THE EFFECTS OF NATURALLY-OCCURRING FATIGUE
AND TASK DIFFICULTY
ON EFFORT RELATED CARDIOVASCULAR RESPONSE

by

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MEDICAL/CLINICAL PSYCHOLOGY

ABSTRACT

Wright’s integrative analysis suggests that effort can be measured via cardiovascular (CV) response. In addition, the analysis breaks with tradition in suggesting that effort varies not with benefit alone, but also with the difficulty of the behavioral challenge at hand. Recent research has focused upon the effects of fatigue on effort related CV response, assuming that fatigue negatively affects perceived ability. Results have supported interactional predictions. Specifically, they have indicated higher levels of CV response among high- as compared to low fatigue participants when tasks were possible and worthwhile and the reverse response pattern when tasks were excessively difficult (given the incentive) or impossible. One implication is that high fatigue individuals may strive harder than low fatigue individuals in meeting challenges perceived as possible and worthwhile. If they do so chronically, this could yield chronically elevated CV responses and increased risk for negative health outcomes such as hypertension and heart disease.

The purpose of the present study was to extend the preceding fatigue research by (1) studying participants with low and high levels of naturally occurring fatigue, and (2) doing so across multiple task difficulty levels, including an extreme difficulty condition. Each participant calculated mentally the sum of increasingly difficult series of audible numbers and was offered a modest monetary reward for each correct sum total. Analysis of CV responses measured during the task periods indicated that for Low Fatigue participants, a quadratic trend for SBP, DBP, and HR responsiveness was present, with re-
responses rising with difficulty up to a point and then declining. CV response was low for High Fatigue participants, regardless of difficulty, and especially low in the impossible task condition. Results were interpreted to suggest that fatigue in High Fatigue participants was so high that it discouraged engagement even when difficulty was low.

Wright’s integrative fatigue analysis implies that a different cardiovascular response pattern might have been observed for High Fatigue participants had a more powerful performance incentive been provided. This work has practical implications not only for health, but also for performance outcomes in social, educational, and occupational settings.

Keywords: fatigue, cardiovascular response, motivation, effort, active coping
DEDICATION

To my wife and parents who provided me with the support and encouragement necessary to complete this work. And to my son Benjamin who reminded me that everyone needs a break by saying, “I can’t play right now Daddy, because I’m doing some work.”
ACKNOWLEDGMENTS

I would like to thank the members of my committee for all of their assistance in making this dissertation research a reality. This project could also not have been completed without the assistance of Brandon Dearen and Katie Tebo, who provided valuable insight regarding the research protocol, helped in contacting potential participants, and ran participants through the research protocol. Casey Borch, Ph.D. provided assistance in understanding trend analyses and how it could be applied in this experiment. This research was also funded by the National Science Foundation Grant # BCS-0450941.
TABLE OF CONTENTS

COPYRIGHT ...................................................................................................................... ii

ABSTRACT ....................................................................................................................... iii

DEDICATION ..................................................................................................................... v

ACKNOWLEDGMENTS ................................................................................................. vi

LIST OF TABLES ............................................................................................................... x

LIST OF FIGURES ........................................................................................................... xi

CHAPTER

1  INTRODUCTION .......................................................................................................... 1

   Effort in Psychology ................................................................................................ 2
   Integrative Analysis of Effort and Cardiovascular Response .............................. 3
   Active Coping and Cardiovascular Reactivity ...................................................... 4
   Intensity of Motivation ............................................................................................ 5
   Effects of Perceived Ability .................................................................................... 9
   Fatigue, Effort, and Cardiovascular Response ..................................................... 13
   Present Research .................................................................................................... 15

2  METHODS ................................................................................................................... 18

   Overview ................................................................................................................... 18
   Participants ............................................................................................................... 18
   Materials .................................................................................................................. 21
      Identification Sheet and Demographics Questionnaire ................................. 21
      Modified Fatigue Severity Scale .................................................................... 22
      Auditory Mental Addition ............................................................................... 24
      Preliminary Affect Questionnaire .................................................................. 26
      Post-Task Questionnaires ................................................................................ 26
      Cardiovascular Parameters and Their Measurement ..................................... 27
   Procedures ............................................................................................................... 27
      Cardiovascular Baseline ................................................................................. 28
      Affect Baseline, Instructions, and Task Periods ............................................. 29
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Analyses</td>
<td>31</td>
</tr>
<tr>
<td>Baseline</td>
<td>31</td>
</tr>
<tr>
<td>Work Period</td>
<td>32</td>
</tr>
<tr>
<td>Subjective</td>
<td>33</td>
</tr>
<tr>
<td>3. RESULTS</td>
<td>35</td>
</tr>
<tr>
<td>Post-task Self Report of Difficulty</td>
<td>35</td>
</tr>
<tr>
<td>Fatigue Self Report</td>
<td>36</td>
</tr>
<tr>
<td>Baseline Cardiovascular Data</td>
<td>39</td>
</tr>
<tr>
<td>Work Period Data</td>
<td>39</td>
</tr>
<tr>
<td>Preliminary Analyses</td>
<td>39</td>
</tr>
<tr>
<td>Second-Half Responses</td>
<td>41</td>
</tr>
<tr>
<td>Trend Analyses</td>
<td>46</td>
</tr>
<tr>
<td>Subjective Effort and Performance</td>
<td>48</td>
</tr>
<tr>
<td>4. DISCUSSION</td>
<td>51</td>
</tr>
<tr>
<td>Overview</td>
<td>51</td>
</tr>
<tr>
<td>Cardiovascular Findings</td>
<td>52</td>
</tr>
<tr>
<td>Subjective and Performance Findings</td>
<td>57</td>
</tr>
<tr>
<td>Considerations for Self-Report and Performance Findings</td>
<td>58</td>
</tr>
<tr>
<td>Health and Social Implications</td>
<td>60</td>
</tr>
<tr>
<td>Limitations</td>
<td>62</td>
</tr>
<tr>
<td>Conclusions</td>
<td>62</td>
</tr>
<tr>
<td>LIST OF REFERENCES</td>
<td>65</td>
</tr>
<tr>
<td>APPENDIX:</td>
<td></td>
</tr>
<tr>
<td>A SCREENING PACKET</td>
<td>77</td>
</tr>
<tr>
<td>B ORIGINAL FATIGUE SEVERITY SCALE AND INSOMNIA SEVERITY INDEX</td>
<td>83</td>
</tr>
<tr>
<td>C EXAMINER PROTOCOL</td>
<td>86</td>
</tr>
<tr>
<td>D PARTICIPANT MATERIALS</td>
<td>91</td>
</tr>
<tr>
<td>E VALIDITY AND RELIABILITY FOR MODIFIED FATIGUE</td>
<td>102</td>
</tr>
</tbody>
</table>
F  FIRST VERSUS SECOND HALF COMPARISONS ..............................104
G  MIXED MEASURES ANOVAS WITH RACE AND GENDER............112
H  IRB FORMS .........................................................................127
LIST OF TABLES

Table                                    Page

1 Predictions for Perceived Difficulty and Cardiovascular Response .........................17
2 Demographic Data for Participants .............................................................................20
3 Excluded Data .............................................................................................................21
4 Post-task Self Report of Difficulty ...........................................................................36
5 Means for Self Reported Fatigue on Day of Testing ..................................................37
6 Correlations for Self Reported Fatigue on Day of Testing .........................................38
7 Baseline Cardiovascular Values ..................................................................................40
8 Post-task Self Report of Expended Effort ...................................................................49
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Effect of Difficulty on Effort</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Combined Effects of Difficulty and Perceived Benefit on Effort</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Interaction between Difficulty and Perceived Ability on Effort</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>Systolic Blood Pressure Response</td>
<td>42</td>
</tr>
<tr>
<td>5</td>
<td>Diastolic Blood Pressure Response</td>
<td>44</td>
</tr>
<tr>
<td>6</td>
<td>Heart Rate Response</td>
<td>46</td>
</tr>
<tr>
<td>7</td>
<td>Percent of Correct Responses</td>
<td>50</td>
</tr>
</tbody>
</table>
CHAPTER 1
INTRODUCTION

Research by Wright and colleagues has focused upon the examination of the effects of fatigue on effort related cardiovascular (CV) response (Wright et al., 2007). In these experiments, fatigue has been manipulated in the laboratory through depletion of resources immediately prior to the target task. Results have supported the notion that fatigued individuals have higher levels of CV response on easier tasks and lower levels of CV response on harder tasks than those who are not fatigued. As it would be more likely for an individual to have multiple exposure to relatively easy tasks, such as mundane tasks of daily living, than very difficult tasks, such as major work presentations, an implication is that chronically fatigued individuals may be more at risk for the development of negative health outcomes, including hypertension and heart disease (Blascovich & Katkin, 1993; Contrada, Cather, & O’Leary, 1999; Dembroski, Schmidt, & Blümchen, 1983; Forsyth, 1969; Herd, Morse, Kelleher, & Jones, 1969). However, there is not yet evidence that individuals who experience higher levels of fatigue on a day-to-day basis demonstrate similar CV response patterns. In the passages below, I will elaborate on the propositions that make up Wright’s integrative analysis and review evidence relevant to them. I will then discuss recent research concerned with CV correlates of fatigue and detail a new fatigue experiment designed to address important fatigue questions that have yet to be answered.
Psychologists have long been interested in the concept of effort. William James (1890) detailed a story of a wet and fatigued sailor who had to exert “great volitional effort” to man the pumps of his waterlogged ship, despite really wanting to lay exhausted on the deck. Social psychologists examine the effects of others on individual effort (i.e.-social loafing). Clinical psychologists must be aware of examinee effort to determine if test results are valid. Health psychologists may be interested how effort affects and is affected by various medical conditions.

