous report. In the previous report, Heslegrave and Colvin (1993) suggested that three parallel research lines be initiated to investigate the problem of selecting personnel for stressful occupations. It was proposed that: (a) occupations should be analyzed in terms of their stress dimensions, (b) since successful copers appear to share a cluster of personality traits, research should be conducted into the personality correlates of successful task performance under stress, and (c) experimentation should begin to assess the proposed psychophysiological model designed to explain individual differences in successful coping under stress.

The present report addresses these recommendations in a limited way due to pragmatic and operational constraints. With respect to the first objective, a variety of organizational and practical limitations did not allow an occupational analysis of stress dimensions in critical occupations at the present time. With respect to the second objective, since our research did not allow an adequate task analysis of current high-stress occupations, the instruments used to measure personality correlates of stress in high-stress occupations were developed on the basis of our knowledge of stressful occupations in general and were not specific to military occupations. The advantage of this constraint is that a more generic personality trait test was developed which may have greater external validity and be more applicable to a variety of occupations. With respect to the third objective, it was proposed that military personnel be investigated under training conditions of high stress while simultaneously having a number of psychophysiological measures monitored. Since military personnel were unavailable for such testing, a laboratory analogue of performance under stress was proposed and accepted as a reasonable protocol to collect preliminary information. In this protocol, subjects performed demanding neurocognitive tests and had their psychophysiological responses during performance simultaneously collected; these tests were performed under increasingly more stressful conditions throughout the experiment. The disadvantage of conducting such a laboratory investigation is that the results may fail to generalize to the external reality of a military occupation. Moreover, any results in such a laboratory setting with respect to the model should be evaluated cautiously since it is unknown how well the laboratory setting results will generalize to the operational setting. On the other hand, the advantages of a laboratory analysis are two-fold. First, the laboratory provides improved experimental control over many psychological and psychophysiological variables that can confound and complicate the applied field setting. Second, a more important advantage is that if the results are reasonable in the laboratory setting and are consistent with results obtained in more applied field experiments, then the laboratory paradigm may be a valid paradigm that can be directly applied in the personnel selection and recruitment setting. In summary, the present report provides the initial development of a new psychometrically-validated instrument to assess successful coping and performance under high stress and the development of a laboratory paradigm designed to increase stress under controlled laboratory conditions. It remains necessary to validate these approaches in a variety of ways in more operational settings with operational personnel.

This report contains three sections. The first section is devoted to a review of the background and rationale for the project. This review will be limited as it is extensively considered in a previous document (Heslegrave & Colvin, 1993). The second section explores the development of a personality measure to assess coping strategies in individuals specifically based on earlier model development. The third section reports on a laboratory investigation designed to relate neurocognitive performance with psychophysiological measures and further relate these results to the personality or psychological constructs developed in the second section.

SUMMARY OF PREVIOUS FINDINGS ON THE PSYCHOLOGICAL AND PSYCHOPHYSIOLOGICAL TOOLS USED IN THE SELECTION OF PERSONNEL FOR HIGH-STRESS ENVIRONMENTS

The problem of selecting military personnel for specialized high-stress assignments presents a major challenge. Currently it remains difficult to discriminate who, from among a group of individuals with appropriate and adequate knowledge, skills, and abilities (KSAs), will perform well in high-stress environments from those who will not. This review will briefly summarize our earlier findings (Heslegrave & Colvin, 1993) and discuss the rationale for the current research.

Performance Impairment Under Stress

In our previous report, it was clear that stress has negative consequences for performance. For instance, performance was shown to be impaired by a variety of stressors such as high noise (Broadbent, 1978; Poulton, 1978), increased workload (Goldstein & Dorfman, 1978), crowding (Hayduk, 1983; Schmidt & Keating, 1979), performance pressure (Baumeister, 1984; Baumeister & Steinhilber, 1984), psychological stress (Berkun, 1964), and anticipatory threat of shock (Wachtel, 1968). In operational performance studies, Villoldo and Tarno (1984) have reported that performance stress alone can cause increased errors while Idzikowski and Baddeley (1983) have reported that the time taken to complete manual tasks will double under conditions of high stress. Performance impairment has also been demonstrated in more dramatic operational settings where individuals have been exposed to dangerous situations such as parachuting (Fenz & Epstein, 1967, 1968; Fenz & Jones, 1972a, 1972b; Hammerton & Tickner, 1969), simulated chemical warfare conditions (Brooks, Ebner, Xenakis, & Balson, 1983; Carter & Cammermeyer, 1985), and bomb disposal (Cox, Hallam, O'Connor, & Rachman, 1983; Rachman, 1983a, 1983b, 1990, 1991).

Theoretical Approach to Stress and Occupational Stressors

Historically stress has been conceptualized in psychology in a variety of ways from the stimulus properties of the situation or event (Appley & Trumbull, 1986) to response characteristics associated with the situation or event (Selye, 1976). The most widely-held current approach is that stress should be defined in a transactional, interactional, or

cognitive-relational manner. In this view, stress is defined in terms of a specific relationship between the individual and the environment. The most detailed theory relating the individual to his or her environment is the cognitive-relational theory of Lazarus & Folkman (1984) (see also, Cox, 1978; Lazarus, 1966, 1968; Lazarus & Launier, 1978). In their approach, stress is an imbalance between the perceived demands of the situation and the perceived resources necessary for successful coping with the situation. Central to this approach is the notion of cognitive appraisal or cognitive evaluation. Rather than defining stress in terms of either objective stimulus characteristics or objective physiological responses, the cognitive-relational theory concentrates on the mediational evaluative process carried out by the individual based on the perceived relationship between demands and resources (Fleming, Baum, & Singer, 1984). Thus, reciprocal causality between individual, situational, and response variables is assumed. At any moment in a given situation or environment, the individual must appraise the environmental demands, assess the availability of the resources applicable to those demands, and then respond. In other words, there is a dynamic and constantly changing appraisal of the situation. Based on this view, individual difference variables become important since factors that affect appraisal can influence one's ability to cope effectively with the environmental demands. For instance, there has been a growing interest in assessing the relationship between different emotional categories (e.g., fear, happiness) and the resulting differential appraisal of the environment (Arnold, 1960; Frijda, 1987, 1988; Frijda, Kuipers, & ter Schure, 1989; Lazarus, 1968; Scherer, 1984; Smith, 1989; Smith & Ellsworth, 1985; 1987; Tesser, 1990).

Given that stress is best characterized as the dynamic relationship between situational demands, the cognitive appraisal of those demands, and one's response to those demands, successful coping under stress requires an appropriate cognitive appraisal of the environmental demands. Effective coping occurs when there is a balance between environmental demands and available resources. For example, those individuals who will successfully cope with a "stressful" situation will be those individuals who will appraise, or reframe, the situation to be within their ability to apply existing resources to the task at hand. From this perspective, the selection and classification goal for "stressful" occupations is to place those individuals who appraise "high stress" conditions as being within their abilities in high stress occupations.

While debate continues over the merits of differing definitions of stress, this literature suggests that individuals who perform successfully in stressful occupations have common characteristics that differentiate them from those who do not. It has been suggested that certain inherent personality characteristics (e.g., locus of control, socialization, sensation-seeking) are perhaps important because these characteristics enable effective copers to appraise high stress conditions as being within their abilities (cf. Heslegrave & Colvin, 1993).

Given that stress is defined interactionally and dynamically, it is prudent to understand not only the personality structures that might influence the relationship but also the environmental conditions that are commonly interpreted as stressful. Previous studies have operationalized stress in a number of ways as shown in Table 1. For example, in a number of studies previously reviewed (cf. Heslegrave & Colvin, 1993), stress has been operationalized as noise (e.g., Fleishman and Quaintance, 1984), position analysis dimensions (Siegel, 1988), ratings of the intellectual and psychomotor loads placed upon individuals, ratings of the effects of prolonged battle stress (Siegel, 1988), and role conflict/role ambiguity (Solomon, 1986). From this review a

Table 1

Dimensions, Operational Definitions, and Research Examples of Job Stress

Stress Dimension	Operational Definition	Research Exemplar
Uncertainty	Intermittent parachute malfunction	Fenz & Jones (1972b)
Ambiguity	Clarity of structure	Solomon (1988)
Conflict	Multiple psychomotor tasks	Cox et al. (1983)
Control	Move a lever in the direction of the tone	Rachman (1989)
Workload	Intellective and psychomotor load	Siegel (1988)
Environmental Stressors	Noise	Fleishman & Quaintance (1989)
Threat	Electrical shock	Rachman (1989)

number of potential dimensions of stress relevant to military occupations were identified and are shown in Table 1. A job analytic approach to stressful occupations would have job incumbents provide behavioral examples of the job stress dimensions shown in Table 1 and their frequency, importance, and intensity would be rated to determine the most significant stressful specific job properties.

Psychological and Psychophysiological Literature on Occupational Selection for High-Stress Occupations

A number of professions have attempted to develop tools for the selection of personnel for high stress occupations. For instance, law enforcement personnel attempt to screen out obvious physical, psychological, and intellectual deficiencies based on standardized psychological screening tools (Behrens, 1985; Goldstein, 1975; Presidential Commission on Law Enforcement, 1967) such as the California Psychological Inventory (Fabricatore, Azen, Schoentgoen, & Snibbe, 1978; Hargrave & Berner, 1984; Hogan & Kurtines, 1975), Minnesota Multiphasic Personality Inventory (e.g., Beutler, 1985), and the Inwald Personality Inventory (Inwald, Knadz, & Shusman, 1983; Ostrov & Cavanaugh, 1986). However, in their quest for sophistication, researchers concluded that there was little empirical support for standard psychological tests and that "situational stress tests" to assess reactivity to specific stress events need to be developed (Mills, 1976; Pugh, 1985).

Others have also investigated the effects of stress on soldiers from a psychological perspective. Merbaum and Hefez (1976) found that the stress of war induced a differential clinical portrait for soldiers who became psychiatric casualties compared to those who remained as medical casualties. They found that psychiatric casualties were significantly higher on scales indicating the presence of painful emotional distress, impulsivity, aggression, and poorly controlled behavior. Keinan (1988) recently investigated training for dangerous task performance and measured personality variables and performance under different conditions. He found that individuals who did not expect to be injured during dangerous training performed better and reported lower stress than the other subjects; this result is consistent with the transactional model of stress appraisal.

Other professions have also examined the utility of psychological tests. For instance, Biersner and LaRocco (1983) used personality measures to assess sensation-seeking, locus of control, socialization, and trait anxiety of Navy divers. They concluded that high-stress Navy divers reported (1) higher internal locus of control, (2) fewer and less friendly social interactions with others, and (3) lower levels of chronic or trait anxiety. Hogan and Hogan (1989) also examined explosive ordnance training/job performance in Navy divers and included tests of cognitive abilities, vocational interests, and physical ability along with personality measures as predictors of performance. They concluded that successful trainees and divers have practical interests, are introverted, well-adjusted, self-confident, adventuresome, prefer to work on practical problems, prefer to work alone, and have attributes such as physical strength and dynamic flexibility.

Still others have investigated more dangerous occupations such as bomb disposal operators. For instance, Cooper (1982) examined bomb disposal operators in Northern Ireland and found that highly successful bomb disposal operators had lower levels of affiliation and affection motivation, had difficulty in forming and maintaining close personal relationships, and had a tendency toward non-conformity with less reliance on conventional values and judgments. In other words, they tended to be social isolates, preferred to work alone (maintain psychological and social distance), preferred to work with things, not people, and were less susceptible to conformity and conventional responses (which may lead to greater flexibility). Cooper (1982) suggested that such characteristics may benefit individuals faced with a high stress environment and critical task performance because these individuals are less distractible and more flexible in their approach to a problem.

From a psychophysiological perspective, Cox, Hallam, O'Connor, and Rachman (1983) examined this same population of bomb disposal operators. They found that decorated operators maintained a lower cardiac rate during difficult discrimination tasks under threat of shock than non-decorated individuals. Later, O'Connor, Hallam, and Rachman (1985) reported that: (a) decorated operators showed lower heart rate (HR) than the other control groups, and (b) during difficult discrimination condition tests, the decorated group showed a lower HR (78 beats per minute (bpm)) than the non-decorated group (87.33 bpm) and the less experienced group (91 bpm). Still with bomb disposal technicians, Rachman (1991) recently found that decorated technicians exhibited lower self-reported anxiety than the non-decorated technicians and HR variability was markedly smaller (by about 50% during the first trial) in decorated operators (see Heslegrave & Colvin (1993) for a more thorough analysis). These studies suggested that a lower

HR response pattern may be a psychophysiological marker characteristic of successful coping. This interpretation is consistent with other findings from the psychophysiological literature. For instance, it has been consistently reported that more successful coping with predictable stressful events, like shock, leads to HR decelerative responses (e.g., Lacey, 1967; Lacey & Lacey, 1974) while failure to cope with stress successfully (e.g., failure to learn shock-avoidance successfully) leads to HR acceleration (e.g., Brener, Phillips, & Conally, 1980).

Finally, studies on parachutists have been conducted to examine the utility of psychophysiological predictors of performance. Fenz and Epstein (1967) concluded that experienced parachutists showed lower values on all heart rate (HR) and respiration rate (RR) measures throughout the course of the jump. Fenz and Jones (1972a) replicated and extended the work by including measures of RR, HR, and performance ratings. They found that novice parachutists showed an increase in RR and HR at the time of the jump, while experienced parachutists showed an increase well before the jump, then a decrease at the time of the jump. For novice parachutists, good performers showed an increase prior to the jump then a decrease at the time of the jump, while poor performers showed an increase at the time of the jump. For experienced parachutists, good performers showed an increase then a decrease at the time of the jump, while poor performers showed an increase at the time of the jump. These authors concluded that the most adaptive response (for both novice and experienced parachutists) is an increase in arousal early in the jump followed by a sharp decrease, so that at jump time, arousal is at normal levels. Others (cf. Deroanne, Cession, Juchmes, Servias, & Petit, 1975; Doerr, Doshier, and Ellerson, 1971) reported similar findings in that experienced parachutists had a lower heart rate compared to novices.

Overall, the literature on predicting successful performance under stress suggests that personnel who perform effectively under stress share several characteristics. In terms of personality characteristics, they tend: (a) to show lower anxiety (Biersner and LaRocco, 1983; Knapp, Capel, & Youngblood, 1976; Rachman, 1991) and fear (Epstein and Fenz, 1965) during dangerous situations, (b) to score higher on internal locus of control and thrill- and adventure-seeking, and have fewer and less friendly social interactions with others (Biersner and LaRocco, 1983), (c) to be introverted, well-adjusted, self-confident, adventuresome, and prefer to work on practical problems (Hogan & Hogan, 1989), (d) to be more stable and less impulsive (Merbaum and Hefez, 1976), and (e) to be social isolates, prefer to work alone (maintain psychological and social distance), prefer to work with things, not people, and be less susceptible to conformity and conventional responses (Cooper, 1982; Hogan & Hogan, 1989). While successful performers under stress generally appear to have lower self-reported anxiety, fear, and arousal, when they do report increases in anxiety and arousal, it is clearly related to a critical event in the stressful situation (Epstein & Fenz, 1965; Knapp et al., 1976; Ursin, Baade, & Levine, 1978; Schedlowski & Tewes, 1992). In addition, there is some evidence (Keinan, 1986) that those individuals more likely to demonstrate successful performance under stress may benefit from a more realistic, higher-fidelity, and more potentially dangerous training regimens.

Regarding psychophysiological patterns of responding while performing successfully under high stress, the literature suggests that such a distinctive pattern may be found in cardiac reactivity during the stressful event. The work of Fenz, Rachman, and others have shown that those individuals who perform successfully under stress exhibit a lower level of HR (and to some

extent a reduction in HR variability as well) during stressful events than do less successful individuals. Perhaps, more importantly, cardiac responses vary systematically as a function of the stage of the task and its demands: the cardiac responses of successful performers increase early in preparation for the stressful task and then decrease prior to critical aspects of task performance so that at the beginning of the task, the physiological arousal (e.g., HR) is essentially at normal (resting) levels.

As a caveat to these conclusions from the literature, it should be noted that successful/unsuccessful coping categorization of personnel are usually confounded by experience since successful and unsuccessful coping are often defined as experienced and inexperienced personnel. Thus, to extent to which these characteristics reflect fundamental differences in the cognitive appraisal of the situation or reflect the influence of experience is unclear. It should also be noted that there is a relative paucity of literature in this area, that the results from the existing studies can be criticized on methodological grounds, and that there are important methodological differences between studies. Therefore, the conclusions from the literature must be regarded as tentative. Nevertheless, the literature provides a rough framework within which further research can be conducted.

A Psychophysiological Model for Coping Under Stress

To integrate the literature in a coherent manner, a psychophysiological model was developed based on the premise that successful individuals employ coping processes that lead them to assess an adverse situation differently (Schedlowski & Tewes, 1992; Ursin et al., 1978), a view consistent with the interactional approach to stress. As detailed in the earlier report (Heslegrave & Colvin, 1993), the more successful copers are introverted, self-confident, show lower anxiety and fear, are more thrill and adventure seeking, have a more internal locus of control, are less social and less susceptible to conformity pressure, and prefer to work with things or on tasks rather than with other people. Generally, the successful copers are internally focused, task-oriented, and less sensitive/responsive to environmental (even social) stressors. These characteristics appear to facilitate a cognitive restructuring of the environment which interprets an environment as being less stressful. Physiologically, the successful copers anticipate the stressful event or task, as indexed by increased arousal (e.g., higher HR or increased skin conductance) prior to the task, and then appropriately appraises the environment such that the task requirements are within his/her resource potential. As one successfully engages in the critical and more demanding aspects of the task, cardiac arousal appears to be specific to the task demands and less influenced by endogenous and exogenous factors.

This interpretation of the literature suggests a psychophysiological profile for individuals likely to perform successfully under stress. The successful copers are one who is internally-focused, task-oriented, and less susceptible to external stress-inducing stimuli under conditions where task performance is the primary means of controlling the threatening or stressful situation. This does not mean that the individual is unaware of the potential danger of the task or situation or fails to respond appropriately to the task or situation. Rather, it has been shown that the individual will successfully anticipate the situation, and cope with the situation by engaging in productive task activity with maximal physiological efficiency.

To explain the cardiac changes in successful copers during task engagement, a psychophysiological model was developed. This model proposed that when individuals are faced with potential threatening or dangerous environments where optimal performance is required, a subset of individuals engage in a task-oriented coping process which **actively suppresses or inhibits** exogenous and endogenous stimuli, as well as the consequent arousal normally associated with those stimuli. Thus, rather than viewing previous results such as a lower HR, or normal HR levels, for decorated bomb disposal operators or experienced parachutists as reflecting less anxiety, or no anxiety, this model views a lower HR level as an active inhibition of the HR increases that are present in non-decorated bomb disposal operators or novice parachutists. Further, this inhibitory control over excessive arousal associated with non-task relevant activity is assumed to facilitate superior task performance. Finally, this model defines successful coping as the active engagement of task-relevant behavior that reduces the disruptive effects of other endogenous or exogenous stimuli.