Psychologists interested in effort have grappled consistently with two challenges. One is measuring effort. Seemingly obvious ways to do this would be to obtain effort reports and examine performance. Unfortunately, both of these strategies are problematic. Effort reports can be profoundly influenced by desires to fit experimenter expectations and to protect self esteem. For example, there is evidence that performers who are uncertain of success consistently under-report effort to provide an excuse in the event of failure (Pyszczynski & Greenberg, 1983; Rhodewalt & Fairfield, 1991). Concerning performance, psychologists have long recognized that it can bear a curvilinear relation to effort, with the peak of the curve changing depending on task characteristics and performance conditions (Yerkes & Dodson, 1908). The other challenge with which psychologists have grappled is predicting effort. Lay people and research scientists alike commonly assume that effort increases with the need for and value of performance incentives. However, there is growing reason to believe this is not always so.
Integrative Analysis of Effort and Cardiovascular Response

A long-running program of research by Wright and his co-workers addresses both of the issues above. The program is guided by an integrative analysis concerned with the determinants and CV consequences of momentary effort. Central propositions of the analysis are twofold (Wright et al., 2007; Wright & Kirby, 2001). First, sympathetically mediated CV responses increase to the degree people are engaged in active coping, or effort. Second, effort is proportional to the difficulty of an imminent or ongoing challenge so long as success is viewed as possible and worthwhile, and low at difficulty levels beyond these points. An extension proposition asserts that ability perception should combine interactively with challenge difficulty to determine effort and associated CV responses (Gendolla & Wright, 2005; Wright, 1996, 1998; Wright et al., 2007; Wright & Franklin, 2004; Wright & Kirby, 2001).

The preceding integrative analysis provides a framework for predicting effort and suggests a novel means of measuring effort, specifically, through CV response assessment. The analysis also highlights conditions under which people should manifest different degrees of CV response. This is noteworthy in part because chronically exaggerated CV responses have been implicated in the development of negative health outcomes, including hypertension and heart disease (Blascovich & Katkin, 1993; Contrada, Cather, & O’Leary, 1999; Dembroski, Schmidt, & Blümchen, 1983; Forsyth, 1969; Herd, Morse, Kelleher, & Jones, 1969).
Active Coping and CV Reactivity

The first central proposition in Wright’s integrative analysis is based on work by Paul Obrist (1981). Obrist postulated that the influence of the sympathetic nervous system (SNS) on CV reactivity is proportional to the amount of effort put forth by an individual (that is, the amount of active coping). This has been demonstrated in various animal and human models, but two experiments were integral to Obrist’s hypothesis. In an experiment involving perceived control in humans (Obrist et al., 1978), some participants were led to believe they could control (avoid) electric shocks by controlling an unspecified aspect of their physiology, while others were led to believe they would have no control over the shocks. In both groups, an array of lights warned when a shock might follow. Those in the perceived control group were told if they could adjust an unspecified physiological response, they would receive no shock. All participants received the same number and sequence of shocks. Participants in the perceived control condition demonstrated the highest amount of reactivity in carotid contractility (dP/dt), systolic blood pressure (SBP), and heart rate (HR). Those in the no control condition demonstrated some initial reactivity, but this quickly lessened. The belief that one had control over a situation affected the amount of effort put forth and consequently resulted in SNS activation with associated CV responses.

In another experiment involving perceived control (Obrist et al. 1978); participants were subjected to three separate stressors: a cold pressor task, a pornographic film, and a reaction time task. The reaction time task had three levels of difficulty based upon speed of reaction criteria: (1) easy, (2) difficult, and (3) impossible. Participants were in-
formed they would be awarded $.25 for each response during the reaction time task that met or beat the criterion or receive a shock if they did not meet the criterion. CV data were recorded during a baseline condition and each of the stressor conditions. The reaction time task demonstrated the highest increase from baseline in CV measures associated with SNS activation: SBP, dP/dt, and HR. Diastolic blood pressure (DBP) increased the greatest in the cold pressor and film conditions. The difference in reactivity within subjects during active coping (reaction time task) and passive coping (cold pressor and pornographic movie) provided further evidence that CV reactivity is proportional to the amount of effort expended.

Perhaps the most interesting results occurred between the groups assigned either the easy, difficult, or impossible condition. The addition of multiple levels of difficulty was an important extension of the traditional control/no control paradigm and revealed an important interaction. While all groups had initial elevations in CV measures, the easy and impossible groups showed the greatest attenuation over trials in SBP, HR, and dP/dt. It seemed that when success was either definite or impossible, individuals put forth relatively little effort.

Intensity of Motivation

The second central proposition of Wright’s analysis was taken from a theory of motivation intensity proposed by Brehm (e.g., Brehm & Self, 1989). In contrast to conventional motivation views, this theory proposes that momentary effort (i.e., effort exerted at a point in time) is not determined directly by success importance, or the benefit contingent on success. Rather, it proposed that such effort is determined by the perceived
difficulty of instrumental behavior, that is, the difficulty of behavior required to satisfy
the motive that has been activated. If success is easy, then low effort should be exerted
regardless of the importance of success. If success is more difficult, then more effort
should be exerted, up to one of two difficulty points. One difficulty point is that at which
success requires more effort than is justified. The other is the point at which success is
viewed as impossible. At and beyond these points, effort is expected to be low. Thus,
the theory suggests that effort should be non-monotonically related to difficulty, first ris-
ing then falling precipitously.

The upper limit of what people will be willing to do – termed the level of poten-
tial motivation - is thought to be determined by perceived success importance. Success
importance, in turn, is believed to be a function of at least three factors, (1) the need for
the available incentive, (2) the value of the incentive, and (3) the perceived likelihood
that the incentive will be attained if the required behavior is carried out (i.e., outcome ex-
pectancy). Figure 1 depicts the proposed relation between difficulty and effort in the case
where effort plunges at a certain difficulty level because effort requirements are exces-
sive.

In combination with Obrist’s active coping hypothesis, Brehm’s theory has a vari-
ety of important implications. One is that CV responsiveness should bear a non-linear
relation to challenge difficulty. This is supported not only by the Obrist studies dis-
cussed above, but by other studies that have examined difficulty influence on CV re-
response. An example is a study by Wright, Contrada, and Patane (1986), which examined
anticipatory CV responses to easy, hard, or impossible conditions of a memory task.
Those in the impossible condition were informed prior to beginning that most people
failed the task. Those in the hard condition had the highest levels of change in SBP. Another example is a study by Light and Obrist (1983). Participants engaged in a reaction time task with an easy, hard, or impossible criterion. Those in the impossible condition had lower levels of CV responses than either the easy or hard condition.

Figure 1. Effort increases as the difficulty of the task becomes harder, until task demands become so great that effort is withdrawn.
An additional implication of Brehm’s theory is that success importance should interact with the difficulty of possible challenges to determine CV responsiveness. So long as importance is high enough to justify effort requirements, effort and associated CV responses should be proportional to difficulty. However, if importance is not high enough to justify effort requirements, then effort and associated CV responses should be low (Figure 2). Support for this implication comes from a study by Waldstein, Bachen, and

![Diagram showing the relationship between effort and difficulty with benefit levels](image)

Figure 2. A higher benefit increases the level of potential motivation. Consequently an individual receiving a high incentive will attempt tasks of greater difficulty than those receiving a moderate incentive. Effort increases as the difficulty of the task becomes harder, until task demands become so great that effort is withdrawn.
Manuck (1997). Half of the participants were offered a monetary reward for successful completion of the Stroop and a mirror tracing task; the other half were offered no reward. CV responses, especially SBP and DBP, were highly elevated for the incentive group compared to the no incentive group. An incentive provided justification for exerting the effort necessary to be successful.

Further support comes from a study that examined the effects of high and low incentive when varying levels of difficulty were incorporated (Eubanks, Wright, & Williams, 2002). Participants were offered chances to win either a $100 prize or $10 prize and were presented with tasks of increasing difficulty. Incentive was found to have a moderating effect on the relationship between difficulty and HR reactivity. When incentive value was high, HR rose steadily with difficulty. In contrast, if incentive was low HR rose with difficulty up to a point and then dropped. A higher incentive raised the level of potential motivation, making individuals more likely to attempt a difficult task.

**Effects of Perceived Ability**

The extension proposition of Wright’s integrative analysis is predicated on a simple assumption: people with low perceived ability with regard to a given challenge should view the challenge as more difficult than people with high perceived ability with regard to the challenge (Gendolla & Wright, 2005; Wright, 1996, 1998; Wright et al., 2007; Wright & Franklin, 2004; Wright & Kirby, 2001). If this is true, an implication is that low ability people should expend more effort than the high ability people so long as they view success as possible and worthwhile. A further implication is that the low abil-
ity people should withhold effort at a lower level of difficulty than the high ability people, because they should conclude at a lower difficulty level that success is too difficult or impossible. This means there should be a range of difficulty levels at which effort should be greater for the high- than low ability people. If difficulty is high enough, even the high ability people should withhold effort. At and beyond this point, there should be no correspondence between ability perception and effort. The reason is because effort should be minimal for both groups. Relations between effort and difficulty for people with low- and high ability perception are depicted in Figure 3.

Evidence for the ability perception implications above comes chiefly from two sources. One is studies that have examined CV responses in low- and high ability participants confronted with more and less difficult challenges. Illustrative of these is an experiment by Wright and Dill (1993). Participants were informed that they performed poorly (low ability) or superior (high ability) compared to others on a visual scanning task. They were then asked to meet either a high or low performance standard on a similar visual scanning task. Results were in accordance with theory expectations. Those placed in the low ability condition had elevated SBP reactivity during a low performance standard task compared to the participants in the high ability condition. During the high performance standard task, the low ability group had lower SBP reactivity compared to the high ability group.

Also illustrative is a study by Wright, Murray, Storey, and Williams (1997). Male and female participants were led to believe that either men or women excelled at a memory task in a set of experiments. When individual gender was conducive to completing the task, perceived ability was high. If gender did not match, perceived ability was low.
Figure 3. Individuals with lower ability perception engage higher levels of effort and withdraw effort sooner than those with high perceived ability. Effort increases as the difficulty of the task becomes harder, until task demands become so great that effort is withdrawn.