This psychophysiological model of coping has several important implications. First, those individuals most likely to be successful in stressful occupations will show task-oriented activity and levels of arousal appropriate to task demands. In other words, their physiological efficiency during task performance should be optimal. Second, when engaging in well-learned behaviors, individuals with smaller physiological reactivity to stressful stimuli should be more resistant to the effects of expected stress. Furthermore, it would be expected that those individuals who show lower reactivity to stressful stimuli during task performance would be more resistant to stress effects when the intensity of the stressor is increased. In addition, it would be expected that as performance becomes impaired with increasing levels of stress, the performance reduction would be related to levels of arousal. Psychophysiological measures would be helpful in predicting performance impairment because they would quantify the distraction of the individual from the task-oriented activity due to endogenous or exogenous stressors. It would be expected that successful task-oriented coping would result in task-oriented, and only task-oriented, psychophysiological changes. Third, individuals with specific personality characteristics, as noted earlier, should typically display arousal appropriate to their task-oriented activity under stress.

The final implication of this psychophysiological model of successful coping under stress is that the physiological mechanism underlying this controlled arousal during stress should involve an active inhibition of "fight or flight" types of arousal. For instance, stress is normally assumed to cause "fight or flight" reflexes designed to energize the individual to accommodate the confrontation with the stressor. In physiological terms, stress elicits heightened arousal through an increase in sympathetic nervous system activity, and/or decreases in the parasympathetic nervous system which should be reflected in such autonomic indicators as heart rate, blood pressure, and respiration rate. This psychophysiological model assumes that the individual is aware of the stressor, but is actively suppressing or inhibiting the extraneous stress responses by focusing on the task. This model also assumes that those individuals who are more capable of inhibiting physiological responses to stress should perform better.

If inhibitory control of arousal is critical to controlling the effects of stress, previous studies can only provide indirect support for this hypothesis as these studies have only attempted to measure excitatory responses to stressors. While it may be the case that the lack of an excitatory response may be the product of inhibitory control, this conclusion is in no way certain.

Direct support can only be obtained by the measurement of excitatory and inhibitory control processes. Such measures would be derived from cardiac measures that have been shown to have some sensitivity for differentiating successful from less successful copers under stress conditions.

Proposed Psychophysiological Measures

Based on this model, potential psychophysiological measures could be proposed to measure these excitatory and inhibitory processes. These measures, however, would have to meet specific pragmatic criteria. First, measures should be able to differentiate the psychological process of interest such as individual differences in reactivity to stress. Second, potentially useful psychophysiological measures should receive some empirical support from the literature or be logically derived from the existing literature. Third, potentially useful psychophysiological measures should be applicable in a practical selection/classification setting. Fourth, as previously noted, the best theoretical formulation of successful coping under stress is an interactional or cognitive-relational approach which defines stress as a dynamic relationship between the individual and the environment. Therefore, to be potentially useful, psychophysiological measures should respond to the dynamic relationship between the individual and the environment. Fifth, since emotional responding seems to underlie the nature of stress and coping, potentially useful psychophysiological measures should be particularly sensitive to emotionally-laden situations and, as such, should reflect autonomic nervous system changes sensitively.

Given these various selection criteria for psychophysiological measures, potential measures would differentiate individual differences in terms of stress, would have received some support in the relevant literature, would be easy to measure and interpret, would be continuous and dynamic, and would reflect excitatory and inhibitory autonomic activity. Specific potential measures could include such traditional measures as heart rate, blood pressure, respiration, and electrodermal (skin conductance) activity. Cardiovascular (e.g. blood pressure) and cardiac measures (e.g., heart rate) appear to best satisfy the stated criteria in that they are methodologically easy to acquire and analyze and may be the most appropriate measures to assess coping responses during stressful conditions (cf., Heslegrave, 1991). More specifically, measures of heart rate and heart rate variability (derived from respiratory sinus arrhythmia) were considered the best candidate psychophysiological measures from the perspective of both the literature and the proposed theoretical model (Heslegrave & Colvin, 1993).

To fully understand the proposed measures, a brief discussion of the regulatory control of HR is necessary. While HR is a measure sensitive to many manipulations, HR does not reflect a single, or for that matter simple, underlying physiological process. In terms of neural control, HR is a mixed measure in that it is dually innervated from both the sympathetic and parasympathetic branches of the autonomic nervous system and is also responsive to homeometric control based on the regulatory demands and feedback loops of the cardiovascular system. Thus, metabolic demands and regulatory control demands (such as through baroreceptor feedback) can overshadow psychological effects and reduce the sensitivity of this measure. In addition, for any measure to be sensitive to inhibitory arousal, it must have two characteristics. First, the measure must be able to respond to inhibitory arousal, and second, the measure must be sensitive primarily to inhibitory arousal. In the case of HR, the first characteristic is true. HR is sensitive to

inhibitory arousal because increases in parasympathetic activity lead to bradycardia or a lowering of HR. In fact, the dynamic control of HR is predominately governed by the parasympathetic nervous system when HR is within a normal range (e.g., 60-100 bpm). Levy (1977) has provided a very good description of the dynamic control of HR by the sympathetic and parasympathetic nervous systems. Thus, with respect to the lower HR of experienced parachutists and bomb disposal operators, it is likely that the lower HR was a function of greater parasympathetic activity. However, HR does not only reflect parasympathetic activity but, as stated above, is sensitive to sympathetic activity as well. Thus, it does not satisfy the second requirement of a psychophysiological measure that is primarily sensitive to inhibitory arousal.

Since stress is known to elicit primarily sympathetic activity, it is important to differentiate sympathetic and parasympathetic influences on HR. In addition, since it is hypothesized that those individuals with greater inhibitory control will perform better under stress, it is important to examine inhibitory processes more directly than by using HR alone. To accomplish this goal, HR variability measures that can be derived from a continuous electrocardiogram are proposed.

To date, HR variability has received only preliminary consideration in the literature, but there is every indication that successful performers under stress show reduced HR variability (Rachman, 1991). However, HR variability has been defined in terms of standard deviations over variable length epochs. More sophisticated analyses of HR variability are available and these measures may prove to be more sensitive. Specifically, HR variability can be analyzed into its constituent parts which are differentially sensitive to specific physiological processes. Using spectral analysis, most of the variance in HR variability can be accounted for by three discrete bandwidths reflecting respiratory, blood pressure and temperature influences. The first of these bandwidths is generally considered a high-frequency bandwidth between 0.2-0.4 Hz which is associated with spontaneous respiration and is labeled respiratory sinus arrhythmia (RSA). This high-frequency component has been shown to be a product of the brainstem modulation of parasympathetic (or vagal) efferent tone (Katona & Jih, 1975). Thus, this measure of respiratory sinus arrhythmia can be conceived of as a measure of vagal tone and reflects inhibitory control over cardiac rate. By measuring both HR and RSA, the degree of parasympathetic involvement in HR changes can be derived in order to determine whether or not HR changes might also provide a good measure of vagal tone. To supplement these measures and to provide a more direct assessment sympathetic involvement, measures of systolic, diastolic, and mean arterial blood pressure can be measured since blood pressure control is more directly under sympathetic control.

In summary, cardiovascular and cardiac measures best meet the stated criteria for useful psychophysiological measures as well as best reflect excitatory and inhibitory arousal processes. HR is a mixed sympathetic/parasympathetic measure but it is unclear in any given circumstance whether this measure will prove to be primarily sympathetic or parasympathetic. On the other hand, the RSA component of HR variability is primarily parasympathetic in origin while blood pressure measures are primarily under sympathetic control. By observing changes in all of these measures it will be possible to examine the relative importance of excitatory and inhibitory arousal with respect to enhancing or maintaining performance under stress. Based on the psychophysiological model proposed, it is expected that RSA measures of vagal tone will be best correlated with superior performance under stress followed by HR depending on the degree to which HR is primarily vagally controlled in these circumstances. Blood pressure measures may

also be strongly related to successful performance under stress to the extent that stress in these circumstances is primarily sympathetically mediated.

Proposed Directions for the Selection of Personnel for Stressful Occupations

Based on the review of the literature and the shortcomings of past and present approaches to selecting personnel for stressful occupations (Heslegrave & Colvin, 1993), we concluded that psychophysiological measures may provide useful tools for the selection/classification of personnel for stressful occupations and for performance under stress in all occupations. However, research specifically focusing on this issue is necessary before such a conclusion can be made with certainty.

To address the issues raised in the earlier report, it was recommended that three parallel approaches to examining the issue of selecting and classifying individuals for stressful occupations be undertaken. First, experimentation is needed to assess the validity of the proposed psychophysiological model designed to explain individual differences in successful coping under stress. Second, since it was suggested that individuals who are more successful at coping under stress appear to have a cluster of personality traits that support their coping strategy of focused task engagement, research should be conducted into the personality correlates of successful task performance under stress. If stable personality variables can be found that are correlated with psychophysiological response patterns and a preference to engage in task performance under stress, then selection and classification of such individuals will be easier and more practical. Third, occupations must be analyzed in terms of their stressful dimensions. This analysis would provide a rationale for the identification of valid predictors and criteria of successful performance across a wide range of stressful jobs. In addition, it was previously suggested that this theoretical model and implications be tested in a high-fidelity field experiment.

Summary of Current Project

A number of circumstances unfortunately prevented the adoption of the proposed future directions in their entirety at the present time. It was found that analyzing the stress dimensions of personnel in specific occupations was impractical at present due to a variety of constraints. Additionally, conducting a controlled demonstration experiment was equally impractical. Thus, the goal of the present project was three-fold. The first purpose was to develop a novel and potentially useful psychometric instrument designed to measure reactivity to stressful situations and assess its psychometric properties and validity against other established and related instruments. This instrument was developed with the explicit purpose of creating a simple tool that might provide a reasonable yet simple and efficient instrument to select personnel for high stress environments. The second purpose was to empirically examine the psychophysiological model proposed in the initial report (Heslegrave & Colvin, 1993). Finally, on the practical side, this investigation was intended to assess the degree to which identified candidate measures are useful predicting performance under stress manipulations.

INVESTIGATION 1: THE DEVELOPMENT AND ASSESSMENT OF THE OCCUPATIONAL STRESS ASSESSMENT INVENTORY

Introduction

In this investigation, the Occupational Stress Assessment Inventory (OSAI) was developed, and its psychometric properties were evaluated. The development of the OSAI was based upon Folkman and Lazarus' (1985) model of primary appraisal, secondary appraisal, and coping style. The internal consistency of the inventory was assessed using coefficient alpha. To validate the construct validity of the OSAI, responses to the inventory were correlated with responses to the Ways of Coping Scale (Carver, Scheier, & Weintraub, 1989), the Self-efficacy Scale (Sherer, Maddux, Mercandante, Prentice-Dunn, Jacobs, & Rogers, 1982), and the Eysenck Personality Inventory (Eysenck & Eysenck, 1963). The OSAI, Self-efficacy Scale and the Eysenck Personality Scale instruments are shown in Appendix A (along with a demographic questionnaire given to all subjects in Investigation 2).

Method

Subjects. Forty-one subjects enrolled in an undergraduate Psychology class participated in this investigation. Their participation was voluntary. Of the 41 subjects, 34 reported their gender as female, 6 reported their gender as male, and 1 failed to report his/her gender. Approximately 44% (n=18) of the subjects were European-Americans, 22% (n=9) were Asian-American, 14% (n=6) were African-American; and 12% were Latino (n=5).

Development of the OSAI. The OSAI included 26 stressful situations that were derived from 13 stress manipulations used by researchers in the field of human stress, 7 of which were identified in the Heslegrave and Colvin (1993) report (i.e., role ambiguity, task conflict, autonomy/control, physical environment, work overload, threat of reprisal, uncertainty) and another 6 dimensions were identified by further reviews of the literature and focus groups (i.e., goal difficulty, career development, decision-making, interpersonal conflict, administrative red tape, individual responsibility). Two questions based on each dimension constitute the OSAI. These dimensions were translated into situations that an individual may encounter at work. For each situation, the subjects were asked to evaluate (1) how stressful they found the situation (Stress); (2) whether or not they would cope with or change the situation (Change); (3) how effectively they would cope with the situation relative to others (Others); and (4) how they would actually cope with the situation in terms of coping strategies (Cope).

To assess Stress, Change and Others, the subject responded on a 5-point Likert scale from "Strongly Disagree" to "Strongly Agree." To determine the actual ways of coping strategies for each situation (described as (4) above and labeled as alternative 4 in each question), the subjects were instructed to select one of four alternative responses that best described how they would cope. The four alternatives were based upon active (or problem-focused) coping styles and passive (or emotion-focused) coping styles and they were ranked in terms of the most effective coping method.

For example, active coping and suppression of competing activities (both active coping styles) were ranked as most effective and subjects received four points if they chose this coping method. Planning, restraint coping, and seeking emotional support for instrumental reasons (active coping styles) were ranked as effective and subjects received three points if they selected one of these alternatives. Seeking social support for emotional reasons and focusing on and venting of emotions were ranked as less effective and subjects received two points if they selected one of these alternatives. Denial, behavioral disengagement, and mental disengagement were ranked as least effective and subjects received one point if they selected one of these alternatives.

Inter-Rater Agreement in the Development of the OSAI. To assess the inter-rater reliability of the 26 stressful situations, 10 raters were asked to identify the type of stressor described by each situation. The 26 situations were based upon 13 stressors including goal difficulty, role ambiguity, role conflict, career development, responsibility, uncertainty, work overload, physical environment, threat, administrative red tape, interpersonal conflict, and decision-making.

With the exception of goal difficulty, the inter-rater reliability for each situation was 80% or greater. Since the goal difficulty situations were identified as role overload by 60% of the raters, these situations were deleted. The role overload stressor was then categorized into two types: quantitative and qualitative overload. The goal difficulty stressor was incorporated into qualitative overload since as Matteson and Ivancevich (1987) suggest, qualitative overload can occur when performance standards are too high.

A second group of six raters evaluated the revised set of situations. Again, they identified the type of stressor described by each situation. For this set of situations, 66% of the raters correctly categorized all the situations according to the stressor that they represented.

Construct Validation of the OSAI. To assess the validity of the OSAI, the construct validation method was used. Subjects' responses to the OSAI were correlated with their responses to several surveys commonly used in stress research: the Cope Scale (Carver, et al. 1989), Self-efficacy Survey (Sherer et al. 1982), and Eysenck Personality Inventory (Eysenck and Eysenck, 1963).

The Cope Scale is a multidimensional inventory that assesses the different ways that people respond to stress. Five scales measure distinct aspects of problem-focused coping (e.g., active coping, planning) and five other scales measure emotion-focused coping (e.g., seeking emotional support, denial). Carver et al. (1989) correlated the Cope scale with measures of optimism, sense of control, self-esteem, locus of control, hardiness, Type A behavior pattern, trait anxiety, and monitoring/blunting style in order to assess its construct validity. Overall, the authors found that problem-focused scales were positively associated with optimism, sense of control, hardiness, and Type A behavior pattern but negatively associated with trait anxiety. On the other hand, emotion focused scales, generally displayed the opposite pattern of correlations with these variables.

The other survey used in the validation of the OSAI was the Self-efficacy Survey (SES) developed by Sherer et al. (1982). The survey is a 23-item scale that measures general levels of belief in one's own competence. The SES has demonstrated sufficient internal consistency with a

coefficient alpha of .86. Sherer et al. (1982) reported good criterion-related validity with significant correlations between the SES and success in vocational, educational, and monetary goals. Furthermore, the SES demonstrated strong construct validity by correlating significantly with the Ego Strength Scale, the Interpersonal Competency Scale, and the Rosenberg Self-esteem Scale.

The final survey included in the validation of the OSAI was the Eysenck Personality Inventory (EPI) developed by Eysenck and Eysenck (1963). The EPI measures several dimensions of personality including introversion-extraversion and neuroticism-stability. Eysenck and Eysenck (1963) also included a lie subscale in the EPI in order to detect deception in the subjects' responses to the survey items.

Procedure. Survey packets including the OSAI, the Cope Survey, the SES, and the EPI were administered to the 41 subjects during class and they were given class time to complete the surveys. Upon completion of the surveys, the subjects returned them to the experimenter and they were allowed to leave the class.

Results and Discussion

Reliability of the OSAI. The internal consistency of the four OSAI subscales was assessed using coefficient alpha. The reliability estimate for the Stress subscale was .81; .86 for the Change subscale; .88 for the Others subscale; and .50 for the Coping subscale.

Construct Validity of the OSAI. The four subscales of the OSAI (Stress, Change, Others, and Coping) were correlated with measures of coping style (Carver, et al. 1989), self-efficacy (Sherer et al. 1982), and emotional stability and extroversion (Eysenck and Eysenck, 1963). Table 2 shows the means and standard deviations for each of these measures. The correlations between these measures are shown in Table 3.

The correlations among the OSAI subscales indicated that people who rated the situations as highly stressful tended to rate their ability to change the situations as low. This latter variable was also significantly associated with comparisons to others: people who rated their ability to change the situations as high also rated their ability, compared to others to change the situations, as high.

Correlations between the OSAI subscales and the other measures were in the predicted direction, and generally, confirmed its validity. The only significant relationship that emerged for the Stress subscale of the OSAI was its correlation with the Lie subscale of the EPI. This suggested that people who reported perceptions of high stress tended to score low on the lie scale.

The Change subscale of the OSAI correlated in a positive manner with the SES, and the Lie subscale of the EPI. A negative relationship emerged between the Change subscale and the neuroticism subscale of the EPI.