In the first experiment, the participants were asked to achieve either a low or high standard on the task. The pattern of SBP response varied based upon the individuals' perceived ability and the standard to be achieved. If individuals had high ability perception, SBP increased with task difficulty. Low perceived ability individuals’ SBP responses were relatively high on the low standard task due to increased effort to complete the task. SBP response was relatively low during high standard tasks because effort was with-
drawn sooner than in the high perceived ability group. In a second experiment, an extremely high standard was added. Results were similar to the first experiment with the addition of both low ability and high ability groups having relatively low SBP response for the extremely high standard condition.

The other main source of evidence for the ability perception implications is a series of studies by Gendolla and colleagues concerned with mood influence on effort related CV responses. These studies are relevant because they assume that mood impacts effort and associated CV responses by impacting ability appraisals. Specifically, they assume that people in a good mood tend to have higher ability appraisals than people in a bad mood. Accordingly, they predict the same relations between mood and CV responsiveness as Wright predicts between ability perception and CV responsiveness.

Typical of the mood studies is an experiment by Gendolla and Krüsken (2002), which asked individuals to recall and describe in a written essay either a positive or a negative event immediately preceding an easy, difficult, or very difficult memory task. Increased CV reactivity was found in the negative mood group during the easy task. In contrast, higher CV reactivity was found in the positive mood group during the difficult task. No effect was found for mood on the very difficult task, presumably because both mood groups withheld effort. In essence, negative affect decreased ability perception, while positive affect increased ability perception having the expected effects on effort and associated CV responses.
Fatigue, Effort, and Cardiovascular Response

Very recently, Wright and his co-workers have begun to explore the impact of fatigue on effort-related CV responses. Studies addressing this issue have assumed that fatigue diminishes ability with respect to relevant challenges and, accordingly, should combine with difficulty and success importance to determine effort and CV responsiveness. More specifically, the studies assume three things. First, effort and CV responsiveness should be greater for high- than low fatigue people so long as high fatigue people view success as possible and worthwhile. Second, high fatigued people should withhold effort at a lower difficulty level than low fatigue people; as a consequence, they should display less CV responsiveness than low fatigue people across a certain range of difficulty levels. Third, even low fatigue people should withhold effort if difficulty is high enough. At and beyond this difficulty level, CV responsiveness should be low and equivalent for low- and high fatigue groups.

To date, five studies have examined these propositions. The earliest (Wright & Penacerrada, 2002) examined the effects of physical fatigue. Participants were asked to make multiple grips on a hand dynamometer every 5 seconds over a period of 1 minute. One group was asked to barely move the recording needle (low fatigue); the other was asked to make their maximum grip strength each time (high fatigue). Equal numbers of participants used either their right or left hand. Following the fatigue inducing period, participants were asked to hold a grip with their right hand equal to half of their initial maximum grip strength. Results of this study were in line with the theory. Participants in the high fatigue group who used their right hand during the fatigue trial had significantly
elevated SBP reactivity compared to participants in the low fatigue group and those who used their left hand during the fatigue trial.

A second study tested whether similar effects might be observed with mental fatigue. Wright, Martin, and Bland (2003) asked participants to either count forward by ones (low fatigue) or count backwards from 375 by threes (high fatigue). Those in the high fatigue group demonstrated elevated CV reactivity compared to the low fatigue group during the counting task. Following the fatigue task, participants were asked to complete some arithmetic problems and achieve either an easy (30th percentile) or difficult (80th percentile) standard. Overall, results during this period were consistent with expectations based upon the theory. Participants in the low fatigue condition tended to have greater CV reactivity during the difficult second task rather than the easy second task. Participants in the high fatigue condition tended to have higher CV reactivity during the easy second task as compared to the difficult second task. In other words, if individuals were fatigued, they tended to withdraw effort at a lower level of difficulty than a non-fatigued individual. Fatigued individuals also tended to put forth more effort at lower levels of difficulty compared to non-fatigued individuals.

The remaining studies were conducted to replicate the mental fatigue effects found in the previous study and to examine whether mental fatigue effects are domain specific (Wright et al., 2007), that is, limited to performance domains relevant to the initial fatiguing activity. The first of these manipulated fatigue by having participants perform initially either an easy or hard counting task. It examined fatigue influence by measuring CV responses to a subsequent challenge that was highly relevant to the initial challenge (mental arithmetic) or mildly relevant to the initial challenge (visual scanning).
under conditions where participants could avoid a noise by meeting a moderate performance standard. The second experiment involved a highly similar procedure; however, it offered an attractive incentive and raised the performance standard on the follow-up challenge from moderate to high. The third experiment manipulated fatigue by presenting participants initially with a visual scanning task that was low or high in inhibitory demand. It evaluated fatigue influence by assessing CV responses to a subsequent challenge with a strong inhibitory component (a version of the classic Stroop test) or a minimal inhibitory component (an arithmetic task). Central findings were twofold. First, the previous mental fatigue results replicated. Second, there was no evidence that mental fatigue influence is performance domain specific. CV fatigue effects were observed regardless of whether follow-up challenges were highly relevant or mildly relevant to the activity that instigated the fatigue.

Present Research

The fatigue studies conducted to date provide a foundation of empirical support for fatigue implications of Wright’s integrative analysis. However, they have several limitations of note. One limitation is that the studies do not include exceptionally high difficulty levels and thus do not address the suggestion that effort and CV responsiveness should be low for low- and high fatigue groups if difficulty is extreme. Another limitation is that the studies do not include manipulations of success importance. This is of concern because the integrative analysis implies that so long as success is viewed as possible, the peak of the effort function for low- and high fatigue groups should depend on success importance, being higher when importance is high. A third limitation is that the
studies involved short-term laboratory manipulations of fatigue. As a result, they are vulnerable to criticism that they may tell us little about the effects of more profound and extended fatigue experienced in real world settings.

Broad purposes of my dissertation research were to obtain additional evidence relevant to the fatigue implications of Wright’s analysis and address the first and third limitations of previous studies conducted to evaluate those implications. The proposed experiment addressed the first limitation by examining fatigue influence across four difficulty levels, ranging from easy to impossible. It addressed the third limitation by examining fatigue influence quasi-experimentally, comparing CV responses of individuals scoring low- and high on a fatigue questionnaire completed prior to the experimental session. Participants were presented four auditory mental addition tasks of increasing difficulty. Difficulty was manipulated by presenting numbers at an increasing rate and range of values. An incentive of $2 was offered for successful performances, to ensure a higher level of potential motivation than if no incentive was offered. CV measures were recorded at baseline and during each mental addition task period. SBP was the primary CV measure used for analyses, although DBP and HR data were also analyzed.

The fatigue reasoning discussed previously suggested that fatigue impact should vary dramatically depending on the difficulty of the challenge with which participants are confronted. For both low- and high fatigue groups, CV responsiveness should rise with difficulty to a point, and then fall sharply. However, CV responsiveness should be greater for high- than low fatigue participants so long as success appears possible and worthwhile. In addition, they should be greater for low- than high fatigue participants
where success appears possible and worthwhile to the former group, but not the latter.

The specific pattern predicted for CV responses is depicted in Table 1.

Secondary hypotheses included ones related to self-reported effort and determining the appropriateness of the fatigue, difficulty, and incentive manipulations. Self-reported effort was expected to follow a pattern similar to that presented in Table 1 insofar as effort reports corresponded to actual effort levels. The Fatigue groups were expected to differ on fatigue-related items presented in a pre-task affect checklist. Self-reported difficulty of task and the amount of effort required to succeed on it were expected to increase with objective task difficulty and be higher for High- than Low Fatigue participants.

Table 1

Predictions for perceived expended effort and associated CV responses

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<tr>
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<th>Low Fatigue</th>
<th>High Fatigue</th>
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<tr>
<td>Easy</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Hard</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Impossible</td>
<td>Low</td>
<td>Low</td>
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CHAPTER 2

METHOD

Overview

Student volunteers ($N = 108$) who reported relatively great (High Fatigue) or relatively little (Low Fatigue) fatigue at the beginning of the academic term were invited to the lab and presented four versions of a cumulative mental addition task. All task versions required participants to add a series of numbers and report the sum of the numbers at the end of the work period. However, the presentation pace and specific numbers to be added (addends) made the first version easy, the second more difficult, the third more difficult still, and the fourth impossibly difficult. All participants were offered $2 for each sum they provided that was correct. Thus, the experimental design was a 4 (Easy, Moderate, Difficult, Impossible) x 2 (High Fatigue, Low Fatigue) repeated measures in which difficulty was the within-subjects factor and CV response was the dependent variable. CV responses were recorded during a preliminary baseline period and during each of the mental addition task periods. CV response during the task periods was operationalized as change from baseline.

Participants

Participants ($N = 108$) were undergraduate volunteers from the Psychology 101 participant pool at the University of Alabama at Birmingham. They received class credit for participating. In mass screening sessions, students were administered a questionnaire
packet including demographic and fatigue questionnaires. Students scoring in the upper (High Fatigue) and lower (Low Fatigue) quartiles of the fatigue distribution were randomly selected to be invited to return to participate in the study proper. Nine individuals were excluded from the study prior to data analysis for at least one of the following reasons: 1) failure of Vasotrac to accurately record CV data (repeated CV data on more than two consecutive data points) due to either participant movement or monitor misplacement; 2) the participant asking to discontinue the experiment; 3) the participant cheated (writing numbers down) or was engaged in another task during the experiment; 4) the participant did not appear to understand the tasks during any point of the experiment; and/or 5) the participant revealed having strong suspicions of deception in psychological experiments. The majority of individuals were excluded due to repeated CV data (n=7). The final group consisted of 50 High Fatigue volunteers (mean age=21.62) and 49 Low Fatigue volunteers (mean age=21.82). Demographic data for these participants are available in Table 2. Fatigue groups were unevenly distributed by gender with more males being present in the Low Fatigue group than the High Fatigue group, \( \text{Mann-Whitney } U = 838.5, \ p = .001 \). Follow-up analysis indicated that male-female frequencies were relatively equal for the Low Fatigue group (\( \chi^2 = .320, \ p = .572 \)), but disproportionate for the High Fatigue group (\( \chi^2 = 14.878, \ p < .001 \)). Analyses indicated that fatigue groups were not disproportionate with respect to black-white frequencies. Preliminary ANOVAs on the main CV response data that included gender and race as factors yielded no effects for the factors. Findings from these are presented in Appendix G.