Compared to the Change subscale, the Others subscale of the OSAI appeared to be a more valid indicator of people's perception of their ability to change or control stressful situations. The Others subscale correlated in a positive way with the problem-focused coping strategies of

Table 2

Descriptive Statistics for All Personality Measures

Personality Measure	Mean	Standard Deviation	N
<u>OSAI</u>			
Stress	104.27	10.67	41
Change	89.88	13.73	41
Others	87.73	12.58	40
Coping	78.30	6.27	33
<u>Ways of Coping</u>			
Total Score	130.31	17.15	36
Active Coping	11.86	2.23	36
Planning	13.33	2.48	36
Suppress Competing Activities	9.44	2.38	36
Restraint Coping	9.36	2.81	36
Social Support-Instrumental	12.33	2.52	36
Social Support-Emotional	12.25	2.95	36
Positive Reinterpretation & Growth	12.36	3.00	36
Acceptance	9.83	2.57	36
Turning to Religion	7.53	4.16	36
Focus on & Vent Emotions	10.97	3.34	36
Denial	5.31	2.19	36
Behavioral Disengagement	6.33	1.79	36
Mental Disengagement	8.08	2.45	36
Alcohol-drug Disengagement	1.27	.63	41
<u>Self-Efficacy</u>	85.35	10.51	31
<u>Eysenck Personality Inventory</u>			
Lie Scale	2.45	1.33	38
Extroversion	13.86	2.94	35
Neuroticism	11.08	4.55	36

Table 3

Correlations Between All Personality Measures*

Personality Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
<u>OSAI</u>																							
1 Stress																							
2 Change																							
3 Others																							
4 Coping																							
<u>Ways of Coping</u>																							
5 Total Score																							
6 Active Coping																							
7 Planning																							
8 Suppress Competing Activities																							
9 Restraint Coping																							
10 Social Support-Instrumental																							
11 Social Support- Emotional																							
12 Positive Reinterpretation & Growth																							
13 Acceptance																							
14 Turning to Religion																							
15 Focus On/Vent Emotions																							
16 Denial																							
17 Behavioral Management																							
18 Mental Disengagement																							
19 Alcohol/Drug Disengagement																							
<u>Self-Efficacy</u>																							
20 Total Score																							
<u>Eysenck Personality Inventory</u>																							
21 Lie Scale																							
22 Extraversion																							
23 Neuroticism																							

* Correlations significant at $p < .05$ are reported.

the Coping Survey including planning, suppressing competing activities, restraint coping, and reinterpretation and growth. Furthermore, this subscale correlated in a positive way with the SES, and the Lie and Neuroticism subscales of the EPI.

The Coping subscale of the OSAI was positively related to the active coping subscale of the Cope survey as well as to the behavioral disengagement subscale. The Coping subscale was also positively correlated with the SES.

Since the OSAI was intended to provide a more specific assessment of coping with stress in the workplace than the Ways of Coping Scale, it is pertinent to ask whether the more specific OSAI can replace the Ways of Coping Scale in subsequent research directed at task-oriented work stress situations. To answer this question the specific pattern of correlations between the scales can be used. In general, there is a lack of correlation between the subscales of the OSAI and the Ways of Coping Scale which suggests that the Ways of Coping Scale is not a measure of how individuals interpret stressful work situations (as measured directly in the Stress subscale of the OSAI) nor does it indicate whether or not individuals would choose to change or cope with the situation (as measured by the Change subscale). On the other hand, there was a positive relationship between choosing active coping strategies in the workplace (Coping subscale on the OSAI) and the more general Active Coping subscale of the Ways of Coping Scale. In addition, there were positive correlations between the task oriented subscales of the Ways of Coping subscale (e.g., suppressing competing activities) and the individuals view of their relative competence with respect to coping with work stress (Others subscale). Finally, the OSAI appeared to tap more general personality characteristics with a positive relationship with self-efficacy and a negative relationship with neuroticism. From these results it seems reasonable to conclude that the OSAI provides valuable information on stress- and coping-related tendencies applied in the workplace that the Ways of Coping Scale does not provide. However, in terms of the essential active coping and task-oriented coping characteristics of individuals, the OSAI provides similar information to the Ways of Coping Scale. Based on these findings, the more specific OSAI appears to be a better instrument to use when attempting to relate performance under stressful work conditions to psychological characteristics since it provides more stress relevant information yet retains the more general personality measures related to active coping. For these reasons, the Ways of Coping Scale was dropped from the subsequent laboratory investigation. The Self-efficacy Scale and the Eysenck Personality Inventory were retained to provide a richer interpretation of the more general personality characteristics related to active coping.

Demographic Data and the OSAI. To examine sex and race differences in responding to the OSAI, a *t*-test and a one-way ANOVA were computed for these two individual difference variables, respectfully. Regarding gender differences, significant findings emerged for the Coping subscale: females ($M=78.93$) reported that they used more active coping styles than males ($M=73.75$) ($t(1,31)=2.92, p<.05$).

Significant race differences emerged only for the Stress subscale of the OSAI. Asian-Americans reported the situations as least stressful ($M=97.67$), followed by Latinos ($M=100.60$), European-Americans ($M=106.83$), and African-Americans ($M=111.50$). A post-hoc analysis (the

Duncan test) revealed that Asian-Americans and Latinos perceived the situations as significantly less stressful ($p < .05$) than did European-Americans and African-Americans.

INVESTIGATION 2: THE PSYCHOPHYSIOLOGICAL ASSESSMENT OF PERFORMANCE UNDER STRESS IN THE LABORATORY

Introduction

The purpose of the second investigation in this report was to explicitly examine the question of whether psychophysiological measures can predict performance under stress. In addition, the newly developed occupational stress assessment inventory (i.e., OSAI) and two related scales (Self-efficacy Scale and Eysenck Personality Inventory) were administered before testing to examine whether these psychological instruments were capable of predicting performance under stress.

To examine whether psychophysiological measures would be able to predict performance under stress, two psychophysiological measures (namely heart rate (HR) and blood pressure (BP)) were continuously recorded in this experiment. Based on the psychophysiological model outlined earlier (see page 12) and the subsequent analysis of potential psychophysiological measures (see page 15), HR and BP measures were chosen. HR was selected because it was expected to be sensitive to stress manipulations and because continuous heart rate measures could be subjected to spectral analysis in order to derive a measure of vagal tone that reflects the HR variability attributable to parasympathetic nervous system activity. It was expected that measures of inhibitory arousal (i.e., vagal tone) would be more sensitive to performance under stress than a mixed (sympathetic and parasympathetic) autonomic measure such as HR. However, it was also suggested that if HR in this experimental context was mediated primarily by vagal influences, then HR too may be a good predictor of performance under stress. BP measures were taken as an index of sympathetic nervous system activity and was not expected to correlate with performance under stress. However, contrasting vagal and sympathetic indices would allow some conclusions to be drawn with respect to the value of the mixed HR measure.

To experimentally address the question of the utility of personality and psychophysiological measures in the laboratory, subjects were required to perform challenging tasks under different levels of stress. To provide a challenging performance environment for subjects, subjects were required to perform two types of neurocognitive tasks: a simple 4-choice reaction time task and a more difficult grammatical reasoning task. These tasks were chosen because they represented different levels of difficulty but, at the same time, represented two types of generic skills (psychomotor performance and cognitive reasoning) required in most highly skilled occupations. By employing two tasks of differing difficulty, the opportunity also existed to examine the differential utility of psychophysiological measures across a (limited) range of task demands. To manipulate stress levels within the experiment, two further manipulations were made. First, following some training and testing trials on these novel tasks, subjects were given negative verbal feedback regarding their level of performance and were informed that they were not performing at a satisfactory level. This feedback manipulation was intended to increase social, evaluative, and performance stress on the subjects. Second, to further augment the stress

associated with negative verbal feedback, distracting levels of background office and equipment noise were added to the performance environment. The hypothesis was that subjects exercising greater control under these stress conditions would perform best on the neurocognitive tests and show a differential psychophysiological response pattern with respect to their performance under stress compared to subjects who did not exercise as much control over stress.

Method

Subjects. The 20 participants were healthy male volunteers (age range = 19-36 years; mean age=26.2 years; SD=4.9 years). Eighty-five percent of the men were 30 years old or younger and 75% were of European-Canadian descent. They were recruited from two Toronto universities via signs posted at both campuses. The advertisements stated that the purpose of the investigation was to assess physiological responses to neurocognitive tasks. All subjects (with two exceptions) participated in regular aerobic exercise, exercising at least 2-3 times a week.

Apparatus. To measure HR continuously throughout the experiment, the Finapres Monitor (Model 2300, Ohmeda, Wilmington, USA) was used. This apparatus enabled the joint measurement of HR as well as systolic, diastolic, and mean arterial blood pressures (SBP, DBP, and MBP, respectively). An inflatable cuff was placed on the middle phalanx of the left middle finger and automatically inflated to a pressure equal to the arterial pressure. The finger rested approximately 12 cm below the level of the heart. Following cuff inflation, the transmural pressure is assumed to be zero. Cuff pressure was dynamically adjusted by a servo-system which monitored the size of the digital arteries with a light plethysmograph. An electromanometer attached to the cuff measured cuff pressure continuously. From these pressures, SBP, DBP, and MBP could be determined for each beat and instantaneous HR was determined from the time between beats (e.g., inter-beat-intervals of 1000 ms would be equivalent to an instantaneous HR of 60 beats per minute). HR, SBP, DBP, and MBP were transferred to and stored on a 386DX personal computer via an interface. These data were stored on a beat-by-beat basis. This technology is based on the work of Penaz (1973, 1976, 1978).

The noise stressor was piped into the subject's room via a two-way intercom system at about 75 to 80 db. The noise consisted of an assortment of office sounds, played on a Sony portable tape-recorder. The sounds were taped from a compact disk, which was originally recorded by the BBC (BBC Sound, Vol. 4, 1986, January). The sounds included a busy scene from the National Newspaper and teleprinter room at London Times, the Public Library and St. Albans (Hearts) and a Public Bar in Hampsted, North London. Largely the noise stimuli consisted of people and equipment noise.

Psychological Questionnaires/Instruments. Prior to the beginning of the experiment, a demographic questionnaire and three psychological test instruments were completed by all subjects (shown in Appendix A). These instruments were the Occupational Stress Assessment Inventory (OSAI), Self-efficacy Scale (SES), and the Eysenck Personality Inventory (EPI). All of these instruments were described earlier in this report (see page 20-23). (Although the Ways of Coping Scale was used in the construct validation assessment of the OSAI, it was not included in

the present investigation because the OSAI addresses the central personality characteristics of the Ways of Coping Scale and provides more specific information concerning individual responses to work-related stressors.)

All three scales and the demographic questionnaire were paper and pencil tests. These tests were administered after the subject was given instructions for the experiment and all questions were answered to their satisfaction.

Cognitive Tasks. The experiment required subjects to perform two neurocognitive tasks in each of the 10 trials. These two neurocognitive tasks were a 4-choice serial reaction time task and a grammatical reasoning task. All neurocognitive tasks were automatically presented on a IBM-compatible 486DX computer.

The 4-choice serial reaction time task is based on a task developed by Wilkinson and Houghton (1975). In this task subjects are presented with a 2x2 enclosed matrix with 4 quadrants. Randomly a small red square will appear in one of the four quadrants and the subject's task is to hit a corresponding key on the keypad. The 4, 5, 1, and 2 keys on the keypad represented the upper left, upper right, lower left and lower right quadrants respectively. Immediately after the key was depressed by the subject, the red square would be extinguished momentarily (<10 ms) and then reappear randomly in one of the four quadrants. The subject continued to depress keys as fast and as accurately as possible for the duration of the one-minute task.

The grammatical reasoning task was modeled after Baddeley (1968) and involved understanding sentences of varying syntactic complexity. The subject is presented with a sentence (such as "A is preceded by B") and a letter pair ("BA") and they are asked to determine whether the sentence and the letter pair are the SAME or DIFFERENT indicated by pressing the "S" or "D" keys on the keyboard. There are a total of 32 possible combinations of sentences and letter pairs possible in this task and they are presented randomly without replacement on each trial. The task duration for this task was also one minute.

On each of the 10 trials of the experiment, the reaction time task and the reasoning task were presented for one minute each for a total of two minutes of task presentation (with at least one minute between each trial). These tasks were always presented in a fixed order with the simpler reaction time task being performed first and the more complex linguistic reasoning task being performed second. This order was fixed so that if there were any intra-trial effects associated with fatigue or stress or if any intra-trial effects interacted with time (i.e., changes with conditions and duration of the experiment), the effects may be more evident on the latter, more complex task.

Procedure. Subjects were tested individually by a female experimenter, during a single session, lasting from one hour to one hour and 15 minutes. Before coming to the experiment, all subjects were instructed that in the 2 hours prior to the experiment they should refrain from caffeine (coffee, cola, chocolate), avoid a heavy meal, avoid exercise, and avoid smoking.

Upon arriving at the laboratory, subjects completed the demographic questionnaire and all three scales described above. They were then hooked up to the Finapres monitor. Once stabilized readings were evident to the technician (after about 5 minutes), a 2-minute baseline was collected where subjects rested with their eyes open. Next, subjects had one practice trial during which they

performed the two cognitive tasks. Following the practice session, the experimental trials began. The cognitive tasks were performed in a sound-proof room while the experimenter monitored HR and BP. All of the relevant experimental instructions (see Appendix B) were given from an adjoining room via an intercom system.

During the first four uninterrupted trials no feedback was provided. After the fourth trial, subjects were told that their performance was poor (regardless of their actual performance), as compared to others, and that they should try harder on the next trial. After the fifth trial, they were admonished to try even harder on the following trial. No feedback was given following the seventh trial, and then background office and crowd noise was presented during the last three trials (see Apparatus section for details). A two-minute post-experimental baseline was taken after the end of the tenth trial.

Upon completion of the experiment, all the subjects were fully debriefed (see Appendix B) and given a token reimbursement for their participation. The actual experimental instructions, more detailed experimental protocol, and debriefing information are available in Appendix B.

Data Analysis. For each trial and task, HR and BP data were collected continuously on a beat-by-beat basis. To reduce these data, the HR and BP measures (SBP, DBP, MBP) were averaged over 30 seconds within each task. In addition, measures of vagal tone were calculated based on the method suggested by Porges (1985). Vagal tone represents that portion of HR variability that is accountable by variation within the respiratory bandwidth from 0.2-0.4 Hz as defined by spectral decomposition. In this technique, the inter-beat-interval series is initially equally sampled at 500 ms in order to conform to the basic requirement of time-series analysis that the data be equally sampled with respect to time. The 500 ms sampling also satisfies the Nyquist statistical rule outlined by Blackman and Tukey (1959) that the sampling rate must be at least twice as fast as the event of interest (here the respiratory frequency). Once these data conform to an equally time-sampled data set, they are detrended using a 21-point moving polynomial and the trend is removed from the data series. Finally, these residual data are aggregated to produce the variance within the power spectral window of .2-.4 Hz in order to capture the variance that can be attributed to respiratory sinus arrhythmia and estimate vagal tone. This procedure produces a stable estimate of vagal tone over a 30 second period. Since vagal tone measures were estimated over a 30 second period and the HR and BP data were also averaged over 30 seconds, identical periods of time were used to produce all cardiac and cardiovascular estimates.

The two samples of each psychophysiological measure for each task and trial were then averaged over each task to produce a single estimate for each task on each of 10 trials. These task estimates on each measure constituted the basic unit of analysis for each dependent variable. Some data will be presented on a trial by trial basis in the Results section. However, to further reduce the data on the basis of the experimental manipulations, further averaging for each task and subject was done. Specifically, the first four trials of uninterrupted task performance were averaged for each task and subject to produce a mean "Performance" measure for each task and subject. The effects of negative verbal feedback (given before trials 5 and 6) on performance were assessed by averaging trials 5, 6, and 7 for each task and subject to produce a mean "Negative Feedback" measure for each task and subject. Finally, since background office noise was an added

stressor during performance on trials 8, 9, and 10, these trials were averaged for each task and subject to produce a mean "Noise" measure for each task and subject.

Performance data were scored in terms of accuracy and total number completed on each task for each trial. Further data reduction also involved summarizing the data in terms of Performance, Negative Feedback, and Noise manipulations.

Results

Personality Measures. The means and standard deviations for the primary personality measures from the questionnaires are presented in Table 4. Both Investigation 1 and 2 results are presented for comparison purposes.

It can be seen in Table 4 that in most respects the two sample populations were very similar. Compared to the American university population of mixed gender and race, there were only minor differences in the more homogeneous (primarily European-Canadian and athletic) Canadian sample. In terms of the degree of stress evoked by the selected situations used in the OSAI, the experimental group (Investigation 2) reported these situations as somewhat less stressful than the survey group ($p < .01$) (Investigation 1). The two groups were similar with respect to their perceived ability to cope with the situations and their ability to cope relative to others. On the last OSAI component, the experimental group reported a somewhat more active coping strategy than the survey group ($p < .01$). On the other hand, the survey group did report somewhat higher self-efficacy than the experimental group ($p < .01$). In terms of the more general personality trait measures from the Eysenck Personality Inventory, the two groups were similar with respect to their reported level of extraversion and neuroticism. The survey group, however, scored higher on the Lie scale although both groups scored low on the scale ($p < .01$).

Neurocognitive Performance. As noted in the data analysis section, the performance data for each of the neurocognitive tasks were summarized for each trial in terms of task accuracy and task performance (defined as the total number completed). Figures 1 and 2 show the change in accuracy and performance over the 10 trials of the experiment. As can be seen in the figures, both accuracy and performance changed over the 10 trials. The NEGATIVE FEEDBACK stressor tended to cause a slight decrease in accuracy (Figure 1) but a relatively large increase in performance (Figure 2). In contrast the NOISE stressor initially showed an increase in both accuracy and performance, but was then followed by a decrease in both measures.

As detailed in the data analysis section, the data for all trials was reduced to the PERFORMANCE, NEGATIVE FEEDBACK, and NOISE conditions for each task and these data were analyzed using a multivariate repeated measures analysis of variance. These analyses revealed that in terms of task accuracy, only a task difference emerged ($F(1,19)=20.04, p<.01$) showing that performance was significantly more accurate on the simpler reaction time task than on the more complex reasoning task. In terms of performance, however, there was a significant task by stressor interaction ($F(2, 18)=9.68, p<.01$) indicating that performance increased after negative feedback and maintained this higher level after the introduction of noise. Moreover, the increase in performance was greater for the simpler reaction time task (left ordinate) than on the more complex reasoning task (right ordinate).

Table 4

Means and Standard Deviations for the Primary Measures Derived from the OSAI, Self-Efficacy, and Eysenck Personality Inventory

Personality Measure	Investigation 1		Investigation 2	
	Mean	Standard Deviation	Mean	Standard Deviation
<u>OSAI</u>				
Stress	104.27	10.67	95.25	13.06
Change	89.88	13.73	90.45	11.57
Others	87.73	12.58	86.25	10.45
Coping	78.30	6.27	95.25	7.14
<u>Self-Efficacy</u>	85.35	10.51	75.20	11.80
<u>Eysenck Personality Inventory</u>				
Lie Scale	2.45	1.33	1.65	1.03
Extroversion	13.86	2.94	11.50	4.64
Neuroticism	11.08	4.55	11.20	4.64

Heart Rate, Vagal Tone, and Blood Pressure Changes During Neurocognitive Performance. Figures 3 and 4 show the detailed results of the primary psychophysiological measures of HR and vagal tone. In the figures it can be seen that in these group data, task performance caused increases in HR and suppression of vagal tone from the resting BASELINE levels that were taken before (labeled "PRE") and after (labeled "POST"). It is also clear in these figures that the changes in HR and vagal tone during task performance are entirely attributable to task performance effects, and factors such as habituation or fatigue do not play a major role. If these factors had played a significant part, then the pre- and post-baseline measures would differ to reflect this change in state. It is clear in the figures that baseline conditions are identical for each measure.

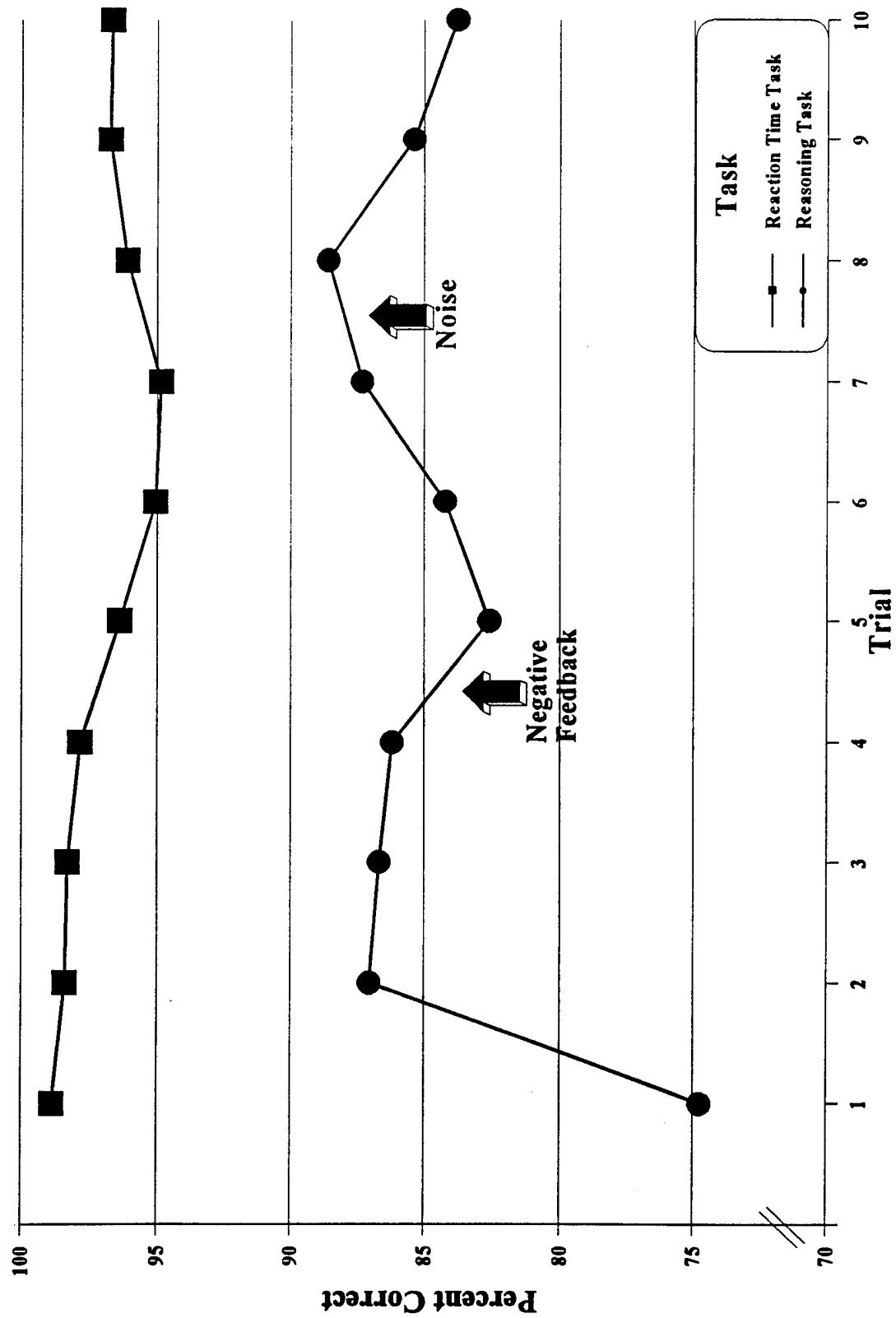


Figure 1. Task Performance Accuracy Across Trials.

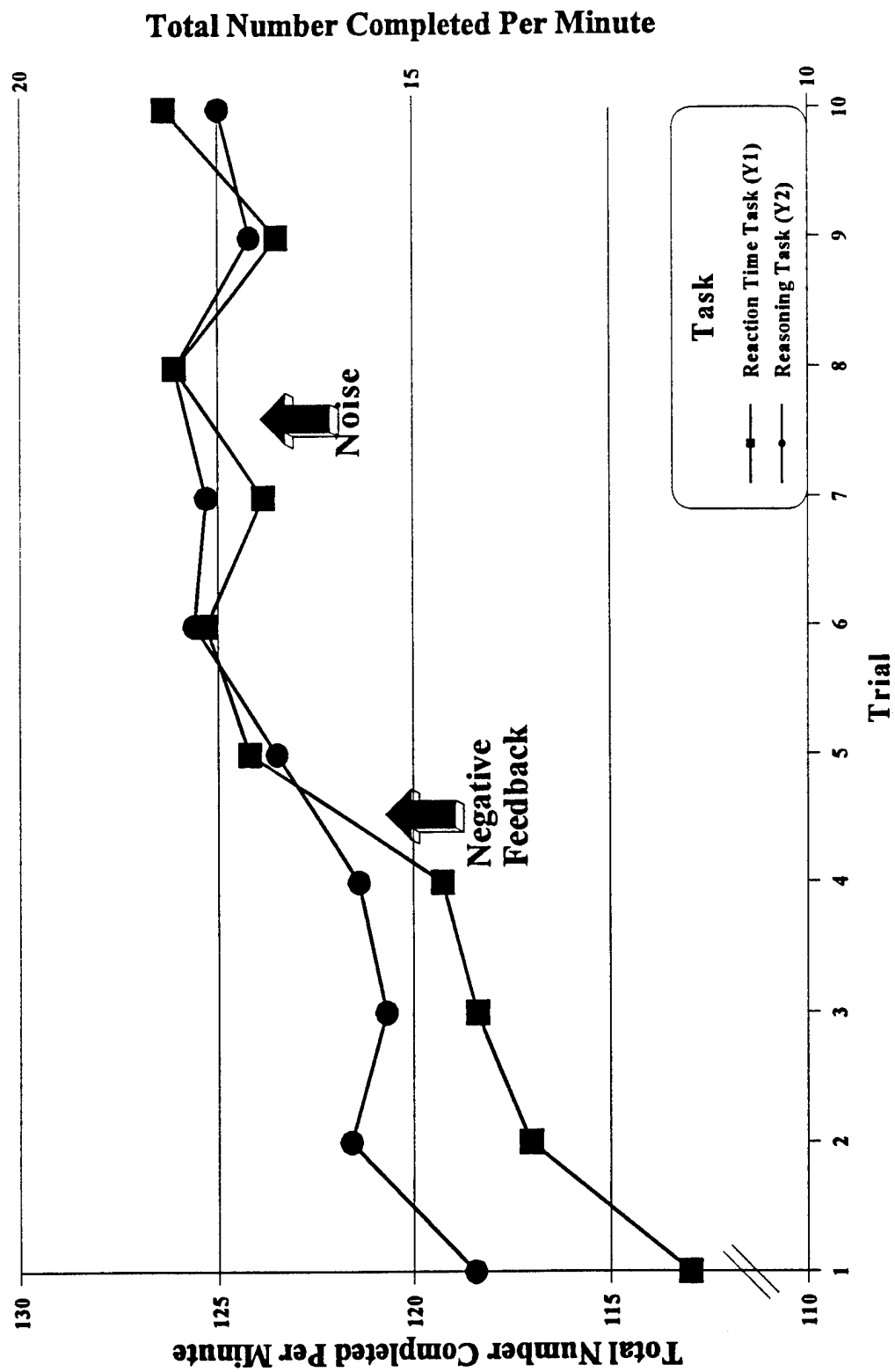


Figure 2. Task Performance Across Trials.

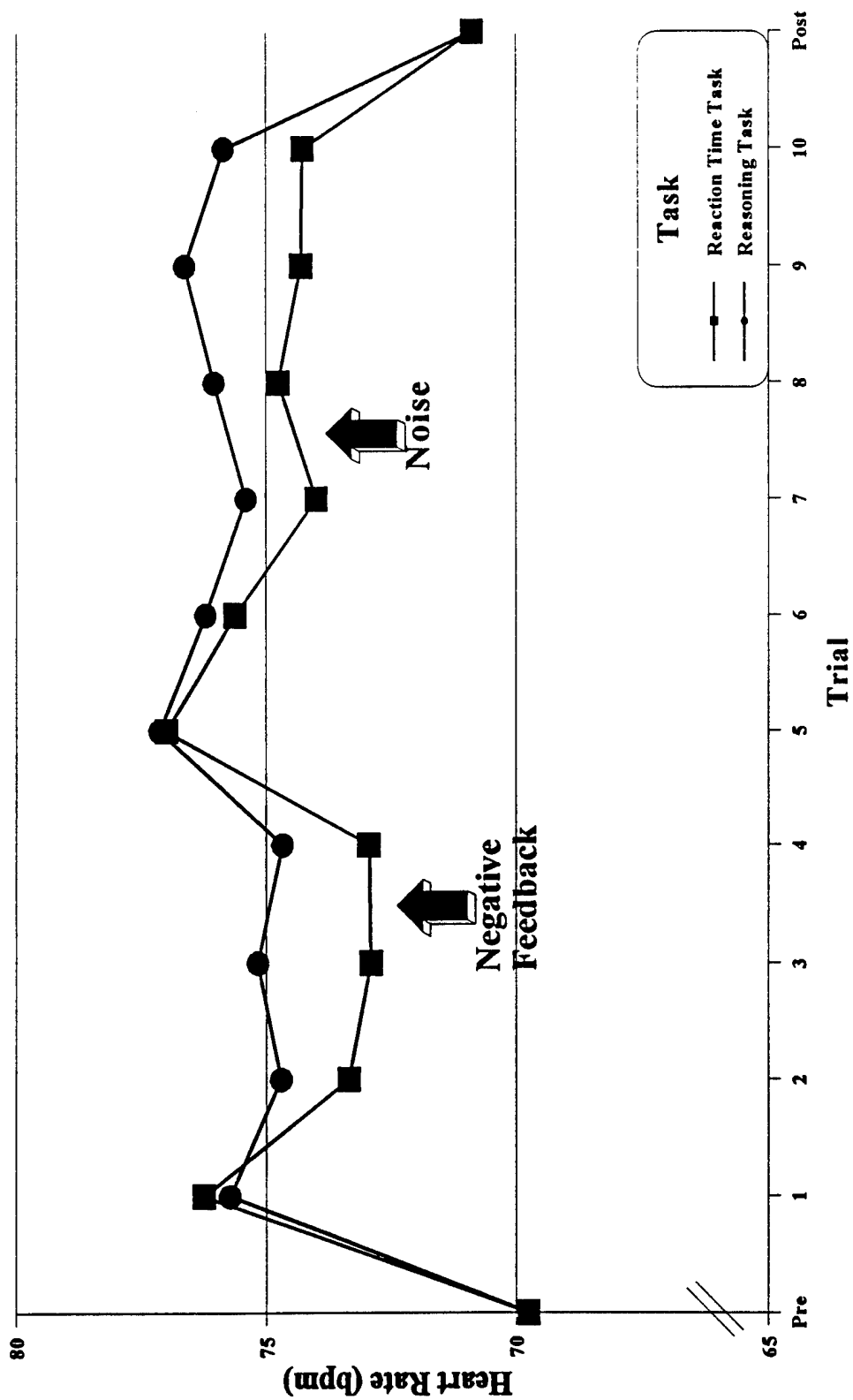


Figure 3. Heart Rate During Task Performance Across Trials.

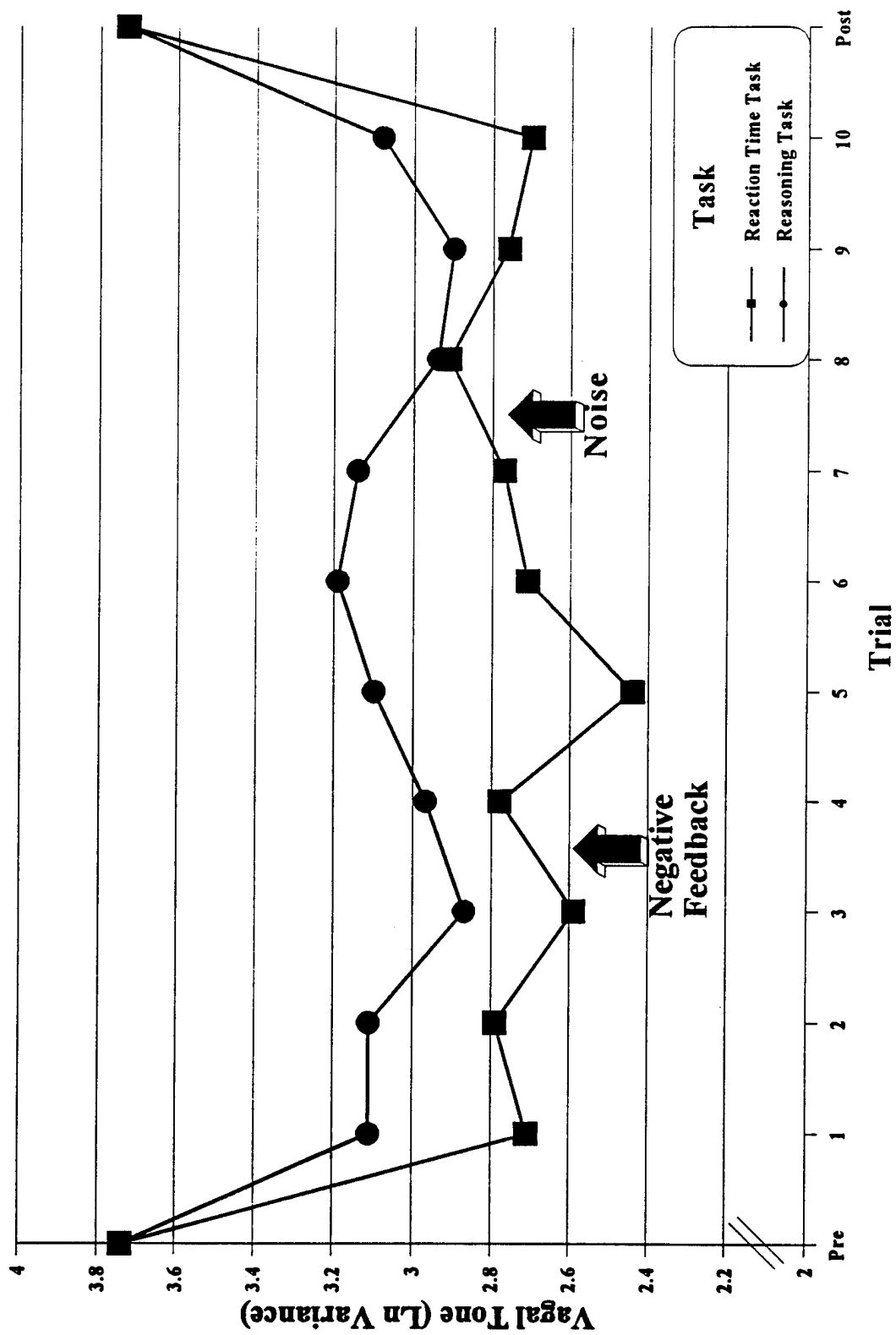


Figure 4. Vagal Tone During Task Performance Across Trials.

Figures 3 and 4 demonstrate that task performance causes increases in HR and vagal tone suppression. These data indicate that the task performance causes an immediate drop in vagal inhibitory control over the heart (Figure 4) which likely accounts for the increase in HR during task performance in Figure 3. These data suggest that the HR change is largely a product of reduced inhibitory control. To further support this interpretation, it is clear in the figures that the demands of the two tasks have a differential effect on the underlying physiology. In terms of HR change, the simpler reaction time task resulted in a generally smaller increase in HR than did the more difficult reasoning task. The opposite was the case for vagal tone. The simpler reaction time task caused greater vagal tone suppression than did the more difficult reasoning task. These data suggest that while the increase in HR is partially accounted for by an decrease in vagal tone, the change in vagal tone cannot explain the HR changes entirely otherwise the differential task-elicited changes would be in the same direction. It can be speculated that the more demanding reasoning task likely elicited an increase in sympathetic activity which reduced the degree of vagal tone suppression (as might be expected based on Levy (1977) analysis of the dynamic interactive nature of sympathetic and vagal systems) and increased HR changes.

To examine the data relative to the major manipulations of PERFORMANCE, NEGATIVE FEEDBACK, and NOISE, see Figures 5 and 6. (For these analyses, the pre- and post-experimental baselines, which were essentially identical, were averaged.) It can be easily seen in Figure 5 that HR increased significantly from BASELINE ($F(3, 57)=19.61, p<.01$) and that this increase was greater for the more complex reasoning task as indicated by a significant interaction ($F(3, 57)=2.81, p<.05$). In contrast, Figure 6 shows that vagal tone was attenuated or suppressed significantly from BASELINE ($F(3, 57)=17.58, p<.01$) and this suppression of vagal tone was significantly greater for the simpler reaction time task than for the more complex reasoning task ($F(3, 57)=4.87, p<.01$).

Figures 7, 8, and 9 show the changes in systolic, diastolic and mean arterial blood pressure. It is clear in these figures that the changes in systolic, diastolic and mean arterial blood pressure are essentially identical. To summarize these three measures of blood pressure, consider the mean arterial blood pressure results in Figure 9. Figure 9 demonstrates that there were significant increases in BP from BASELINE to PERFORMANCE and further identical increases to the other two (NEGATIVE FEEDBACK and NOISE) stress conditions ($F(3, 17)=24.77, p<.01$).

Figures 5-9 illustrate the relationship between HR, vagal tone, blood pressures measures and neurocognitive performance. For all measures, the demand associated with neurocognitive performance alone and under stress resulted in increases in HR and blood pressure and suppression of vagal tone from baseline. However, on closer inspection, all three measures show a slightly different pattern with respect to these changes. For the HR measure (Figure 5), HR increased during task performance and then increased further during task performance under stress. The blood pressure measures (Figures 7-9) showed a similar pattern but the further increase under the stress conditions was somewhat larger than the increase under stress in HR. On the other hand, the suppression in vagal tone that occurred under cognitive performance was not further suppressed under the stress conditions.