To address the problem of movement artifact, I excluded outliers from final CV response analyses, defining outliers as change values that deviated 2 or more standard
deviations from the mean of their fatigue group. This resulted in the loss of 11 data points for SBP, 13 data points for DBP, and 14 data points for HR. Other less stringent degrees of SD criterion were considered and evaluated empirically (±2.5 SDs and ±3 SDs). These yielded no change in the significance of central effects, but greater error, and thus were rejected. Data from 12 individuals from the Low Fatigue group and 13 individuals from the High Fatigue group were excluded from at least one analysis. Data from five individuals from the Low Fatigue group and six individuals from the High Fatigue group were excluded from two or more analyses. I elected not to exclude all CV data for participants who had at least one outlying CV change score, because this would have resulted in the loss of CV data from an unacceptably high number of participants. The pattern of dropped cases is presented in Table 3.
Table 3
Excluded Data

<table>
<thead>
<tr>
<th></th>
<th>Low Fatigue</th>
<th>High Fatigue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n$</td>
<td>$n$</td>
</tr>
<tr>
<td>SBP</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>DBP</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>HR</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>SBP &amp; DBP</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>SBP &amp; HR</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>DBP &amp; HR</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>ALL</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Materials

*Identification sheet and Demographic Questionnaire*

The identification sheet was included as part of the screening packet (see Appendix A). It asked the respondent to write their full name and phone number. This information was requested for two reasons, (1) to give respondents course credit for participating, and (2) to allow us to contact respondents if they met inclusion criteria for the experiment. An identification number was stamped on the sheet so that the respondents’ responses and classification as High Fatigue or Low Fatigue were not directly associated
with their name and contact information. The demographic questionnaire asked participants to report their age, class status, gender, race, ethnicity, and handedness. It is available in Appendix A for review.

*Modified Fatigue Severity Scale*

Chronic fatigue was assessed with a modified version of the Fatigue Severity Scale (FSS). The FSS was originally designed to measure fatigue in patients diagnosed with multiple sclerosis and lupus (Krupp, LaRocca, Muir, & Steinberg, 1990; Krupp, LaRocca, Muir-Nash, & Steinberg, 1989), and has been used extensively for this purpose (Austin, Maisiak, Macrina, & Heck, 1996; Bakshi et al., 2000; Barak & Achiron, 2006; Chipchase, Lincoln, & Radford, 2003; Gladman, Urowitz, Ong, Gough, & MacKinnon, 1996; Heesen et al., 2006; Lobentanz et al., 2004; Miller & Dishon, 2006; Moller, Wiedemann, Rohde, Backmund, & Sonntag 1994; Omdal, Mellgren, Koldingsnes, Jacobsen, & Husby 2002; Petri et al., 2004; Romani et al. 2004; Stanton, Barnes, & Silber, 2006; Tartaglia et al. 2004; Tellez et al., 2006; Yozbatiran, Baskurt, Baskurt, Ozakbas, & Idiman, 2006). The measure also has been used to measure fatigue in other populations. Included among them are populations comprised of people afflicted with sleep disorders (Hossain et al., 2005; Lichstein, Means, Noe, & Aguillard, 1997;), Hepatitis C (Arora et al., 2006; Kleinman et al., 2000), stroke (Schepers, Visser-Meily, Ketelaar, & Lindeman, 2006), Guillain-Barre syndrome (Garssen et al., 2006), obesity (Grieve, Harris, & Fairbanks, 2000), traumatic brain injury (LaChapelle & Finlayson, 1998; Zino & Ponsford, 2006), Parkinson’s disease (Alves, Wentzel-Larsen, & Larsen 2004; Ondo, Fayle, Atassi, & Jankovic, 2005), seasonal affective disorder (Lundt, 2004), cancer
(Stone, Hardy, Huddart, A'Hern, & Richards, 2000; Stone, Richards, A'Hern, & Hardy, 2000, 2001; Winstead, 1998), and epilepsy (Soyeur, Erdoğan, Şenole, & Arman, 2006). Also included are populations comprised of people engaged in shift work (Hossain, Reinish, Kayumov, Bhuiya, & Shapiro, 2003; Shen, Botly, Chung, Gibbs, & Sabanadzovic, 2006), recovering from tissue transplantation surgery (Berg-Emons et al., 2006), and caring for chronically ill patients (Schneider, 2004).

Although the FSS has been used extensively and endorsed as a fatigue index (Buysse, Ancoli-Israel, Edinger, Lichstein, & Morin, 2006), it is problematical in one important respect. Specifically, it focuses on physical aspects of fatigue and ignores mental aspects of the state (Appendix B). This is of concern because fatigue can be – and, in the context of the present research, is – conceived broadly as involving not only somatic components, but also cognitive ones. In the modified version of the FSS used here, items referring to physical fatigue were either eliminated or modified so that they refer to fatigue in general (Appendix A). The modified version of the FSS also (1) included expanded instructions, (2) included a more engaging visual display and verbal anchors, and (3) omitted an item concerned with fatigue influence on motivation. Like items from the original FSS, items from the modified FSS are scored from 1 to 7, yielding a total score ranging from 7 to 49.

A study was conducted to assess the validity and reliability of the modified FSS in an undergraduate sample (N = 715). The modified FSS was compared to a modified version of the Insomnia Severity Index (ISI; Appendix A; Appendix B) a measure of sleep disorder severity (Morin, 1993). Basic descriptive statistics, including quartiles, were calculated for individual items and total scores for the modified FSS and ISI and are pre-
sented in Appendix E. Total FSS score ($M = 21.02, SD = 9.21$) and total ISI score ($M = 14.24, SD = 5.25$) had a Pearson’s $r$ of $.51$ ($p < .001$), indicating that while the FSS and ISI do evaluate domains with overlapping characteristics they are indeed separate. An exploratory principle components analysis, entering all seven items of each measure, with Promax rotation revealed two distinct components. The first was defined by all 7 items of the FSS (47.79% of variance explained); the second defined by all 7 items of the ISI (15.65% of variance explained); with the total solution explaining 63.44% of the variance. Cronbach’s $\alpha$ was also very good for the modified FSS (Cronbach’s $\alpha = .92$) indicating good internal reliability. Upper and lower quartiles were calculated for total modified FSS scores to determine potential participation criteria (High Fatigue, FSS $\geq 28$; Low Fatigue, FSS $\leq 14$).

**Auditory Mental Addition**

Different versions of the cumulative mental addition task were constructed using the Paced Auditory Serialized Attention Task (PASAT) computer program (Brainmetric Software) and the freeware program Audacity. All versions lasted approximately two minutes and fifty seconds and required participants to add mentally (i.e., without benefit of a writing instrument or calculator) a series of numbers presented to them, reporting the sum of the numbers at the end of the work period. Difficulty was varied through adjustment of two task parameters, (1) the latency in seconds between each addend, and (2) the numbers used for the addends. In the easy condition, addends were 1 and presented at 5-second intervals. In the moderate condition, addends ranged between 1 and 9 and were presented at the same 5-second intervals. In the hard condition, addends ranged between
1 and 9 and were presented at 2-second intervals. In the impossible condition, addends ranged between 1 and 9 and presented without pause. Each number was presented verbally within a one second time window. Task versions were converted into .wav files for presentation via speakers placed within the testing area. All participants received the same series of numbers for each task period; numbers were not randomly generated for each participant. Task periods were presented in a fixed order beginning with easy, followed by moderate, then hard, and finally impossible. This particular order was chosen due to the natural order of the presentation (increasing difficulty) and to reduce fatigue effects.

Participants were instructed to add the numbers mentally to obtain a final sum and to put forth as much or as little effort as they wished for each set. They also were informed that the pace and addend procedure would be consistent within each task period (i.e., each task version). At the beginning of each task period, the participants heard, “Start Set (A, B, C, or D)”. Number presentations began 3-seconds later. At the end of each task period, the participants heard “End Set (A, B, C, or D)”. Each task period, including the start and end cues, lasted approximately 180 seconds. Participants were instructed to sit quietly during the periods. At the end of the periods, participants wrote down their sum on a sheet of paper and responded to questions concerning their perceived expended effort, perceived task difficulty, and perceived level of effort required for success.
Preliminary Affect Questionnaire

A questionnaire was administered at the beginning of each session to measure baseline affective fatigue relevant to the study. It asked participants to rate on 11-point scales (0 = not at all, 10 = extremely) the extent to which they felt refreshed, weary, lively, full-of-pep, fatigued, rejuvenated, burnt-out, and tired (Appendix D). A total affective fatigue score was obtained by subtracting the average of positive items (refreshed, lively, full-of-pep, rejuvenated) from the average of negative items (weary, fatigued, tired, and burnt-out). Thus a higher value indicates feeling more fatigued while a lower value indicates feeling less fatigued. These items were drawn from the “Tired” subscale of Thayer’s Activation-Deactivation Adjective Check List (Thayer, 1986) or were identified as being near synonyms or antonyms of “fatigue”. They were included to provide evidence relevant to the assumption that fatigue would be greater among High Fatigue participants at the outset of the experimental session. The non-fatigue items included in the questionnaire served as distractors.