These results suggest that the suppression of vagal tone, or the decrease in parasympathetic activity, appears to be a more sensitive measure of task oriented activity and is

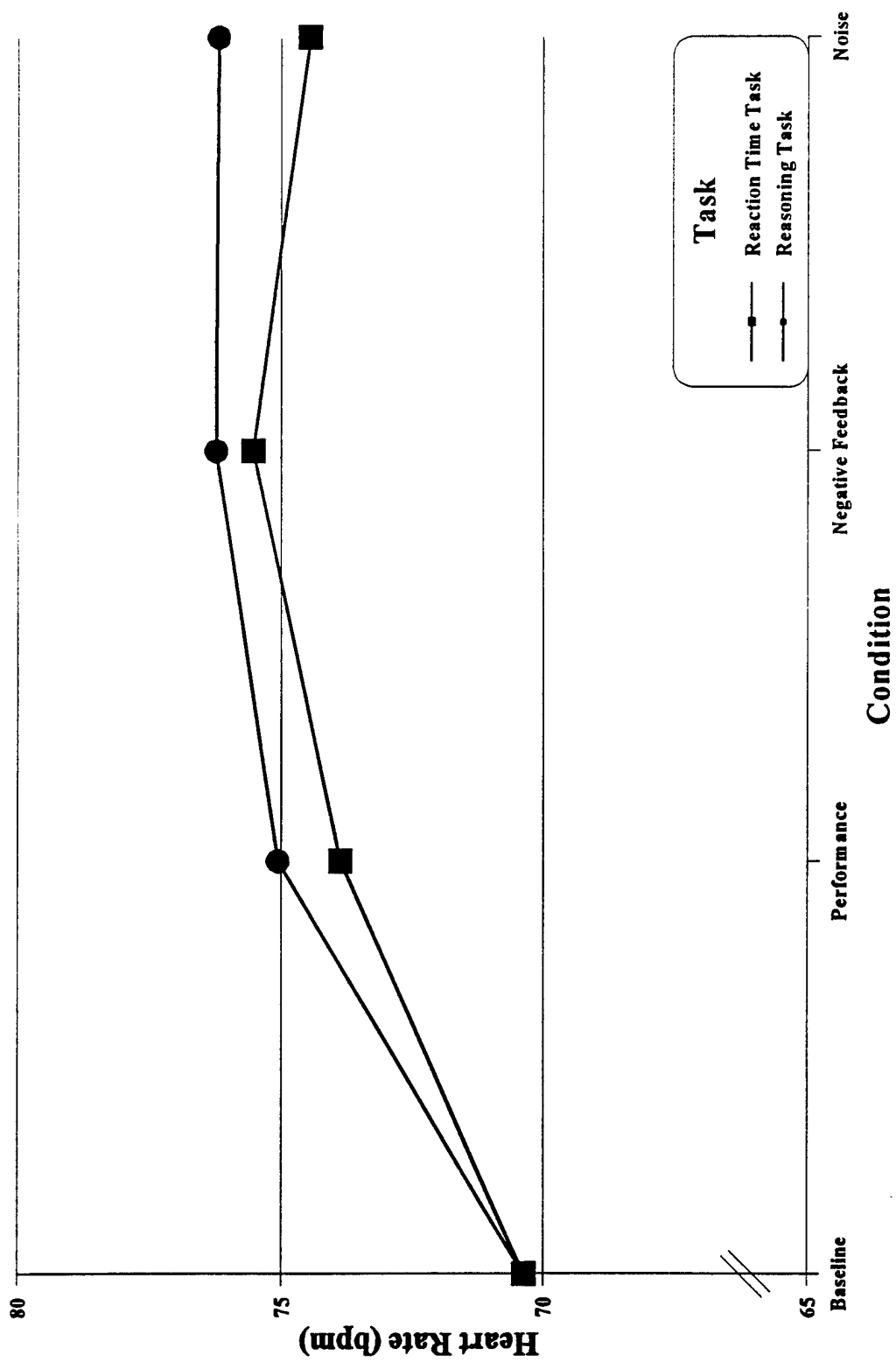


Figure 5. Heart Rate During Task Performance Across Conditions.

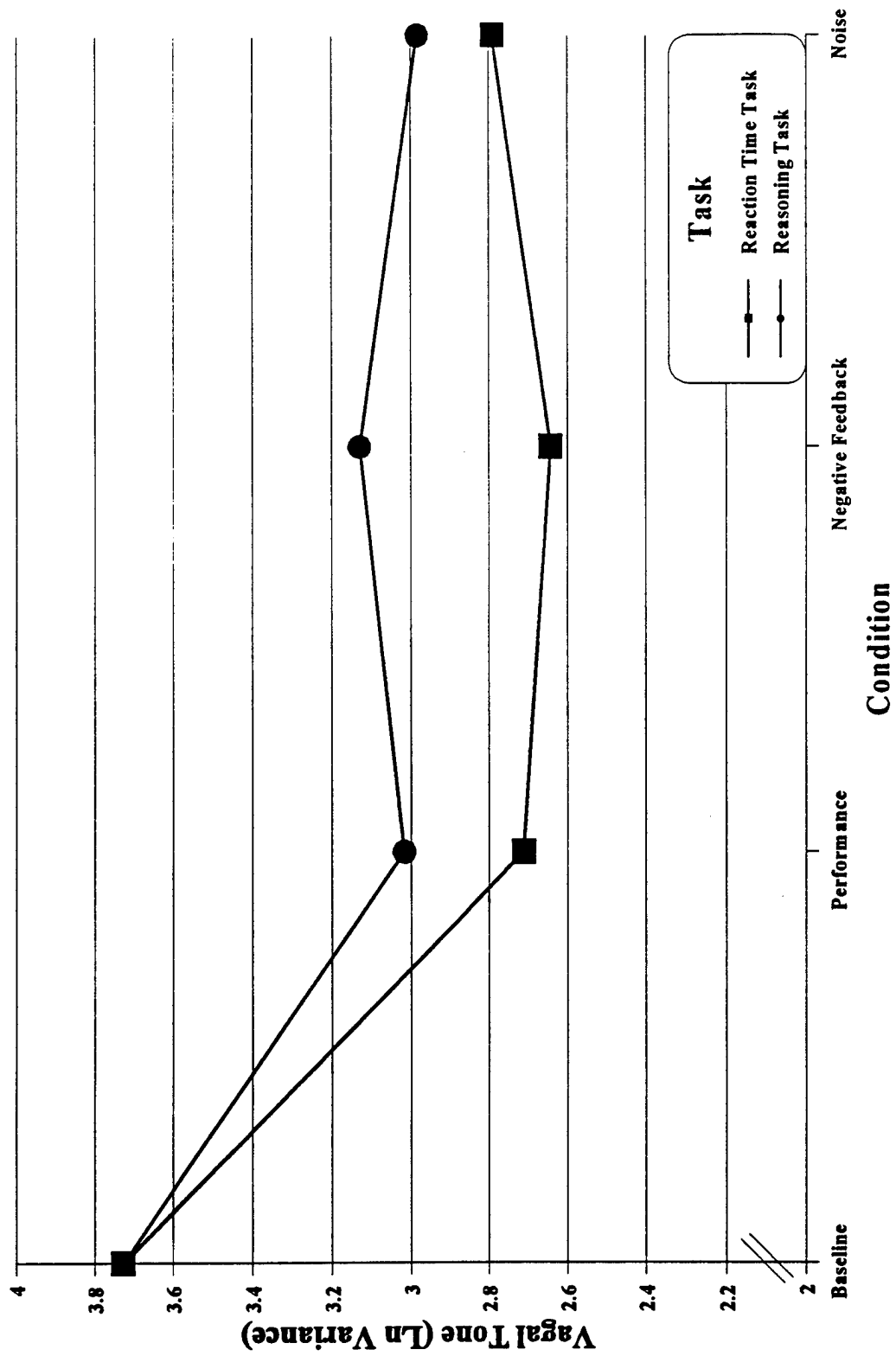


Figure 6. Vagal Tone During Task Performance Across Conditions.

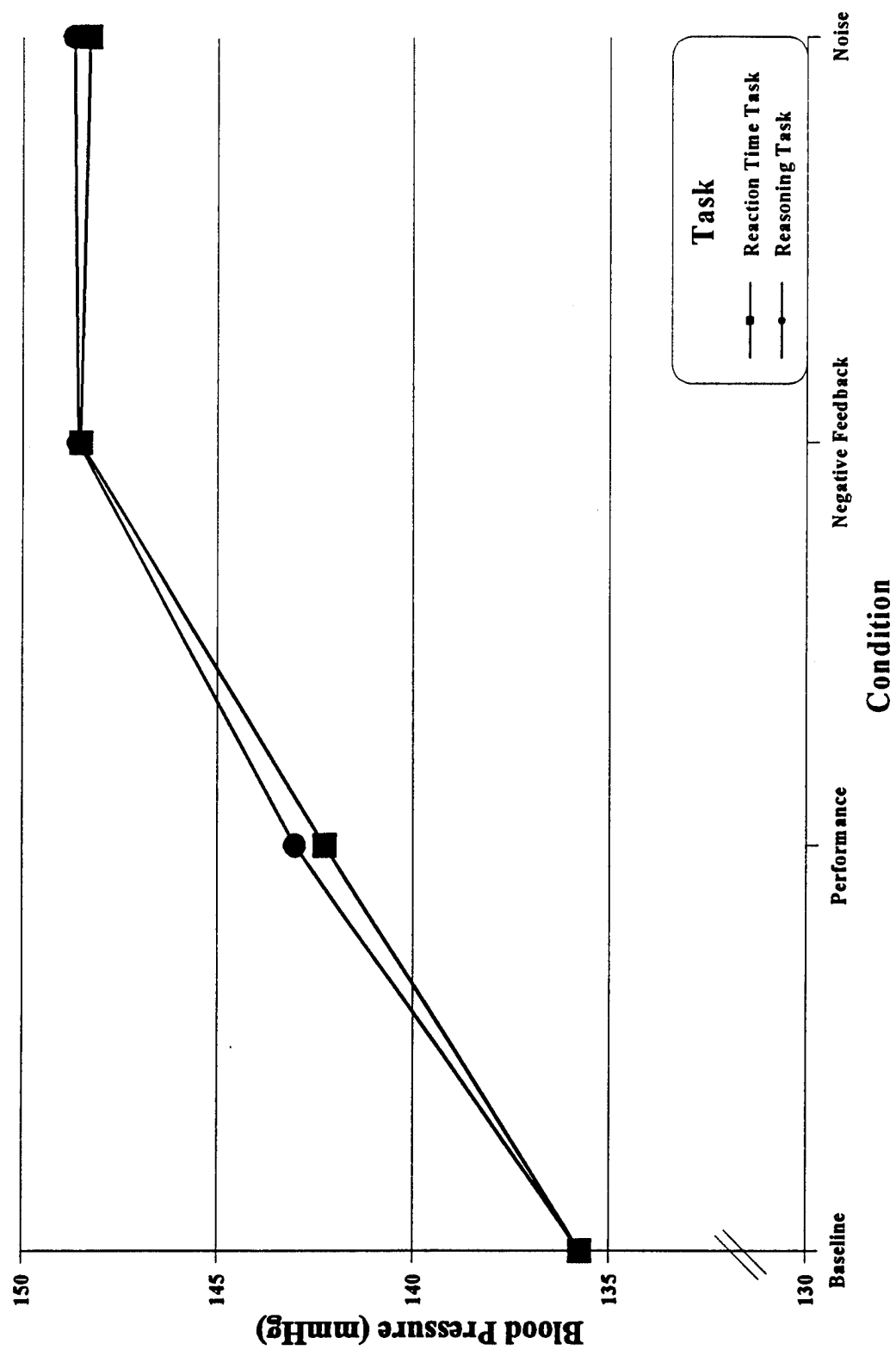


Figure 7. Systolic Blood Pressure During Task Performance Across Conditions.

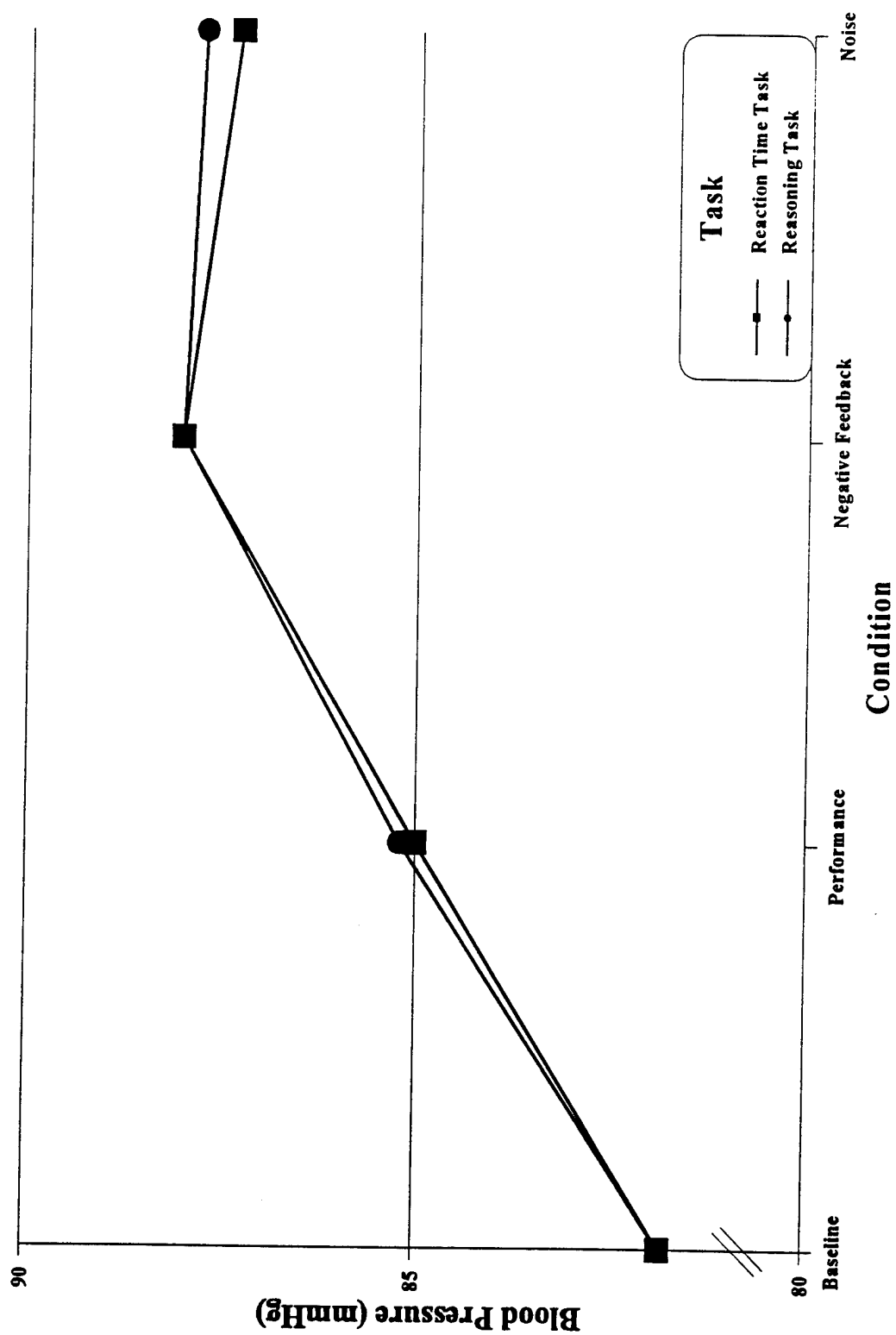


Figure 8. Diastolic Blood Pressure During Task Performance Across Conditions.

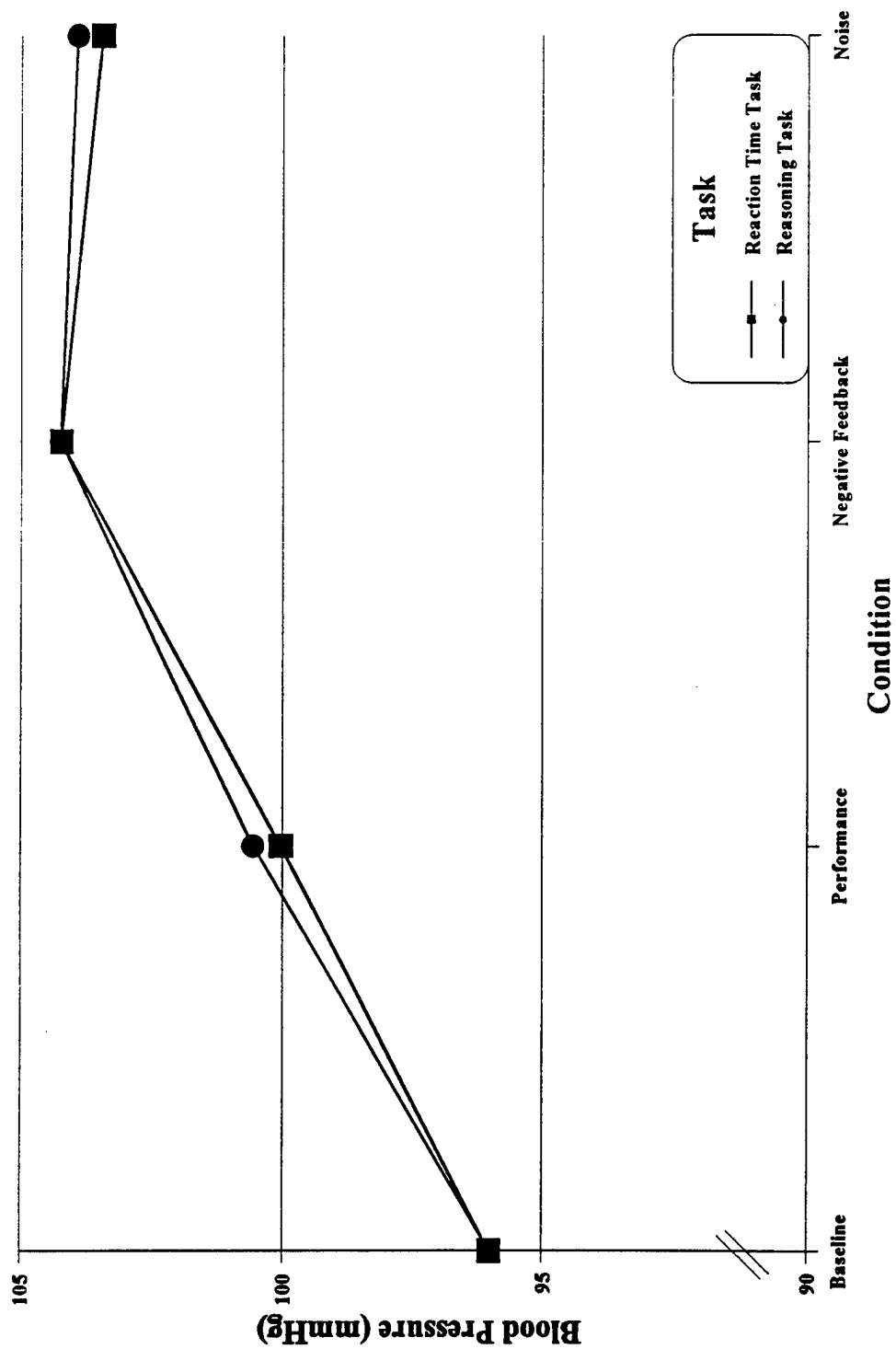


Figure 9. Mean Arterial Blood Pressure During Task Performance Across Conditions.

relatively unaffected by increasing stress. Further, the results suggest that increases in blood pressure, or increases in sympathetic activity, appear to be sensitive to both task oriented activity and stress; in particular, the increases in blood pressure under the stress manipulation seem to suggest that blood pressure measures are more sensitive to stress than is vagal tone. The final HR measure appears to be sensitive to both task oriented activity and stress but appears to be less responsive than blood pressure measures to stress manipulations. Thus, HR seems to lie mid-way between vagal tone and blood pressure with respect to its sensitivity to these different manipulations. This is not surprising since HR receives input from both the sympathetic and parasympathetic systems so it reflects a "mixed" result with respect to the manipulations.

There is a further difference between these three measures with respect to their sensitivity to detecting differential neurocognitive effort. It is clear that during the more complex reasoning task, HR showed a greater increase and vagal tone suppression was lower than during the simpler reaction time task. These data would suggest that the degree of vagal tone change is sensitive to the type of task oriented activity as well since less vagal tone suppression would result in a greater HR. In addition, it is clear that none of the blood pressure measures were sensitive to the differential demands of the two different tasks. These results suggest that parasympathetic activity may be more useful in assessing the degree of task oriented activity.

Together, these results can be interpreted in the following manner. Parasympathetic, or vagal tone, measures appear to be more sensitive to task oriented demands while sympathetic measures appear to be more sensitive to stress manipulations. Since the psychophysiological model (page 12) suggests that individuals who will cope well in high stress situations or occupations will be more task oriented and be less influenced by stress arising endogenously or exogenously, measures which reflect task oriented activity and/or responsiveness to stress may be useful in assessing better coping and performance under stress. However, there is no *a priori* rationale to suggest whether task oriented coping or reduced responsiveness to stress should be better. In fact, it is possible that the type of coping mechanism may indeed be an individual difference variable and more successful copers may employ task oriented coping or reduced responsivity to stress in different degrees depending on individual difference and/or environmental circumstances. In subsequent sections, the relationships between individual differences on these psychophysiological variables and neurocognitive performance (alone and under stress) will be explored to examine whether any of these psychophysiological variables can predict better performance under stress. This exploration will allow some preliminary analysis of whether different psychophysiological measures (perhaps reflecting different coping strategies) differentially reflect performance under stress.

Correlations Between Predictor Variables. Before proceeding to the relationships between specific predictor variables and performance under stress, it is worth noting some of the relationships that exist between predictor variables.

To summarize these intercorrelations, it is clear that HR levels were highly correlated within individuals across manipulations (including BASELINE) and tasks (HR, $r > .90$). Vagal tone measures were also highly correlated within individuals across stress manipulations and tasks ($r = .65$ to $.85$) but were less well correlated with BASELINE levels ($r = .35$ to $.55$). Blood pressure measures were highly correlated as well within individuals across manipulations and

tasks ($r = .50$ to $.80$). These data suggest that individual responses to manipulations and tasks are highly predictable and individuals respond to challenges in a characteristic fashion. In short, these data suggest that there is strong response stereotypy among individuals.

The intercorrelations among the psychophysiological variables are also of interest. HR was found to be moderately positively correlated with mean arterial and diastolic blood pressure ($r = .30$ to $.55$) but uncorrelated with systolic blood pressure. Positive correlations of moderate magnitude would be expected since HR and blood pressure are strongly innervated by sympathetic input though HR also receives parasympathetic input. In addition and as expected, there was also a moderate negative correlation between HR and vagal tone ($r = -.40$ to $-.60$) which supports the contention that HR and vagal tone are inversely correlated and that vagal tone accounts for a significant percentage of the variance in HR. Much of the variance in HR, however, is left to be explained by the sympathetic nervous system input and other cardiac dynamic mechanisms. Vagal tone and blood pressure measures are uncorrelated. It seems clear from these data that the psychophysiological measures that share autonomic input are correlated but the correlations are only moderate which means that each measure can contribute uniquely to explain individual reactivity.

The most interesting aspect is that the reactive component (i.e., change scores) of these psychophysiological measures are largely uncorrelated or only slightly correlated ($r < .3$) with their absolute levels during stress manipulations. This difference between absolute and reactive psychophysiological measures has long been known in the psychophysiological literature so this result is not surprising. However, in light of the goal of predicting performance, these reactivity measurements could yield different information than the absolute measurements. Thus, both absolute and changes from BASELINE scores are important to the analysis of the relationship between psychophysiological variables and performance scores.

Finally, the personality variables were largely uncorrelated with each other with a few exceptions. Specifically, self-efficacy was highly and positively correlated with a higher perceived ability to cope with stress relative to others ($r = .72$), a lower perception of situations as stressful ($r = -.45$), and a low level of neuroticism ($r = -.72$). As might be expected based on these results, there was also a significant negative correlation between neuroticism and a greater perceived ability to cope relative to others ($r = -.73$). These data suggest that those who view themselves as being self-efficacious relative to others also view situations as less stressful and are unlikely to be neurotic. Apart from these findings, the various personality measures are only moderately correlated with each other which suggests that each measure may uniquely contribute to the prediction of successful performance under stress.

With respect to the relationship between personality and psychophysiological variables, these personality variables were largely uncorrelated with the psychophysiological variables indicating that both psychophysiological and personality variables could contribute uniquely to the prediction of performance scores.

Correlations Between Performance Variables. Some interesting relationships emerged with respect to the performance variables and it may be helpful to briefly note these relationships before proceeding to the predictive relationships. For the Wilkinson reaction time task, a

speed/accuracy trade-off across individuals emerged; specifically, accuracy on this task was moderately negatively correlated with total performance on the task for all stress conditions ($r = -.37$ to $-.52$). Therefore, in interpreting later data on the predictive relationships, the speed/accuracy trade-off must be considered.

A speed/accuracy relationship did not emerge for the logical reasoning task. In fact, there was a small positive relationship between accuracy and total performance in the PERFORMANCE manipulation which probably reflected a general aptitude for this complex task. However, once the stress manipulations were introduced, this slightly positive relationship disappeared.

In examining inter-task effects, there was no relationship between reaction time and reasoning task performance with respect to accuracy or total performance. Accuracy on one task was unrelated to accuracy on the other task. However, those who were more accurate on the more complex task showed a positive relationship ($r = .40$ to $.62$) with respect to total performance on the reaction time task. Again, this may reflect a general ability difference across individuals.

Predictive Correlations Between Heart Rate, Vagal Tone, and Blood Pressure Measures and Performance Under Stress. In order to determine whether HR, vagal tone, or blood pressure measures could predict performance under stress, initial resting levels and absolute levels for all stress conditions were correlated with performance during the respective stress condition. These results showed that for the Wilkinson reaction time task, task accuracy was uncorrelated with the psychophysiological measures with the exception that there was a positive correlation of vagal tone under stress (negative feedback and noise conditions) and task accuracy. However, when the total performance on the task was correlated with the psychophysiological measures, all measures except systolic blood pressure showed significant correlations. These correlations are listed in Table 5.

Table 5 shows that there are significant relationships between almost all (except systolic blood pressure) psychophysiological variables and performance. It is clear in the figure that all of the correlations are in the expected direction and almost all of the correlations that do not attain significance at the .05 level are significant at the .10 level. The data in Table 5 suggest that those individuals with better performance in general and under stress, have a higher HR, higher mean arterial and diastolic blood pressure, and lower vagal tone. In terms of the strength of the correlations across the different psychophysiological parameters, HR was significantly correlated with performance but did not significantly predict performance under stress. On the other hand, lower vagal tone did predict performance and performance under stress. Both mean arterial blood pressure and diastolic blood pressure predicted performance under all conditions significantly. These data suggest that these psychophysiological parameters predict performance and performance under stress and that the stress associated with performing is sufficient to predict performance under negative verbal feedback and environmental distraction (noise) conditions for this relatively simple psychomotor task.

For the logical reasoning task, the correlations were generally lower. In terms of the total performance on this more complex task, no correlations reached the .05 level of significance. However, given the more complex nature of the task, task accuracy is probably a better measure

Table 5

Correlations Between Absolute Physiological Levels and Total Performance on the Wilkinson Reaction Time Task as a Function of Stress Condition^a

Physiological Parameter	Performance	Negative Feedback	Noise
Baseline HR	.43 *	.26	.32
Performance HR	.54 *	.36	.41
Verbal Feedback HR	.48 *	.35	.42
Noise HR	.51 *	.36	.41
Performance Vagal Tone	-.48 *	-.32	-.34
Verbal Feedback Vagal Tone	-.43 *	-.29	-.28
Noise Vagal Tone	-.58 *	-.46 *	-.47 *
Baseline Mean Arterial Pressure	.45 *	.49 *	.42
Performance Mean Arterial Pressure	.55 *	.59 *	.48 *
Verbal Feedback Mean Arterial Pressure	.47 *	.53 *	.40
Noise Mean Arterial Pressure	.50 *	.54 *	.41
Baseline Diastolic Pressure	.45 *	.48 *	.46 *
Performance Diastolic Pressure	.55 *	.56 *	.46 *
Verbal Feedback Diastolic Pressure	.45 *	.49 *	.40 *
Noise Diastolic Pressure	.51 *	.53 *	.44 *

^a Only physiological parameters with one or more statistically significant correlations are listed.

* $p < .05$, $n = 20$.

of task performance than total number completed. (The argument can also be made with respect to the simpler reaction time task. In that task, accuracy was very high so total performance was a better indicator of task performance.)

In terms of task accuracy on the logical reasoning task, the correlations with HR and vagal tone were all in the expected direction (i.e., positive for HR and negative for vagal tone) but were

only moderate in magnitude (.20 to .34 for vagal tone). However, for mean arterial and diastolic blood pressure the correlations were significant. (For systolic blood pressure the correlations were moderately positive generally in the range of .25 to .40). Table 6 shows the correlations for mean arterial and diastolic blood pressure for the reasoning task.

Table 6 demonstrates that accuracy on the reasoning task alone and under stress conditions was significantly and positively related to mean and diastolic blood pressure. These data suggest that there are individual differences in terms of the blood pressure change during performance. Individuals who perform well under stress show higher blood pressures. It is interesting to note that the more labile and more generally responsive systolic blood pressure measure was not as well correlated with performance as the diastolic measure.

As was noted in the section examining the correlation between predictor variables (page 50), the reactive component of the psychophysiological measures (i.e., change from baseline scores) are largely uncorrelated with the absolute levels of these variables during manipulations. Since change scores can yield independent information from the analysis of absolute scores, the correlations between these reactivity change scores and performance are now considered.

Initially the blood pressure results will be considered. In the earlier analysis of the correlations between absolute levels of blood pressure (mainly mean arterial and diastolic) and performance, it was found that blood pressure measures were highly positively correlated with performance on both tasks. However, in the analyses of blood pressure change scores and performance, blood pressure change scores were uncorrelated with performance. It can be speculated that the lack of correlation between blood pressure change and performance is that the vascular system is a more integrated system and the control of blood pressure is more strictly controlled than the control of changes in HR or rhythmicity (vagal tone). Thus, there are more homeostatic regulatory factors that control the change in pressure dynamically or responsively in order to maintain pressures within acceptable and strict limits. While individual differences in terms of absolute levels during performance appear to be good predictors of performance, changes from baseline levels do not appear to be good predictors.

Changes in HR and vagal tone from baseline will be considered next for each task variable separately since there is a speed/accuracy trade-off to consider with respect to task performance.

Tables 7 and 8 show the correlations for HR and vagal tone with performance (in terms of accuracy and total performance) for the Wilkinson reaction time task. To interpret these results correctly, it should be remembered that in general there was a speed/accuracy trade-off in performance as well so that positive relationships with one variable (accuracy) should generally result in the opposite, or a negative, relationship with the other variable (total performance). It should also be remembered that since accuracy was high and varied between 95% and 99% (see Figure 1), total performance on this task is likely a better measure of task performance than accuracy. (In Tables 7

Table 6

Correlations Between Absolute Physiological Levels and Accuracy Performance on the Logical Reasoning Task as a Function of Stress Condition^a

Physiological Parameter	Performance	Negative Feedback	Noise
Baseline Mean Arterial Pressure	.50 *	.40	.43 *
Performance Mean Arterial Pressure	.47 *	.48 *	.35
Verbal Feedback Mean Arterial Pressure	.52 *	.56 *	.46 *
Noise Mean Arterial Pressure	.58 *	.57 *	.50 *
Baseline Diastolic Pressure	.40	.26	.45 *
Performance Diastolic Pressure	.46 *	.46 *	.39
Verbal Feedback Diastolic Pressure	.48 *	.49 *	.49 *
Noise Diastolic Pressure	.53 *	.48 *	.53 *

^a Only physiological parameters with one or more statistically significant correlations are listed.

* $p < .05$, $n = 20$.

through 10, note that the symbol "" represents "change" to indicate that these are change from baseline scores.)

Table 7 shows the correlations between change in HR and vagal tone with accuracy performance on the reaction time task across the three stress conditions. It can be seen in the table that all of the correlations between HR change scores and performance in the different conditions were all negative and consistent in terms of magnitude, though they did not reach significance. This indicates that there appears to be a small but clear relationship between HR change and accurate performance with smaller HR increases reflecting better accuracy. On the other hand, the correlations of change in vagal tone with performance accuracy were all positive and high with all correlation coefficients either being significant or near significance at the .05 probability level. These results show that in terms of task accuracy on the reaction time task, less vagal tone suppression reflects more accurate performance. However, as discussed earlier in this section, since task accuracy was high in this reaction time task and because there is a speed/accuracy trade-off in this task, performance is probably better reflected in terms of total responses on the task.

Table 7

Correlations Between Physiological Reactivity and Accuracy Performance on the Wilkinson Reaction Time Task as a Function of Stress Condition^a

Physiological Parameter	Performance	Negative Feedback	Noise
Performance HR Δ	-.34	-.13	-.29
Verbal Feedback HR Δ	-.11	-.22	-.13
Noise HR Δ	-.28	-.28	-.26
Performance Vagal Tone Δ	.39	.56 *	.44 *
Verbal Feedback Vagal Tone Δ	.41	.62 *	.52 *
Noise Vagal Tone Δ	.39	.67 *	.59 *

Note. " Δ " represents "change" to indicate that these measures are change from baseline scores.

* Only physiological parameters with one or more statistically significant correlations are listed.

* $p < .05$, $n = 20$.

Table 8 shows the correlations between change in HR and vagal tone with total performance on the reaction time task. These results show a similar pattern to the results in Table 7 in that HR correlations with performance were only moderate and nonsignificant (but consistent). On the other hand, vagal tone correlations with performance were all significant and of high magnitude. However, it should be noted that for all correlations, the signs of the correlations are the opposite to those in Table 7 because of the speed/accuracy trade-off (i.e., better performance is reflected by greater productivity at the expense of accuracy). For these analyses, better performance was associated with greater increases in HR to some degree. Again the correlations were consistently positive and about the same magnitude (.2-.3). For the vagal tone change measure, vagal tone suppression was significantly related to better performance under all conditions with correlations ranging from -.43 to -.61. Thus, these correlations demonstrate a substantial relationship between changes in vagal tone and performance with better performance reflecting greater vagal tone suppression. These results are also consistent with those correlations shown in Table 5 where better

Table 8

Correlations Between Physiological Reactivity and Total Performance on the Wilkinson Reaction Time Task as a Function of Stress Condition^a

Physiological Parameter	Performance	Negative Feedback	Noise
Performance HR Δ	.62	.26	.20
Verbal Feedback HR Δ	.11	.21	.22
Noise HR Δ	.31	.32	.31
Performance Vagal Tone Δ	-.45 *	-.47 *	-.48 *
Verbal Feedback Vagal Tone Δ	-.43 *	-.47 *	-.46 *
Noise Vagal Tone Δ	-.55 *	-.60 *	-.61 *

Note. " Δ " represents "change" to indicate that these measures are change from baseline scores.

^a Only physiological parameters with one or more statistically significant correlations are listed.

* $p < .05$, $n = 20$.

performance was positively correlated with lower absolute levels of vagal tone (or more suppression from baseline).

For the reasoning task, shown in Tables 9 and 10, the results were less striking. Table 9 shows the results for accuracy performance. Since the accuracy on this task was much lower than on the reaction time task, it was argued earlier in this section that task accuracy may be a better index of performance than total responses for this task. In terms of accuracy, HR increases positively predicted higher performance during performance alone and under the stress of negative verbal feedback but did not predict performance under the noise stress condition. Vagal tone suppression, on the other hand, showed a consistent correlation with accuracy performance, especially in the case of the NOISE condition where greater vagal tone suppression was significantly correlated with better accuracy ($r = -.47$).

Table 10 shows the correlations of HR increases and vagal tone suppression with total performance on the reasoning task. Comparing these results with the accuracy results in Table 9, the same relationships were evident and consistent but the magnitude

Table 9

Correlations Between Physiological Reactivity and Accuracy Performance on the Logical Reasoning Task as a Function of Stress Condition*

Physiological Parameter	Performance	Negative Feedback	Noise
Performance HR Δ	.54 *	.44 *	.00
Verbal Feedback HR Δ	.43 *	.34	.02
Noise HR Δ	.53 *	.49 *	.03
Performance Vagal Tone Δ	-.17	-.04	-.36
Verbal Feedback Vagal Tone Δ	-.33	-.27	-.41
Noise Vagal Tone Δ	-.33	-.25	-.47 *

Note. " Δ " represents "change" to indicate that these measures are change from baseline scores.

* Only physiological parameters with one or more statistically significant correlations are listed.

* $p < .05$, $n = 20$.

of the effects was weaker. HR increases were related to better productivity and greater vagal tone suppression was related to better productivity, especially under the noise stress condition.