Post-Task Questionnaires

Questionnaires also were administered after the task periods (Appendix D). These began by asking participants to write down the sum of the numbers that were presented in the preceding task period. Participants then rated on 11-point scales (1) perceived task difficulty (0 = not at all, 10 = extremely), (2) perceived effort exerted (0 = very little, 10 = very much), and (3) perceived effort required to be successful (0 = very little, 10 = very much). These questions were to provide evidence that the individual counting tasks were of appropriate difficulty and to examine perceived ability.
**CV Parameters and Their Measurement**

CV measures collected were SBP, DBP, and HR; however, SBP was the measure of primary interest. SBP received special attention because it is believed to bear an especially close relationship to SNS activation (Obrist, 1981; Obrist et al., 1978). CV measures were recorded at 20-second intervals during each counting task (eight data points) with a non-invasive Vasotrac (APM205A) automatic monitor manufactured by Medwave. The Vasotrac made assessments painlessly from the radial artery using a wrist cuff with an embedded sensor. No manual calibration was required and sensors were changed on a regular basis. Values obtained with the monitor have been found to be accurate and reliable ($r = .97$) when compared with invasive arterial line readings (Medwave, 2002). In a convenience sample of adults with indwelling catheters ($n = 15$), there was no significant difference between MAP readings obtained via the catheter and the Vasotrac, $r = .95$ (Thomas, Winsor, Pang, Driscoll, & Parry, 2004). A separate study comparing results obtained by indwelling catheters and the Vasotrac in adults ($n=80$), correlations between the Vasotrac and the catheter were very high: SBP $r^2 = .93$; DBP $r^2 = .89$; MAP $r^2 = .95$; HR $r^2 = .95$ (Belani et al. 1999).

**Procedure**

The study was carried out by three separate investigators who played different roles throughout the experiment. The roles were: One (the scheduler) who was aware of participants’ fatigue status and one (the experimenter) who was not aware of this. The scheduler had two primary responsibilities. One was to contact qualified participants, set
up participation appointments for them, and make reminder calls the day before the participants’ appointments. The other was to ensure that cell ns were relatively equal for the fatigue groups. The experimenter had the responsibility of running participants through the experimental protocol. This dual investigator procedure was employed to avoid experimenter expectancy effects.

When participants arrived for their appointment, they were greeted by the experimenter, escorted into the testing room, and seated at a table (Appendix C). On the table was an intercom with a “CALL” button and two copies of an informed consent statement, one copy for the participants and one for the investigator (Appendix F). The experimenter (1) provided orally a study overview, (2) invited participants to read carefully the consent form and sign the copies of it, and (3) exited to a control room so the participants could read and make their participation decision in private.

*Cardiovascular Baseline*

Once informed consent was obtained, the experimenter attached the Vasotrac cuff to participants’ non-dominant wrist and began recording baseline CV data. The experimenter allowed the Vasotrac to sample continuously (i.e., at intervals of approximately 15 seconds) during an eight minute baseline period. Note that the Vasotrac monitor did not require arterial occlusion via an inflating cuff, which allowed for pain free sampling at relatively brief intervals. Six minutes into the baseline, the experimenter began actually recording CV samples at 20 second intervals. This procedure yielded eight baseline values for each CV parameter (values for 6:00, 6:20, 6:40, 7:00, 7:20, 7:40, 8:00, and 8:20). Baseline for each CV parameter was taken as the average of the eight baseline
values. Measurements were taken from the control room and while participants were relaxing, with the option of browsing through popular magazines that the experimenter made available. Occasionally, the monitor experienced an error and did not record CV values correctly. During those instances, the baseline recording was stopped, the monitor adjusted, and the 8-minute recording period started over again.

Affect Baseline, Instructions, and Task Periods

Following the CV baseline period, the experimenter returned to the testing room with an envelope containing the baseline affect checklist. The experimenter first presented the envelope to participants and asked the participants to report on the sheet inside their current feelings, replacing the sheet in the envelope when they had done so. The experimenter then returned to the control room. Participants pressed the CALL button on the intercom when they were finished. At this point, the experimenter brought to the testing room five envelopes. One was marked “INSTRUCTIONS” and contained instruction pages that conveyed details about the experimental procedure, including details about the incentive that was available (Appendix D). The other envelopes were marked “QUESTIONNAIRE - SET A”, “QUESTIONNAIRE - SET B”, “QUESTIONNAIRE - SET C”, and “QUESTIONNAIRE - SET D”. They contained the post-task questionnaires to be administered after the task periods. The experimenter (1) placed the envelopes on the table, (2) directed participants to take out and read carefully material in the INSTRUCTIONS envelope, (3) directed participants to press CALL when they were ready to begin the first task period, and then (4) returned to the control room.
Participants pressed CALL when they were ready. The experimenter told them over an intercom system that in approximately 30 seconds they would be presented their first series of numbers and that they should add them mentally. After delivering this instruction, the experimenter cued the Vasotrac to begin recording CV data and waited until 30 seconds had passed. The 30 second time period was necessary for the Vasotrac to obtain an initial reading, but was not recorded as a data point. In some instances the monitor did not properly record any CV data. For those times, the experimenter readjusted the strap and ran the monitor until a valid reading was obtained. The experimenter then played the appropriate .wav file to begin the first number set. Participants listened and added for approximately two minutes and 50 seconds while the experimenter took CV samples, sampling every 20 seconds (eight data points), beginning 20 seconds into the period. The extra 10 seconds were included to ensure that CV sampling was completed during the task. When the first task period was over, the experimenter asked participants to open the QUESTIONNAIRE - SET A envelope, complete the questionnaire inside, and press CALL when they were finished. Upon hearing the CALL signal, the experimenter told participants that there would be a 3-minute rest period during which they should sit quietly, but feel free to look through the magazines provided. Following this 3-minute period the experimenter told the participants that in approximately 30 seconds they would be presented their second series of numbers and that they should add them mentally. The experimenter again, started the Vasotrac and waited until 30 seconds elapsed before beginning the task period. CV samples were recorded at 20 second intervals, beginning at 20 seconds into the period. At the end of the period, the experimenter asked participants to open the QUESTIONNAIRE - SET B envelope and complete the
questionnaire inside. Participants pressed CALL when they completed the set B questionnaire and the same procedural cycle continued through the end of the fourth (impossible) task period. Task periods were presented in the following fixed order: easy, moderate, hard, and impossible.

Once all task periods were completed, the experimenter returned to the testing room and debriefed the participants, probing for confusion and suspicion and answering questions participants had. Only one participant reported having unusual concerns about the study, such as being tricked or possibly being shocked. The majority of participants voiced some knowledge of deception in experiments, but no significant concerns. Toward the end of the debriefing period, the experimenter asked participants if they wanted their “sum” responses to be scored for payment. If participants indicated “yes”, the experimenter identified the number of correct responses and paid participants according to the incentive plan. If participants indicated “no”, the experimenter was to not score the sum responses unless the participants requested them to do so. Interestingly, a few participants indicated that they did not want the monetary incentive, but all participants wished to know if their responses were correct. The experimenter provided all participants PY 101 research credit prior to the point of dismissing them.

Analyses

Baseline Analyses

A one-way ANOVA (High Fatigue vs. Low Fatigue) was performed on the baseline CV measures to determine if there were any significant differences between the groups at rest.
**Work Period Analyses**

CV reactivity during the work periods was defined as the change from baseline. Change scores were calculated by subtracting the mean baseline score from the mean of scores obtained during each work period. Four (difficulty) x 2 (fatigue) mixed design ANOVAs were conducted on the change scores, with difficulty as a repeated measures factor. At least for SBP, it was expected that there would be a two-way interaction consistent with prior findings. Follow-up t-tests were used to decompose interactions.

An estimated power analysis for the 4 x 2 mixed design was conducted using G*Power (Buchner, Erdfelder, & Faul, 1997; Erdfelder, Faul, & Buchner, 1996; Faul & Erdfelder, 1992) to determine if the total sample size would be adequate. This analysis was an estimate for two reasons. First, differences of CV reactivity experienced during mental tasks between identified groups of High and Low Fatigue have not been examined previously. Second, the tasks used in this experiment were constructed specifically for this experiment and no data are available from previous studies to calculate an effect size or provide a population correlation between levels of difficulty. A moderate effect size ($f^2 = .0625$) was used to calculate the between subject effects (fatigue), within subject effects, and the fatigue x difficulty interaction. Predicted power for the between subject effect was very good with a proposed sample size of 100 and an estimated correlation of $r = .5$ between the difficulty levels ($1-\beta=.8792$). If the assumption of sphericity was met, for the within subject effect the predicted power was perfect, $1-\beta=1.0$. This was the case with the interaction as well. The assumption of sphericity over multiple time periods is notoriously difficult to satisfy. Therefore it was not likely that the assumption would be
met. If not met, predicted power would decrease for the within-subjects and interaction effects, but would still be very high. Using the most conservative estimate for \( \varepsilon (\varepsilon=1/3) \), the estimated within-subjects effect power and power for the interaction were both \( 1-\beta=0.9813 \).

**Subjective Measures**

A one-way ANOVA (High Fatigue vs. Low Fatigue) was conducted on the affective fatigue score provided by the participants at baseline. This analysis provided a manipulation check on the suitability of the participants for this study. It was expected that High Fatigue groups would indicate experiencing significantly higher levels of fatigue-related feelings.

Four (difficulty) x 2 (fatigue) mixed-measures ANOVAs were conducted on the participants’ responses to the perceived task difficulty and perceived effort required for success items in the post-task questionnaire. This check ensured that the different tasks were of an appropriate level of difficulty. Expectations were that there should be a main effect for difficulty.

A 4 (difficulty) x 2 (fatigue) mixed-measures ANOVA was conducted on the responses to the perceived effort exerted item from the post-task questionnaire. Findings were expected to resemble the pattern of predictions presented in Table 1.