In summary, this section addresses the primary question of this report and the overall investigation into the utility of psychophysiological measures as selection and classification tools, namely, do the psychophysiological measures investigated predict the performance of individuals under stress? The data in Tables 5 through 10 show that the absolute levels of HR, vagal tone, and mean arterial and diastolic blood pressures, as well as reactivity-based change measures of vagal tone (and to a lesser extent HR), predict performance on both simple psychomotor reaction time and more complex logical reasoning tasks. Not only do these measures predict performance levels under little stress but they also predict altered performance levels under heightened levels of stress. Perhaps more importantly, the correlations from this investigation were consistent in direction and magnitude for each of the predictor psychophysiological variables

Table 10

Correlations Between Physiological Reactivity and Total Performance on the Logical Reasoning Task as a Function of Stress Condition^a

Physiological Parameter	Performance	Negative Feedback	Noise
Performance HR Δ	.19	.23	.21
Verbal Feedback HR Δ	.26	.24	.18
Noise HR Δ	.20	.19	.11
Performance Vagal Tone Δ	.02	-.03	-.20
Verbal Feedback Vagal Tone Δ	-.01	-.21	-.41
Noise Vagal Tone Δ	-.06	-.16	-.33

Note. " Δ " represents "change" to indicate that these measures are change from baseline scores.

^a Only physiological parameters with one or more statistically significant correlations are listed.

^{*} $p < .05$, $n = 20$.

indicating that these measures consistently explained some proportion of the variance even if the correlations themselves did not reach statistical significance. In fact, given the lower power associated with this pilot investigation of only 20 subjects and the usually high variability associated with performance abilities and psychophysiological responses to challenges, these psychophysiological measures demonstrated unexpectedly impressive predictive power with respect to predicting performance under stress with significant correlations ranging from .43 to .67. Clearly these results warrant further exploration in more naturalistic settings with specific populations. Moreover, procedures similar to those used in the present investigation may serve as a laboratory protocol that can be easily applied in selection and classification settings to be used in validation studies.

Personality Correlates of Performance Under Stress. Tables 11 to 14 show the relationship between the personality measures and performance on the two tasks under the three stress manipulations. Table 11 shows the correlations of all personality

Table 11

Correlations Between Personality Measures and Accuracy Performance on the Wilkinson Reaction Time Task as a Function of Stress Condition^a

Personality Measure	Performance	Negative Feedback	Noise
<u>OSAI</u>			
Stress	.08	.34	.33
Change	-.19	.06	-.07
Others	-.15	-.09	-.09
Coping	-.54 *	-.02	-.16
<u>Self-Efficacy</u>	-.05	.07	.02
<u>Eysenck Personality Inventory</u>			
Lie Scale	-.01	-.25	-.10
Extroversion	.19	.18	.30
Neuroticism	.09	.07	.23

^a Only physiological parameters with one or more statistically significant correlations are listed.

* $p < .05$, $n = 20$.

measures with accuracy performance on the Wilkinson reaction time task. While most of the correlations were somewhat inconsistent and low, there was a significant relationship between Active Coping and performance. For the simple reaction time task, accuracy was negatively related to Active Coping indicating that individuals who cope more actively with stress have less accurate performance. One interpretation for this finding is that this task is a simple task requiring more automatic and simple stimulus-response processing. Perhaps those who attempt to more actively cope with this task use strategies. The application of strategies to a non-strategic task could lead to performance impairment. If this hypothesis is tenable then the more complex reasoning task should show the opposite pattern since strategies could be helpful on that task.

Table 12

Correlations Between Personality Measures and Total Performance on the Wilkinson Reaction Time Task as a Function of Stress Condition^a

Personality Measure	Performance	Negative Feedback	Noise
<u>OSAI</u>			
Stress	-.07	-.07	.00
Change	.17	.07	.08
Others	.04	.00	-.07
Coping	.33	.15	.13
<u>Self-Efficacy</u>	.08	.03	-.02
<u>Eysenck Personality Inventory</u>			
Lie Scale	.00	-.39	-.01
Extroversion	-.27	-.36	-.39
Neuroticism	.05	.02	.06

^a Only physiological parameters with one or more statistically significant correlations are listed.

^{*} $p < .05$, $n = 20$.

Table 12 shows the correlations of all personality measures with total performance on the Wilkinson reaction time task. As was noted in the previous section, since accuracy on this task was high, total performance measures may provide a better measure of task performance than accuracy. While none of the correlations reached significance, two sets of results are worth noting. First, in terms of Active Coping, the correlation between Active Coping and performance was positive in contrast to the data in Table 11. This result would indicate that individuals were attempting to improve their performance on this task by actively coping with the task and attempting to be more productive. As has been noted earlier, this increase in productivity was at the expense of accuracy. Second, although the correlations were not significant, there appeared to be a

Table 13

Correlations Between Personality Measures and Accuracy Performance on the Logical Reasoning Task as a Function of Stress Condition^a

Personality Measure	Performance	Negative Feedback	Noise
<u>OSAI</u>			
Stress	-.38	-.16	.25
Change	-.39	-.15	-.09
Others	.24	.07	-.12
Coping	.19	.14	-.09
<u>Self-Efficacy</u>	.10	-.01	-.02
<u>Eysenck Personality Inventory</u>			
Lie Scale	-.18	-.01	-.02
Extroversion	-.37	-.47 [*]	-.26
Neuroticism	-.21	-.05	-.04

^a Only physiological parameters with one or more statistically significant correlations are listed.

^{*} $p < .05$, $n = 20$.

consistent pattern with respect to Extraversion and performance. Extraversion and performance were negatively correlated during performance alone ($r = -.27$) and during performance under stress ($r = -.36$ and $-.39$). In fact, the correlations were higher under stress. These data suggest that the less extroverted individuals (or the more introverted individuals) were better performers under stress. These data are consistent with the limited data available from the literature review and our earlier hypotheses that more successful copers will be more introverted.

Table 13 shows the correlations of all personality measures with accuracy performance on the more complex Logical Reasoning task. As with the results in Table 12, there were systematic negative correlations between Extraversion and performance

Table 14

Correlations Between Personality Measures and Total Performance on the Logical Reasoning Task as a Function of Stress Condition^a

Personality Measure	Performance	Negative Feedback	Noise
<u>OSAI</u>			
Stress	-.16	-.22	-.10
Change	-.24	-.47 *	-.37
Others	.26	.15	.18
Coping	.45 *	.39	.38
<u>Self-Efficacy</u>	-.05	-.12	-.16
<u>Eysenck Personality Inventory</u>			
Lie Scale	-.29	-.38	-.29
Extroversion	-.02	-.27	-.42 *
Neuroticism	-.05	-.06	-.13

^a Only physiological parameters with one or more statistically significant correlations are listed.

* $p < .05$, $n = 20$.

with the correlation between Extraversion and performance under negative verbal feedback reaching significance ($r = -.47$). These data would be consistent with the interpretation in the preceding paragraph that more introverted individuals perform better under stress.

Table 14 shows the correlations of all personality measures with total performance on the Logical Reasoning task. Several important relationships are worthy of note. First, the data in this table show consistent negative correlations between the individual's perceived ability to cope with stress and their performance under stress and this correlation was significant under stress ($r = -.47$). These data suggest that those individuals who perceive themselves as being less able to cope with stressful situations perform more

poorly under stress conditions as well. This result is important to selection and classification issues since it suggests that normal individuals perceive their ability to cope with stress accurately. (Of course, the demand characteristics of selection and classification situations may limit one's ability to accurately assess these self-perceptions.) Second, there were significant and consistent positive correlations between Active Coping and performance. These data suggest that those individuals who more actively engage in active coping will apply this tendency in coping situations where performance is required. Finally, these data also show a negative relationship between extraversion and performance especially under stress such that more introverted individuals perform better under stress.

In summary, the personality predictor variables were less consistent than the psychophysiological predictor variables but nevertheless showed some consistent patterns of response (though the magnitude of the relationships was weaker). Two primary conclusions can be drawn. First, these data suggest that those individuals who perceived themselves as having more of an ability to cope with stress and those individuals who more actively cope with stressful situations indeed are more successful performers when they encounter the need to perform under stress. (As a caveat to this conclusion, the data in Table 11 suggest that if the task at hand is a relative simple task requiring automatic processing, however, the tendency to cope with stress may lead to some performance impairment.) Second, there seems to be a consistent trend that more introverted individuals appear to be more successful performers when given a novel task to perform and remain more successful performers when asked to engage in this novel task under stress. In fact, the relationship between introversion/extraversion appears to become more pronounced under stressful conditions.

DISCUSSION AND GENERAL SUMMARY

The primary purpose of the present investigation was to examine the potential utility of personality and psychophysiological measures to predict performance under stress and to predict which individuals would be most suitable for high-stress occupations. In the initial steps of this project a theoretical framework was developed from the limited existing literature which suggested that those individuals who adopt active coping strategies, actively engage in task-oriented behavior, and who are more self-confident and introverted will more successfully cope with task demands under stress. However, in reviewing the literature it was concluded that psychometric tools specifically designed to measure the perceived stress associated with specific occupational situations as well as the perceived ability of individuals to actively cope with these specific situations were not available. The first investigation in this report was aimed at developing a more appropriate measure of occupational stress and coping.

In terms of psychophysiological measures that may be useful in predicting performance under stress, a review of the literature led to the development of a psychophysiological model of successful coping under stress. This model integrated the existing literature and stated that

successful copers who actively engage in task-oriented behavior and actively suppress or inhibit responses to exogenous or endogenous stressful stimuli will differentiate themselves from others in terms of their psychophysiological responses during performance under stress. Based on this model, it was proposed that psychophysiological measures that more clearly differentiated excitatory from inhibitory processes would be more likely to separate individuals who would show stronger active inhibition. This proposal was in contrast to most of the psychophysiological measures used previously since most studies had employed autonomic measures, such as HR, which are a product of both excitatory (sympathetic) and inhibitory (parasympathetic) processes. Thus, it was proposed that cardiovascular parameters that more uniquely reflect excitatory, such as blood pressures, and inhibitory, such as vagal tone, control processes should be more predictive of superior performance under stress than more "mixed" psychophysiological measures, such as HR. It was suggested that cardiac and cardiovascular measures be investigated as candidate psychophysiological measures since (a) there was some support in the literature for these measures, (b) these measures can differentiate excitatory and inhibitory processes, and © these measures have pragmatic advantages over other potential psychophysiological measures. The second investigation in this report was intended to assess the utility of personality and psychophysiological measures in a laboratory analogue of performance under stress.

The first investigation in this document reported the developmental efforts to construct a new occupational stress inventory that can be applied in general terms to occupations. This new instrument showed reasonably good convergent validity with other measures and good internal consistency. For instance, it was found that individuals who rated situations as highly stressful tended to rate their ability to change the situations as low. In addition, the perceived ability of individuals to change or control stressful situations was positively correlated with such problem-focused coping strategies as planning, suppressing competing activities, restraint coping, and reinterpretation and growth.

The second investigation directly attempted to examine psychophysiological reactivity (using HR, vagal tone, and blood pressure) under various stress conditions and assess the degree to which these psychophysiological measures predict performance under stress. In addition, the personality measures developed in the first investigation were included in subsequent research to assess the degree to which personality measures predict performance under stress. This investigation was a pilot investigation with only 20 subjects and is further constrained in terms of being a laboratory investigation rather than a field investigation where realistic stress levels may be enhanced. Nevertheless, the results were impressive.

The results of the second investigation showed that the absolute levels of HR, vagal tone, and mean arterial and diastolic blood pressures, as well as reactivity-based change measures of vagal tone (and to a lesser extent HR), predict performance on both simple psychomotor reaction time and more complex logical reasoning tasks. Not only do these measures predict performance levels under limited stress but they also predict different performance levels under heightened stress conditions. Specifically, individuals with better performance under stress showed higher heart rates and blood pressure under stress, as well as lower vagal tone and greater suppression of vagal tone from baseline levels. Perhaps more importantly, the correlations from this investigation were consistent in direction and magnitude for each of the predictor psychophysiological variables indicating that these measures consistently explained some proportion of the variance even if the

correlations themselves did not reach significance. In fact, given the low power associated with this pilot investigation of only 20 subjects and the usually high variability associated with performance abilities and psychophysiological responses to stress, these psychophysiological measures demonstrated unexpectedly impressive ability to predict performance under stress with statistically significant correlations ranging from .43 to .67. Clearly these results warrant further exploration in more naturalistic settings with larger samples.

In general, the results showed that psychophysiological measures did well in terms of predicting neurocognitive performance under stress. In addition, this investigation partially validated the proposed psychophysiological model in that those subjects who performed better under stress exercised greater inhibitory control (via lower vagal tone) as well as greater suppression of vagal tone from baseline conditions. However, the blood pressure measure, reflecting sympathetic activity, also showed that individuals who performed better under stress also showed greater sympathetic activity and demonstrated greater blood pressure levels under stress. Thus, individuals who perform better under stress engaged in task-oriented activity to a greater extent and this task-oriented activity resulted in both greater excitatory responses in blood pressure and greater inhibitory responses in vagal tone. While HR also showed some relationships with performance under stress, this mixed autonomic measure was less sensitive than the other, somewhat more pure measures of sympathetic and parasympathetic activity.

In terms of the personality measures, the results were less consistent than the psychophysiological measures but nevertheless showed some consistent patterns of response. These data suggested that those individuals who perceived themselves as having more of an ability to cope with stress and those individuals who more actively cope with stressful situations indeed are more successful performers when they encounter the need to perform under stress. These results reinforce the view that active copers view themselves as more capable and respond with task-oriented activity. In addition, there seemed to be a consistent trend that more introverted individuals appear to be more successful performers when given a novel task to perform and remain more successful performers when asked to engage in this novel task under stress. In fact, the relationship between introversion/extroversion appears to become more pronounced under stressful conditions. Again, this result would seem to be consistent with the trends in the literature.

In summary, it would appear that psychophysiological measures can be an extremely valuable addition to the selection process to select those individuals who will perform better under stress. While these data come from a laboratory investigation, they are nevertheless impressive given the low level of stress that can be generated. It will be very important to validate these findings in more realistic settings such as recruitment centers and training environments. The results from the current work appear to be very encouraging.

RESEARCH IMPLICATIONS

It is clear from this report that psychophysiological measures, and perhaps to a lesser extent personality measures, may provide valuable information for the selection and classification of personnel for high-stress occupations. Specifically, measures of blood pressure and vagal tone seem to be particularly sensitive with respect to predicting superior performance on cognitive

tasks under stress. In addition, measures of active coping, task-oriented coping, and introversion/extroversion seem to be personality measures that are sensitive to superior performance under stress. However, to truly validate these findings from this laboratory investigation, these measures must be assessed in selection and classification settings in a way that manipulates stress in a specific setting. These findings must then be related to performance under more realistic stress situations that occur in actual occupations of interest.

The procedure employed in the current investigation could be applied in selection settings. It would be relatively easy to set up the psychophysiological measures in an unobtrusive manner and test individuals on a variety of neurocognitive tests such as those employed in the present report. Personality measures centering on active coping strategies and introversion/extroversion could also be collected. In addition, the simple negative verbal feedback manipulation could be easily employed to attempt to manipulate stress levels. Since the noise distraction manipulation in the current report did not appear to add significantly to the stress levels and did not have a significant impact on performance or psychophysiological measure, there do not appear to be valid reasons for continuing this manipulation. This type of protocol would allow an assessment of performance and predictor variables without and with external stress. These variables could then be used to predict successful performance under stress in training situations where performance was clearly and objectively defined and evaluated. Such a research program would confirm the utility and efficacy of psychophysiological and personality measures in realistic settings.

As a caveat to the above recommendation, it should be noted that the actual selection setting may be a highly stressful setting because of the importance and salience of the testing situation for the individual. It may be the case that adding additional augmentation of stress is unnecessary. Thus, it is further recommended that some pilot data be collected that will further assess these measures in realistic selection settings for a specific population of interest. If the results are similar to those found in the laboratory investigation, a more thorough and extensive effort to validate these findings under realistic occupational stress settings would be warranted.

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APPENDIX A

BACKGROUND INFORMATION SHEET AND PSYCHOLOGICAL INSTRUMENTS

Background Information Sheet

1. Sex: ____ Male ____ Female
 2. Age: ____
 3. Education: ____ High school degree
____ Some college/university
____ College/university degree
____ Technical degree
____ Some graduate work
____ Graduate degree
 4. Handedness: ____ Right ____ Left ____ No dominance
 5. Smoking: ____ No. cigarettes/week
____ last cigarette smoked
 6. Caffeine: ____ how many caffeinated drinks/chocolate per week
____ last caffeinated drink/choc.
 7. Last meal: ____ what ate ____
 8. Exercise: ____ no. times/week ____ type

- Duration: ____ < 30 min. ____ > 30 min & < 60 min
____ > 60 min ____ > 60 min & < 120 min
____ > 120 min
____ when exercised last

OCCUPATIONAL STRESS ASSESSMENT INVENTORY

Please read each situation and respond to the set of 4 statements that follow each situation. For **statements 1 and 2** of each situation, use **Scale A** below to indicate the extent to which you agree with each statement. For example, if you strongly agree with a statement, write down a "+2", or if you strongly disagree with a statement, write down a "-2". For **statement 3** of each situation, use **Scale B** below to indicate the extent to which you would cope better or worse than other people with the situation. For example, if you would be much better than other people, write down a "+2", or if you would do much worse than other people, write down a "-2". Write your answer on the blank line to the right of each statement. For **statement 4**, circle the response (a, b, c, or d) that describes how you are most likely to respond to the situation.

Scale A - Statements 1 and 2				
-2	-1	0	+1	+2
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Scale B - Statement 3				
-2	-1	0	+1	+2
Strongly Disagree	Disagree	Same As Others	Agree	Strongly Agree

1. After you successfully completed an assignment, your supervisor has increased your performance goal for you next assignment to an exceptionally high level.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by: _____
 - a) Telling my supervisor that I feel that this new goal is unfair.
 - b) Thinking about how I can best meet this new goal.
 - c) Working toward meeting my previous performance goals.
 - d) Doing what had to be done one step at a time.

2. You have been temporarily transferred to a new unit to work on an assignment. So far, neither your supervisor nor your new coworkers have told you if you are performing up to standard.

1. I would find this situation to be stressful _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by: _____
 - a) Scheduling a performance review with my supervisor.
 - b) Asking one of my coworkers if I am doing OK.
 - c) Reminding myself that the assignment is temporary and that it will soon be over.
 - d) Getting involved with other projects to take my mind off things.

3. You do not get along with one of your coworkers. You do not agree on anything, especially the you should do you job. Your coworker makes it public that the two of you do not get along by openly criticizing you in front of others.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Standing my ground and fight for what I believe in.
 - b) Continuing to do my job, and act as if nothing is happening.
 - c) Holding off doing anything until I can talk to this coworker in private.
 - d) Getting my friends to back my up.

4. On day at work, you and your coworkers learn that you are in danger from a sniper who is situated in the building next to where you are located.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Waiting for instructions from police officers about what to do.
 - b) Hiding underneath my desk until the situation is over.
 - c) Trying to find a safe exit out of the building.
 - d) Looking to my supervisor for support and encouragement.

5. New procedures for doing your job have been put into place. Since you have not received training on these procedures or been given directions on how to use them, it is not clear to you what you are supposed to do.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Doing my job the way I always have.
 - b) Telling my supervisor that I feel that the new procedures are unfair.
 - c) Learning the new procedures and, if necessary, letting other things slide a little.
 - d) Accepting the new procedures, and realize that they cannot be changed.

6. Due to budget cuts, a hiring freeze has been put into effect. In addition, your unit has been downsized due to retirements and transfers. You and each of your coworkers are now doing the work of two people.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Recognizing that this bothers me, and try to deal with how I am feeling.
 - b) Setting priorities for getting things done.
 - c) Admitting that I cannot do the work of two people, and stop trying to.
 - d) Working extra hours even if it interferes with other things in my life.

7. Your supervisor is closely monitoring your work. Every time that you make a decision about how to get things done, you have to ask him if it is OK.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Avoiding my supervisor as much as possible.
 - b) Talking to someone who has had a similar experience about why they did.
 - c) Getting my supervisor to agree that I only need his approval for important decisions.
 - d) Letting my supervisor know that I am upset about this situation.

8. As the safety monitor of your work unit, you are responsible for ensuring the safety of your coworkers during emergency situations. One morning a big fire breaks out in your building.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Directing my coworkers to make protective covers for their faces.
 - b) Making a joke about the situation to take our minds off of the fire.
 - c) Letting my coworkers know that I am as upset as they are.
 - d) Waiting for the firefighters to let me know what to do.

9. There are many rumors going around about your unit's next assignment. There is a lot of talk about getting a really important assignment, but the actual assignments will not be made for a couple of months.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Asking my supervisor to give us the facts so we can stop the rumors.
 - b) Acting as if the rumors do not exist.
 - c) Accepting the fact that we will not know anything definite for a couple of months.
 - d) Talking to my coworkers about how they feel things are going to work out.

10. There is a lot of paperwork in your job. You have to submit weekly logs of your activities, respond to daily memos, and often fill out requests for equipment and supplies.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Asking my coworkers how they handle all of the paperwork.
 - b) Working on other tasks first.
 - c) Getting my supervisor to understand how much paperwork I have to do.
 - d) Doing my best to get it done.

11. You are working in a hot and humid environment. The temperature is 105 degrees with 90% humidity. After a few days of this weather, the heat and humidity start to interfere with getting you work done.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Telling your supervisor that I am concerned about my performance.
 - b) Trying to sleep as much as I can.
 - c) Working at night.
 - d) Getting used to the weather.

12. You have not progressed in your career as quickly as other people have in your company. In fact, people with education and experience similar to your own are senior managers while you remain in a lower position.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Getting involved with a project that will give me a lot of recognition in the company.
 - b) Making a career development plan and try to follow it.
 - c) Talking with my coworkers about my lack of progress.
 - d) Realizing that I am not perfect, and put my energy into other things.

13. After you started working in another unit in your company, one of your old coworkers calls you and asks for sensitive information about your current unit's projects.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Holding off doing anything until I talk to my supervisor.
 - b) Getting upset and telling my coworker how I feel.
 - c) Asking my coworker why he wants the information.
 - d) Telling my coworker that I am too busy to talk and that I will get back to him.

14. One of your coworkers has developed a drug problem that is interfering with his performance. Your supervisor has asked you to take responsibility for this coworker and his problem.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Giving my coworker brochures on drug/alcohol abuse and treatment.
 - b) Getting advice from someone who knows how to deal with drug problems.
 - c) Telling my coworker how our supervisor feels about his problem.
 - d) Letting my coworker work out his own problem.

15. Your supervisor has given you an important project to complete. Although you have several weeks to do this project, you do not have the skills to complete it.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Realizing my weaknesses, and work on things that I know how to do.
 - b) Reading a book or taking a class to learn the skills that I need.
 - c) Asking a coworker who does have the necessary skills to help me.
 - d) Telling my supervisor how I feel about the project.

16. You are an effective employee: you get the work done on time and the quality of your work is high. Even though you do a good job, your supervisor never recommends you for promotion.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Asking my supervisor to identify my strengths and weaknesses.
 - b) Stop working so hard since it does not matter what I do.
 - c) Finding out about promotion opportunities in other units of the company.
 - d) Talking to my friends or family about the situation.

17. During a staff meeting, one of your coworkers becomes very angry, throws chairs, and turns over tables. After a few minutes of this behavior, he threatens to beat you up.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Waiting until my coworker calms down and then talk to him.
 - b) Leaving the room.
 - c) Calling building security.
 - d) Becoming visibly angry with my coworker.

18. A major storm has hit your city and it is so bad that your supervisor is letting everyone go home early. Radio reports indicate that the storm has made driving treacherous and many roads are blocked.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Taking public transportation to get home
 - b) Thinking about alternative routes I can take to get home.
 - c) Going to a bar or restaurant near my office to take my mind off things.
 - d) Recognizing my fears, and try to deal with them.

19. In your unit, you choose assignments based on seniority. You really wanted to work on a particular project, but since you have low seniority you did not get your first choice.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Working extra hours so I can work on the project that I really want rather than the one that I am assigned to.
 - b) Talking to my coworkers about what I can do to get assigned to the project that I want.
 - c) Working on the project that I am assigned to.
 - d) Telling my supervisor that I feel that seniority is not a good way to make assignments.

20. Due to medical reasons, one of your coworkers will be on leave for the next three months. Your supervisor has asked you to do his work in addition to doing your own.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Letting my supervisor know that I am upset about having to do extra work.
 - b) Putting other things aside to concentrate on the work that I have to do.
 - c) Asking my coworkers to help me get the work done.
 - d) Getting my own work done first.

21. Your supervisor has an office in another building of the company. Since you do not see him on a regular basis, he cannot always tell you if you are doing your job correctly.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Recognizing that this bothers me, and try to deal with my feelings.
 - b) Taking time once a week to talk to my supervisor about how things are going.
 - c) Doing what I want until someone tells me not to.
 - d) Waiting until the time is right to approach my supervisor about my performance.

22. You and one of your coworkers have been involved with each other in a secret romantic relationship for quite a while. You recently ended the relationship, and it is clear to you that your coworker is not happy about the breakup.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Meeting with both my supervisor and coworker to straighten things out.
 - b) Getting upset and letting my coworker know how I feel.
 - c) Starting the relationship again to keep my coworker quiet.
 - d) Talking to a trusted coworker about what to do.

23. Your supervisor has announced that your company is cutting its workforce by 50%. It will be another month before you know who will be laid off.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Making a plan to deal with getting laid off.
 - b) Calling acquaintances at other companies to find out about job opportunities.
 - c) Talking to my friends and relatives about what is happening.
 - d) Trying to act as if nothing is happening.

24. When you want to order new equipment for your office, the red tape that you have to go through is tremendous. You have to fill out several forms, file the forms with different offices, and get approval from three different managers to order the equipment.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Working with the equipment that I currently have.
 - b) Focusing on dealing with the red tape, and let other things go for a while.
 - c) Accepting that this is the way things are.
 - d) Letting my supervisor know that I feel the red tape is an unnecessary burden.

25. You have recently been made team leader for your work group. Your coworkers continue to treat you as if you are still one of the guys, but your supervisor expects you to supervise them.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Writing my coworkers up for poor performance if they do not listen to me.
 - b) Giving my coworkers time to get used to me as their team leader.
 - c) Letting my coworkers supervise themselves.
 - d) Letting my coworkers know that their lack of cooperation is bothering me.

26. Your supervisor is not very good about making work assignments: you and your coworkers never know what you are supposed to be working on or what your work objectives are.

1. I would find this situation to be stressful. _____
2. I would be able to change or do something about this situation. _____
3. I would cope with this situation better than most people I know. _____
4. I would respond to this situation by:
 - a) Letting my supervisor know that I am upset about the way he is supervising us.
 - b) Coordinating the work with my coworkers to get it done.
 - c) Asking another supervisor about what to do.
 - d) Working on the parts of my job that I like to do.

Self-Efficacy Scale

This questionnaire is a series of statements about your personal attitudes and traits. Each statement represents a commonly held belief. Read each statement and decide to what extent it describes you. There are no right and wrong answers. You will probably agree with some of the statements and disagree with others. Please indicate your own personal feelings about each statement below by marking the letter that best describes your attitude or feeling. Please be very truthful and describe yourself as you really are, not as you would like to be.

A = Disagree strongly
B = Disagree moderately
C = Neither agree or disagree
D = Agree moderately
E = Agree strongly

- _____ 1. I like to grow house plants.
- _____ 2. When I make plans, I am uncertain I can make them work.
- _____ 3. One of my problems is that I cannot get down to work when I should.
- _____ 4. If I can't do a job the first time, I keep trying until I can.
- _____ 5. Heredity plays the major role in determining one's personality.
- _____ 6. It is difficult for me to make new friends.
- _____ 7. When I set important goals for myself, I rarely achieve them.
- _____ 8. I give up on things before completing them.
- _____ 9. I like to cook.
- _____ 10. If I see someone I would like to meet, I go to that person instead of waiting for him or her to come to me.
- _____ 11. I avoid facing difficulties.
- _____ 12. If something looks too complicated, I will not even bother to try it.
- _____ 13. There is some good in everybody.
- _____ 14. If I meet someone interesting who is very hard to make friends with, I'll stop trying to make friends with that person.
- _____ 15. When I have something unpleasant to do, I stick to it until I finish it.
- _____ 16. When I decide to do something, I go right to work on it.
- _____ 17. I like science.
- _____ 18. When trying to learn something new, I soon give up if I am not initially successful.
- _____ 19. When I'm trying to become friends with someone who seems uninterested at first, I don't give up very easily.
- _____ 20. When unexpected problems occur, I don't handle them well.
- _____ 21. If I were an artist, I would like to draw children.
- _____ 22. I avoid trying to learn new things when they look too difficult for me.
- _____ 23. Failure just makes me try harder.
- _____ 24. I do not handle myself well in social gatherings.
- _____ 25. I very much like to ride horses.
- _____ 26. I feel insecure about my ability to do things.
- _____ 27. I am a self-reliant person.
- _____ 28. I have acquired my friends through my personal abilities at making friends.
- _____ 29. I give up easily.
- _____ 30. I do not seem capable of dealing with most problems that come up in life.

Eysenck Personality Inventory

Circle YES or NO if the question applies to you.

- | | | | |
|-----|--|-----|----|
| 1. | Do you often long for excitement? | Yes | No |
| 2. | Do you often need understanding friends to cheer you up? | Yes | No |
| 3. | Are you usually carefree? | Yes | No |
| 4. | Do you find it very hard to take no for an answer? | Yes | No |
| 5. | Do you stop and think things over before doing anything? | Yes | No |
| 6. | If you say you will do something do you always keep your promise, no matter how inconvenient it might be to do so? | Yes | No |
| 7. | Does your mood often go up and down? | Yes | No |
| 8. | Do you generally do and say things quickly without stopping to think? | Yes | No |
| 9. | Do you ever feel "just miserable" for no good reason? | Yes | No |
| 10. | Would you do almost anything for a dare? | Yes | No |
| 11. | Do you suddenly feel shy when you want to talk to an attractive stranger? | Yes | No |
| 12. | Once in while do you lose your temper and get angry? | Yes | No |
| 13. | Do you often do things on the spur of the moment? | Yes | No |
| 14. | Do you often worry about things you should not have done or said? | Yes | No |
| 15. | Generally do you prefer reading to meeting people? | Yes | No |
| 16. | Are your feelings rather easily hurt? | Yes | No |
| 17. | Do you like going out a lot? | Yes | No |
| 18. | Do you occasionally have thoughts and ideas that you would not like other people to know about? | Yes | No |
| 19. | Are you sometimes bubbling over with energy and sometimes very sluggish? | Yes | No |
| 20. | Do you prefer to have few but special friends? | Yes | No |
| 21. | Do you daydream a lot? | Yes | No |
| 22. | When people shout at you, do you shout back? | Yes | No |
| 23. | Are you often troubled about feelings of guilt? | Yes | No |
| 24. | Are all your habits good and desirable ones? | Yes | No |
| 25. | Can you usually let yourself go and enjoy yourself a lot at a party? | Yes | No |
| 26. | Would you call yourself tense or "highly-strung"? | Yes | No |
| 27. | Do other people think of you as being very lively? | Yes | No |
| 28. | After you have done something important, do you often come away feeling you could have done better? | Yes | No |
| 29. | Are you mostly quiet when you are with other people? | Yes | No |
| 30. | Do you sometimes gossip? | Yes | No |
| 31. | Do ideas run through your head so that you cannot sleep? | Yes | No |
| 32. | If there is something you want to know about, would you rather look it up in a book than talk to someone about it? | Yes | No |
| 33. | Do you get palpitations or thumping in your heart? | Yes | No |
| 34. | Do you like the kind of work that you need to pay close attention to? | Yes | No |
| 35. | Do you get attacks of shaking or trembling? | Yes | No |
| 36. | Would you always declare everything at customs, even if you knew that you could never be found out? | Yes | No |
| 37. | Do you hat being with a crowd who play jokes on one another? | Yes | No |
| 38. | Are you an irritable person? | Yes | No |
| 39. | Do you like doing things in which you have to act quickly? | Yes | No |

40.	Do you worry about awful things that might happen?	Yes	No
41.	Are you slow and unhurried in the way you move?	Yes	No
42.	Have you ever been late for an appointment or work?	Yes	No
43.	Do you have many nightmares?	Yes	No
44.	Do you like talking to people so much that you would never miss a chance of talking to a stranger?	Yes	No
45.	Are you troubled by aches and pains?	Yes	No
46.	Would you be very unhappy if you could not see lots of people most of the time?	Yes	No
47.	Would you call yourself a nervous person?	Yes	No
48.	Of all the people you know are there some whom you definitely do not like?	Yes	No
49.	Would you say you were fairly self-confident?	Yes	No
50.	Are you easily hurt when people find fault with you or your work?	Yes	No
51.	Do you find it hard to really enjoy yourself at a lively party?	Yes	No
52.	Are you troubled with feelings of inferiority?	Yes	No
53.	Can you easily get some life into a rather dull party?	Yes	No
54.	Do you sometimes talk about things you know nothing about?	Yes	No
55.	Do you worry about your health?	Yes	No
56.	Do you like playing pranks on others?	Yes	No
57.	Do you suffer from sleepiness?	Yes	No

APPENDIX B

**EXPERIMENTAL PROTOCOL SUMMARY, EXPERIMENTAL
INSTRUCTIONS, AND DEBRIEFING FORM**

Experimental Protocol Summary

Protocol

- 1) Briefly explain investigation
- 2) Subjects sign Consent form
- 3) **Finapres** hook up for HR and blood pressure measures
- 4) Background Data Sheet and Questionnaires administered
- 5) Pre-Experimental 2-min Baseline
- 6) Explain tasks (see Experimental Instructions)
- 7) Practice Trial with no physiological data acquired
- 8) Experimental Trials
- 9) Post-Experimental 2-min Baseline
- 10) Debriefing

Experimental Trials

Trials 1-4 - 4 Uninterrupted Performance Alone Trials

Trials 5-7 - 3 Negative Feedback Trials

Trials 8-10 - 3 Noise Trials

Experimental Instructions

"As you already know, the purpose of this investigation is to assess physiological responses to cognitive tasks. I'm going to attach this painless sensor to the **middle** finger of your **dominant** hand. So, if you could let me know which one that is ... thanks. We'll just be monitoring your **HR**, while you perform these 2 short computer tasks. First, could you please fill out the following questionnaires? ... thanks. The HR monitor needs a slight adjustment period, so why don't you just sit back and relax for a few minutes, close your eyes and think of something pleasant, until I make sure that everything is functioning properly. Ok, everything seems to be working well."

Subjects received the following instructions prior to starting the experimental trials:

"I'll be monitoring your HR, while you perform these 2 short computer tasks. First, I will explain the 2 computer tasks to you. The first one is a Reaction Time task. In this task a 2X2 box will appear on the screen with a red square in one of the four sections, as is illustrated on this card. These two sections correspond to the 1, 2, 4, & 5 keys on the key pad. Your task is to hit the key that corresponds to where the red square is in the box as fast and as accurately as possible. When you hit the correct key, the light will go out but will then reappear in any of the 4 sections. Remember the square can reappear in the same section several times. If you hit the wrong key, you will hear a beep, and you just go on and do the next trial.

In the second task -- a Reasoning task -- you will see a sentence such as "**A follows B**" followed by a letter pair "**AB**." Your task is to judge whether the sentence and the letter pair are the same or different. If you think they are the same, hit the "**S**" key, and hit "**D**" if you think they are different.

Remember, for both tasks your job is to work as quickly and accurately as possible. Do you understand these tasks?

You will have to help me each time we do the two tasks. I'll set up the first one for you and tell you what you'll have to do after this practice session. For now, just hit the return key when I tell you from the other room and begin the practice trial."

Following practice trial:

"You will have to help me, by letting me know when you're ready to begin. Once you have told me that you're ready, please wait until I tell you to start. After a few trials, I'll let you know how you're doing.

Please keep in mind that the accuracy of the physiological data depends on you trying to do the tasks as quickly and accurately as possible. Feel free to ask questions between trials, but it is important that once you start a trial to continue until it is completed, otherwise we will have to redo the entire session over again."

Experimental Negative Feedback Instructions

Negative Feedback Instructions given as follows:

Following Trial 4: **"WE FIND THAT PEOPLE GENERALLY PERFORM
VERY WELL ON THESE TASKS. YOUR PERFORMANCE
DOESN'T SEEM TO BE AS GOOD; COULD YOU PLEASE
TRY AGAIN."**

Following Trial 5: **"CAN YOU TRY EVEN HARDER!"**

Following Trial 6 **"GET READY TO START THE NEXT TRIAL"**

Debriefing Form

Thank you for participating in our investigation. Your contribution is invaluable to conducting this kind of research. The general aim of this research is to develop valid techniques for selecting people who will perform well under stressful situations. This was, in fact, the purpose of both the negative feedback which you received as well as the noise to which you were exposed. Therefore, please be assured that your performance on the cognitive tasks is in no way a measure of your intelligence, nor were we interested in that dimension. The questionnaires were intended to measure how well you might deal with occupational stress, and the extent to which you display self-efficacy, and some personality characteristics like introversion/extraversion. We are also investigating whether any of these personality variables predict one's performance under stress.

If something has not been made clear to you or you have further questions, please do not hesitate to ask. Once again, thank you very much for helping us with this investigation!