While having multiple dependent variables did increase the risk of overall Type I error, Huberty and Morris (1989) suggest that multiple ANOVAs are appropriate in this case. Most of these analyses were conducted to ensure that the levels of independent variables or manipulations were appropriately selected, thereby providing useful informa-
tion if the pattern of CV results was not consistent with expectations. Huberty and Morris also suggest using multiple univariate analyses when this has been standard for prior research, which was also the case for this research. In this experiment each DV was considered to belong to a different set or family of hypotheses which also supported the use of multiple ANOVAs.
CHAPTER 4

RESULTS

Post-Task Self Report of Difficulty

One implication of Wright’s integrative analysis is that an individual’s perception of task difficulty should be determined by the character (objective difficulty) of a task and the individual’s perception of ability with respect to that task. In this experiment, it was expected that High Fatigue (i.e., low ability) participants would perceive tasks as being more difficult than Low Fatigue (i.e., high ability) participants. In addition, it was expected that all participants would view the tasks as increasingly difficult the more demanding they were objectively.

Difficulty perception was assessed through the post-task questionnaire items that asked participants to rate on 11-point scales the difficulty of their task (0 = Not at all; 10 = Extremely) and the effort that would be required to succeed consistently on it (0 = Very little; 10 = Very much). Responses to these items were highly correlated ($r = .80$) and in a similar pattern across experimental conditions. Consequently, they were combined to form a single difficulty index (Table 3). A 4 (difficulty) x 2 (fatigue) mixed design ANOVA was performed on the data, with task difficulty as the repeated variable and fatigue as the between subjects variable. Although there were violations of sphericity, corrections to $df$ led to no changes in significance. Consequently, for the sake of simplicity, no corrections were made to $df$. Significant effects were obtained for difficulty, $F (3, 91) = 653.13, p < .0001$, and fatigue, $F (1, 97) = 4.37, p = .04$. The difficulty * fatigue inter-
Table 4

Post-task self report of difficulty

<table>
<thead>
<tr>
<th>Task Difficulty</th>
<th>Low Fatigue</th>
<th></th>
<th>High Fatigue</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Easy</td>
<td>Mod</td>
<td>Hard</td>
<td>Imp</td>
</tr>
<tr>
<td>PD M</td>
<td>.76</td>
<td>3.10</td>
<td>6.40</td>
<td>9.38</td>
</tr>
<tr>
<td>SE</td>
<td>.22</td>
<td>.28</td>
<td>.30</td>
<td>.17</td>
</tr>
<tr>
<td>PER M</td>
<td>3.00</td>
<td>4.84</td>
<td>7.56</td>
<td>9.44</td>
</tr>
<tr>
<td>SE</td>
<td>.41</td>
<td>.39</td>
<td>.30</td>
<td>.20</td>
</tr>
<tr>
<td>COM M</td>
<td>1.88</td>
<td>3.97</td>
<td>6.98</td>
<td>9.41</td>
</tr>
<tr>
<td>SE</td>
<td>.27</td>
<td>.31</td>
<td>.29</td>
<td>.16</td>
</tr>
</tbody>
</table>

Note. PD= perceived difficulty; PER= perceived effort required for success; COM= combined perceived difficulty/perceived effort required for success; Mod=Moderate; Imp=Impossible. Low Fatigue n= 50; High Fatigue n= 49.

action approached, but did not attain significance F (3, 291) = 2.02, p = .11. The difficulty effect reflected steadily increasing values from the easy- to the impossible condition. Pair-wise comparisons indicated that values were higher in the moderate condition than in the easy condition, higher in the hard condition than in the moderate condition, and higher in the impossible condition than in the hard condition (ts≥11.67, ps<.0001).

The fatigue effect reflected higher values for High Fatigue participants.

Fatigue Self Report

A self-report fatigue scale was administered immediately prior to the baseline period to document that the fatigue groups differed in fatigue at the time they arrived. Participants indicated on 11-point scales (0 = not all; 10 = extremely) the degree to which
they felt fatigued, tired, weary, burnt-out (forward scored items); lively, full-of-pep, refreshed, and rejuvenated (reverse scored items). Tables 4 and 5 contain (1) mean responses to each item, and (2) the Pearson correlation coefficients among the fatigue items for the overall sample.

Table 5

Self-reported fatigue on day of testing

<table>
<thead>
<tr>
<th></th>
<th>Low Fatigue</th>
<th></th>
<th>High Fatigue</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatigued</td>
<td>2.60</td>
<td>.41</td>
<td>5.57</td>
<td>.42</td>
</tr>
<tr>
<td>Tired</td>
<td>4.36</td>
<td>.46</td>
<td>6.33</td>
<td>.38</td>
</tr>
<tr>
<td>Burnt-out</td>
<td>2.76</td>
<td>.42</td>
<td>4.53</td>
<td>.51</td>
</tr>
<tr>
<td>Weary</td>
<td>2.20</td>
<td>.37</td>
<td>3.45</td>
<td>.42</td>
</tr>
<tr>
<td>Lively *</td>
<td>4.96</td>
<td>.35</td>
<td>5.80</td>
<td>.32</td>
</tr>
<tr>
<td>Full-of-Pep *</td>
<td>6.50</td>
<td>.38</td>
<td>7.00</td>
<td>.38</td>
</tr>
<tr>
<td>Rejuvenated *</td>
<td>7.26</td>
<td>.38</td>
<td>7.12</td>
<td>.35</td>
</tr>
<tr>
<td>Refreshed *</td>
<td>5.48</td>
<td>.37</td>
<td>5.43</td>
<td>.34</td>
</tr>
</tbody>
</table>

Note. * reverse coded. Low Fatigue n=50; High Fatigue n= 49.
Table 6

Correlations for self-reported fatigue on day of testing

<table>
<thead>
<tr>
<th></th>
<th>Fatigued</th>
<th>Tired</th>
<th>Weary</th>
<th>Burnt-out</th>
<th>Lively</th>
<th>Rejuvenated</th>
<th>Full-of-pep</th>
<th>Refreshed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatigued</td>
<td>--</td>
<td>.79 †</td>
<td>.54 †</td>
<td>.55 †</td>
<td>.29 **</td>
<td>.33 **</td>
<td>.29 **</td>
<td>.27 **</td>
</tr>
<tr>
<td>Tired</td>
<td>.79 †</td>
<td>--</td>
<td>.56 †</td>
<td>.56 †</td>
<td>.49 †</td>
<td>.55 †</td>
<td>.44 †</td>
<td>.44 †</td>
</tr>
<tr>
<td>Weary</td>
<td>.54 †</td>
<td>.56 †</td>
<td>--</td>
<td>.49 †</td>
<td>.46 †</td>
<td>.46 †</td>
<td>.42 †</td>
<td>.41 †</td>
</tr>
<tr>
<td>Burnt-out</td>
<td>.55 †</td>
<td>.56 †</td>
<td>.49 †</td>
<td>--</td>
<td>.23 *</td>
<td>.31 **</td>
<td>.28 **</td>
<td>.31 **</td>
</tr>
<tr>
<td>Lively</td>
<td>.29 **</td>
<td>.49 †</td>
<td>.46 †</td>
<td>.23 *</td>
<td>--</td>
<td>.59 †</td>
<td>.66 †</td>
<td>.51 †</td>
</tr>
<tr>
<td>Rejuvenated</td>
<td>.33 **</td>
<td>.55 †</td>
<td>.46 †</td>
<td>.31 **</td>
<td>.59 †</td>
<td>--</td>
<td>.57 †</td>
<td>.72 †</td>
</tr>
<tr>
<td>Full-of-pep</td>
<td>.29 **</td>
<td>.44 †</td>
<td>.42 †</td>
<td>.28 **</td>
<td>.66 †</td>
<td>.57 †</td>
<td>--</td>
<td>.49 †</td>
</tr>
<tr>
<td>Refreshed</td>
<td>.27 **</td>
<td>.44 †</td>
<td>.41 †</td>
<td>.31 **</td>
<td>.51 †</td>
<td>.72 †</td>
<td>.49 †</td>
<td>--</td>
</tr>
</tbody>
</table>

Note. N= 99; * p<.05; ** p<.01; † p<.001

All of the items were significantly correlated with each other, with *r* ranging from .23 (burnt-out and lively) to .79 (fatigued and tired). Twenty-three pairs were moderately correlated or higher, while 5 pairs were toward the upper end of small correlations. The smaller correlations involved pairings of (1) the item fatigue with the items lively, full-of-pep, and refreshed; and (2) the item burnt-out with the items lively and full-of-pep. It could be argued that only the forward scored items should be used to assess levels of fatigue at the time of testing. However, when one examines the entire correlation matrix, it becomes clear that the reverse scored items have moderate to high correlations with other forward scored items and hence are important components in how an individual may ex-
press fatigue. Also, Cronbach’s $\alpha$ for the 8-item index indicated good internal reliability ($\alpha = .869$). Therefore, a composite self-reported fatigue score was calculated summing the forward and reverse scored items. A one-way ANOVA on the composite fatigue score confirmed that values were higher for High Fatigue participants ($M = 5.65, SD = 2.08$) than for Low Fatigue participants ($M = 4.52, SD = 1.89$), $F (1, 97) = 8.12, p = .005$.

A review of the means for the fatigue self-report indicated that the greatest areas of discrepancy between the two fatigue groups were their reported values for fatigued and tired. This taken into account with the very high correlation between the two items suggests that "fatigued" and "tired" represent key differences between the two groups.

Baseline Cardiovascular Data

Baseline CV values are in Table 6. One-way two-level (fatigue) ANOVAs yielded no significant effects for DBP, $F (1, 94) = 1.59, p = .21$, but did demonstrate levels approaching significance for SBP, $F (1, 96) = 3.22, p = .08$, and for HR, $F (1, 94) = 3.33, p = .07$. These reflected lower levels of SBP and higher HR in High Fatigue participants.

Work Period Data

Preliminary Analyses

A concern in developing the research procedure was how quickly participants would recognize the difficulty of their mental addition tasks. Difficulty recognition is crucial because effort and CV responsiveness can be influenced by difficulty only to the degree that performers perceive it. Where difficulty is unknown (e.g., due to lack of experience with a task), effort and associated CV responses should correspond to success.
Table 7
Baseline cardiovascular values

<table>
<thead>
<tr>
<th></th>
<th>Low Fatigue</th>
<th></th>
<th>High Fatigue</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SE</td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>SBP</td>
<td>136.4</td>
<td>1.8</td>
<td>50</td>
<td>131.7</td>
</tr>
<tr>
<td>DBP</td>
<td>77.4</td>
<td>1.1</td>
<td>49</td>
<td>75.3</td>
</tr>
<tr>
<td>HR</td>
<td>75.4</td>
<td>1.6</td>
<td>49</td>
<td>79.6</td>
</tr>
</tbody>
</table>

Note. Participants with scores that deviated ±2 SD units from their group mean were omitted.

Importance and, thus, tend to be high (e.g., Richter & Gendolla, 2006, 2007; Wright & Kirby, 2001).

Preliminary ANOVAs were performed on the CV change scores including work period half as a factor. These revealed powerful effects for half ($F_s \geq 16.80$, $p_s \leq .001$) reflecting stronger responses in the first half than in the second. For SBP and DBP, half effects were especially pronounced in the easy and impossible conditions. For HR, they were present in the easy and hard conditions, but not the moderate and impossible conditions. A possible suggestion is that participants did not fully appreciate the difficulty of their challenge early in the work periods, but came to understand it later on. With this in mind, I chose to focus on data from the second half of the work periods. Complete findings from the preliminary analyses that included half as an IV and from analyses performed on the first half data only are in Appendix F.
Second Half Responses

The broad expectation was that CV response patterns would correspond with Wright’s integrative analysis. One specific expectation was that CV responses for both fatigue groups would first rise and then fall with difficulty. A second was that CV responses would be stronger for High- than Low Fatigue participants so long as both groups remained engaged, that is, strove to meet their counting challenge. A third was that High Fatigue participants would reach their peak of CV reactivity in an earlier work period than Low Fatigue participants, most likely in the moderate difficulty condition. A fourth was that both fatigue groups would show minimal CV reactivity where calculation success was impossible. A crucial assumption was that High Fatigue participants would view success as possible and worthwhile at least where objective difficulty was low. If High Fatigue participants in fact viewed success as impossible or excessively difficult even in the easy condition, then one would expect them to evince relatively reduced CV responses in all difficulty conditions.

Means for the CV measures are in Figures 4-6. Separate 4 (difficulty) x 2 (fatigue) mixed measures ANOVAs were performed on the SBP, DBP, and HR data. Although there were violations of sphericity, no corrections were made since there was relatively little difference between results calculated with a corrected df versus results without a correction. For SBP, significant effects were found for difficulty, $F(3, 258) = 11.84, p < .0001$; fatigue, $F(1, 86) = 8.23, p = .005$, and difficulty * fatigue, $F(3, 258) = 3.27, p = .02$. The difficulty and fatigue effects reflected (1) stronger responses in each of the possible conditions than in the impossible condition ($t_s \geq 6.44, ps < .0001$), and (2) stronger responses on possible tasks for Low Fatigue participants ($t_s \geq 2.16, ps \leq .03$).
The more important interaction reflected different difficulty effects for the fatigue groups and different fatigue effects at different levels of difficulty.

Among Low Fatigue participants, responses first rose and then fell with difficulty, attaining their peak in the moderate condition (Figure 4). Among High Fatigue participants, responses began low and became increasingly diminished as difficulty increased. Pair-wise comparisons indicated that values for Low Fatigue participants tended to be higher in the moderate condition than in the easy condition, $t(258) = 1.70, p = .09$, and

Figure 4. Mean SBP response ($\pm SE$) for Low Fatigue ($n = 44$) and High Fatigue ($n = 44$) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated $\pm 2 \, SD$ units from their group mean at any level of difficulty were omitted.
were higher in all possible conditions than in the impossible condition ($t_s \geq 4.23, ps < .0001$). Further comparisons indicated that values for High Fatigue participants were consistent across the easy, moderate, and hard conditions ($t_s \leq .75, ps \geq .45$). Responses in the impossible condition were lower than those in the easy and hard conditions ($t_s \geq 2.19, ps \leq .03$). There was not a significant difference between the moderate and impossible condition ($t = 1.53, p = .13$). Comparisons of values for the fatigue groups at each difficulty level indicated that Low Fatigue participants evinced stronger responses than High Fatigue participants in all possible conditions ($t_s \geq 2.16, ps \leq .03$), but not in the impossible condition, $t (344) = .80, p = .43$.

Figure 5 shows that DBP responses were highly similar to SBP responses. The chief difference between the SBP and DBP response patterns was that DBP values were somewhat elevated for Low- relative to High Fatigue participants in the impossible condition, whereas SBP values were not. Analysis revealed effects for difficulty $F (3, 252) = 11.15, p < .001$, and fatigue, $F (1, 84) = 23.53, p < .001$. These effects reflected stronger responses in the possible conditions than in the impossible condition ($t_s \geq 3.08, ps \leq .002$) and higher values overall for Low Fatigue participants ($t_s \geq 2.88, ps \leq .004$).

Although the difficulty * fatigue interaction was not significant in the analysis of DBP data, $F (3, 252) = 1.60, p = .19$, a priori hypotheses support the use of pair-wise comparisons. These indicated that difficulty effects were different for the fatigue groups. Among Low Fatigue participants, DBP responsiveness increased from the easy condition to the moderate condition, $t (252) = 2.83, p = .005$, tended to remain sustained in the hard condition [easy v. hard: $t (252) = 1.68, p = .09$; moderate v. hard: $t (252) = 1.15, p =$
Figure 5. Mean DBP response (±SE) for Low Fatigue (n = 45) and High Fatigue (n = 41) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty were omitted.

.25], and then dropped sharply in the impossible condition [hard v. impossible: t (252) = 4.01, p = .0001]. Among High Fatigue participants, DBP responsiveness was relatively low across the easy, moderate, and hard conditions (ts ≤ .37, ps ≥ .70) and declined further in the impossible condition (t ≥ 2.07, p ≤ .04). Comparisons of values for the fatigue groups at each difficulty level indicated higher values overall for Low Fatigue participants (ts ≥ 2.88, ps ≤ .004).
As can be seen in Figure 3, the response pattern for HR was somewhat different from the patterns observed for SBP and DBP. Analysis of the HR data revealed an effect for difficulty, $F(3, 249) = 16.48, p < .0001$, and a difficulty * fatigue interaction, $F(3, 249) = 3.03, p = .03$. The difficulty effect reflected stronger responses where success was possible than where it was not ($t_s \geq 7.27, ps < .0001$). The interaction reflected different difficulty effects for the fatigue groups and different fatigue effects at different difficulty levels.

Among Low Fatigue participants, differences in responses approached significance slightly rising from the easy condition to the hard condition, $t(249) = 1.66, p = .09$ (Figure 6); and then declined sharply in the impossible condition, $t(249) = 5.00, p < .0001$. Among High Fatigue participants, responses remained relatively constant between the easy and moderate conditions, $t(249) = 1.46, p = .15$, declined from the moderate condition to the hard condition, $t(249) = 2.76, p = .006$, and then declined again in the impossible condition, $t(249) = 2.63, p = .009$. Comparisons of values for the fatigue groups at each difficulty level indicated that Low Fatigue participants evinced stronger responses than High Fatigue participants where difficulty was high, $t(332) = 2.42, p = .02$, but not where it was easy, moderate, or impossible ($t_s \leq .76, ps \geq .45$). Notably HR responses tended to be minimal for all groups, with the largest elevation being only 3.06 beats per minute. As will be discussed shortly, this could indicate a strong, slowing, parasympathetic (vagal) influence in the context of this procedure.
Figure 6. Mean HR response (±SE) for Low Fatigue (n = 43) and High Fatigue (n = 42) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty were omitted.

Trend Analyses

Given the patterns that were expected for the different fatigue groups across levels of difficulty, it was appropriate to also examine the CV response data with trend analyses. Analysis of the SBP data revealed reliable linear, $F(1, 86) = 21.96, p < .0001,$ and quadratic, $F(1, 86) = 17.15, p < .0001,$ trends for difficulty. The linear trend suggests that overall, CV response decreased as difficulty increased. The quadratic trend reflects stronger responses overall in the moderate and hard conditions than in the easy and im-
possible conditions. The analysis also yielded a linear * fatigue interaction, $F(1, 86) = 4.00, p = .05$, and a quadratic * fatigue interaction, $F(1, 86) = 5.55, p = .02$, which is the most important finding. The linear * fatigue interaction reflected a steeper decline in response with difficulty among Low Fatigue participants, $F(1, 86) = 22.35, p < .0001$, than among High Fatigue participants, $F(1, 86) = 3.61, p = .06$. The quadratic * fatigue interaction reflected the presence of a quadratic effect among Low Fatigue participants, $F(1, 86) = 21.11, p < .0001$, but not High Fatigue participants, $F(1, 86) = 1.59, p = .21$.

Analysis of the DBP data revealed reliable linear, $F(1, 84) = 10.57, p = .002$, and quadratic trends, $F(1, 84) = 24.72, p < .0001$. The linear trend reflected an overall decrease in CV responsiveness from the easy condition to the impossible condition. The quadratic trend shows elevating values initially followed by decreasing values as difficulty increases. Analysis also revealed a quadratic * fatigue interaction, $F(1, 84) = 4.47, p = .04$. The quadratic * fatigue interaction reflected the presence of a stronger quadratic effect among Low Fatigue participants, $F(1, 84) = 26.23, p < .0001$, than among High Fatigue participants, $F(1, 84) = 3.90, p = .05$.

Analysis of the HR data revealed linear, $F(1, 83) = 24.55 p < .0001$, and quadratic, $F(1, 83) = 23.05, p < .0001$, trends for difficulty. The linear trend reflected an overall decline in HR response from the easy- to the impossible condition. The quadratic trend suggests that HR responses first rose and then fell as difficulty increased. Neither the linear * fatigue interaction nor the quadratic * fatigue interaction approached significance ($Fs <1.59$). On the other hand, there was a reliable cubic * fatigue interaction, $F(1, 83) = 7.35, p = .008$. When low levels of fatigue were present, HR response demonstrated an upward curvilinear path as difficulty increased during possible tasks, then di-
minished rapidly during the impossible task, $F(1, 83) = 5.91, p = .017$. When high levels of fatigue were present, no cubic trend was present, $F(1, 83) = 1.99, p = .16$. The cubic trend for the Low Fatigue group is interesting, but was wholly unexpected and is difficult to explain *post-hoc*. Pending replication, it should be considered cautiously.

Although the quadratic * fatigue interaction did not approach reliability in the analysis of the HR data, it is of some note that the quadratic trend was somewhat stronger for Low Fatigue participants, $F(1, 83) = 14.86, p = .0002$, than for High Fatigue participants, $F(1, 83) = 8.64, p = .004$. This should not be over interpreted, but is broadly consistent with the interactional pattern observed for SBP and, to a lesser degree, DBP. It also is consistent with the implication that effort first rose and then declined for those who reported low fatigue.

**Subjective Effort and Performance**

Subjective effort ratings were obtained after each work period (11-point scales, 0 = very little, 10 = very much). Means and standard errors are in Table 7. A 4 (difficulty) x 2 (fatigue) mixed ANOVA yielded only an effect for difficulty, $F(3, 291) = 56.83, p < .0001$. Pair-wise comparisons indicated that effort ratings (1) rose from the easy condition to the moderate condition, $t(388) = 4.049, p < .0001$, (2) rose again from the moderate condition to the hard condition, $t(388) = 3.59, p = .0004$, and (3) then fell from the hard condition to the impossible condition, $t(388) = 2.55, p = .01$. 
Table 8

Post-task Self Report of Expended Effort

<table>
<thead>
<tr>
<th></th>
<th>Low Fatigue</th>
<th></th>
<th>High Fatigue</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Easy</td>
<td>Mod</td>
<td>Hard</td>
<td>Imp</td>
</tr>
<tr>
<td>EE</td>
<td>2.52</td>
<td>4.62</td>
<td>6.90</td>
<td>5.16</td>
</tr>
<tr>
<td>SE</td>
<td>.38</td>
<td>.38</td>
<td>.32</td>
<td>.50</td>
</tr>
</tbody>
</table>

Note. EE= self-reported expended effort. Mod= Moderate; Imp=Impossible. Low Fatigue n= 50; High Fatigue n= 49.

Performance was assessed by examining whether the sum total provided by participants was the correct response for a task period. Responses meeting this criterion were coded as 1; those falling beyond were coded as 0. Percentages of correct responses are in Figure 7. The figure shows that there was blanket failure in the impossible conditions.

Accordingly, the performance data were examined with a 3 (difficulty) x 2 (fatigue) mixed ANOVA in which the difficulty factor included values only from the easy, moderate, and hard conditions. Analysis revealed a difficulty effect, \( F (2, 194) = 108.67, p < .0001 \), and a near-reliable fatigue effect, \( F (1, 97) = 3.74, p = .056 \). The difficulty effect reflected a steady decline in performance as difficulty increased [easy v. moderate \( t (194) = 5.74, p <.0001 \); moderate v. hard \( t (194) = 14.42, p <.0001 \)]; the near-reliable fatigue effect reflected relatively improved performance among the Low Fatigue partici-
pants. Although the interaction was not significant, $F (2, 194) = .99, p = .375$, pair-wise comparisons indicated that the fatigue effect was carried by values in the moderate difficulty conditions. Whereas performance was better for Low Fatigue participants in the moderate condition, $t (291) = 2.20, p = .03$, it was equivalent for the fatigue groups in the easy, $t (291) = .29, p = .77$, and hard conditions, $t (291) = 1.02, p = .31$. The broad suggestion is that, where success was possible, the Low Fatigue participants maintained performance in the face of increasing difficulty better than did the High Fatigue participants.

Figure 7. Percent of correct responses (±SE) for Low Fatigue ($n = 50$) and High Fatigue ($n = 49$) groups during auditory mental addition tasks of increasing difficulty.
CHAPTER 5
DISCUSSION

Overview

Wright's integrative analysis suggested that fatigue impact on effort and associated CV responses should vary dramatically depending on the difficulty of the challenge with which participants were confronted (Wright, et al., 2007; Wright & Kirby, 2001). Several effects were anticipated. First, it was expected that for both fatigue groups, CV responsiveness would rise with difficulty to a point, and then fall sharply. Second, it was expected that CV responses would be stronger for High than for Low fatigue participants, as long as success appeared possible and worthwhile. Third, it was expected that High Fatigue participants would reach their peak CV responses during an earlier task period than Low Fatigue participants, specifically during the moderate difficulty condition. Fourth, it was expected that both fatigue groups would demonstrate minimal CV response during the impossible task period. A crucial assumption was that High Fatigue participants would view success as possible and worthwhile at least at the point where objective difficulty was low. If High Fatigue participants, in fact, viewed success as impossible or excessively difficult even in the easy condition, then it is likely that they would evince relatively reduced CV responses in all difficulty conditions.
Cardiovascular Findings

SBP response findings for the Low Fatigue participants were generally consistent with expectations based on Wright’s integrative analysis. The Low Fatigue group demonstrated a quadratic arch, with SBP responses increasing and then decreasing, as difficulty grew. The group also showed minimal SBP responsiveness during the impossible condition for both fatigue groups. By contrast, SBP response findings for the High Fatigue participants were contrary to expectation in an important respect. Rather than exceeding by a constant the SBP responses of the Low Fatigue participants in the easy and moderate difficulty conditions and then dropping sharply, the SBP responses of High Fatigue participants were consistently low in the easy and moderate conditions and tended to decline further as difficulty increased. Thus, the findings for High Fatigue participants fit expectations in the difficult and impossible conditions, but not in the easy and moderate conditions. DBP response findings were similar to the SBP response findings, with DBP responses first rising and then falling with difficulty among Low Fatigue participants and declining steadily with difficulty among High Fatigue participants.

One explanation for the unexpected blood pressure response patterns in the easy and moderate conditions would focus on the high level of fatigue in the High Fatigue participants. A working assumption at the outset of the study was that High Fatigue participants would not be so fatigued that they considered success on the easy and moderate tasks as excessively difficult or impossible. However, it could be that High Fatigued participants were more depleted than anticipated and, as a result, unwilling to do what was required to succeed on any of the tasks. Consistent with this would be the fact that High Fatigue participants were selected because of their exceptionally high modified FFS
scores. Also consistent would be the very high fatigue and tiredness ratings that participants provided when they arrived for the session (see top of Table 4). Contrary to the interpretation would be the low and modest difficulty ratings the participants provided after the easy and moderate work periods, respectively. However, these ratings might be interpreted guardedly. One reason is because ratings may have been primarily influenced by objective characteristics of the tasks and, thus, not reflected well participants’ private difficulty appraisals. Another is because they reflect only difficulty appraisals, and even the slightest exertion may seem excessive in a highly depleted state.

Post-hoc correlation analyses support the notion that self-reported difficulty ratings likely reflect objective difficulty as the combined score did not correlate with CV response for the majority of the comparisons. There were a few exceptions for the High Fatigue group. For DBP, response values tended to be lower as individuals reported difficulty increased during the moderately difficult task ($r = -.309, p = .049$). For HR, response values tended to be lower as reported difficulty increased during the hard task ($r = -.366, p = .017$). Response values for HR also tended to be higher as difficulty appraisals increased during the impossible condition ($r = -.366, p = .017$). Given the very limited variability in the difficulty appraisals in across conditions these correlations should be interpreted guardedly.

Corroborating empirical support for the preceding interpretation is seen in a study published after the present investigation was initiated (Nolte, Wright, Turner, & Contrada, 2008). Using regression techniques and a fatigue index comprised of subscales of Thayer’s ADACL, investigators examined relations between fatigue and CV responsiveness under easy and moderately difficult cognitive task conditions. A central finding was
that blood pressure responsiveness rose to a point with reported fatigue under easy task conditions, but was low under these conditions for participants reporting very high fatigue. Investigators interpreted the result to indicate low effort under very high fatigue conditions.

Like the blood pressure response data, the HR response data fit with expectations in some respects, but not others. On the one hand, HR responses for Low Fatigue participants first rose and then fell with difficulty. Further, HR responses were stronger for Low- than High Fatigue participants in the hard condition and low for both fatigue groups in the impossible conditions. On the other hand, HR responses were not stronger for High Fatigue participants than for Low Fatigue participants in the easy and moderate conditions. In contrast to the blood pressure response data, the HR response data showed no evidence of greater effort among the Low Fatigue participants in the easy and moderate conditions. They also produced an unanticipated cubic * fatigue interaction and indicated surprisingly limited responses across all conditions.

The HR findings do not blend perfectly with the blood pressure findings. However, they do not clash with them entirely either. Differences between the two sets of findings might trace to the fact that HR is partially determined by sympathetic nervous system activation and partially determined by parasympathetic activation, with sympathetic activation increasing HR and parasympathetic activation slowing it. There are believed to be conditions under which parasympathetic influence dominates (Andreassi, 2007). When these conditions occur, HR can show little change in the presence of a significant sympathetic discharge. Given the low HR change values obtained here, it is rea-
sonable to speculate that HR was largely under parasympathetic control in the context of this procedure and this may have prevented it from tracking directly SBP and DBP.

Interpretation of future HR findings might be improved by more frequent HR assessment. In a study by Steele & Lewis (as cited in Andreassi, 2007) using mental arithmetic there were sharp increases in HR immediately following the presentation of the problem, for up to three cardiac periods, followed by a drop in HR. It could be that the task in this study involved multiple attending periods (attending for the number stimulus) and multiple active coping periods (mental calculations). This is in line with other work on attending (Jenning, 1986, 1992; Lacey, 1967; Lacey et al., 1963; Lacey & Lacey, 1980), which found that decreased HR occurs when individuals are awaiting a specific stimulus and an increased HR response when actively processing information. When the participant was listening for the next number, HR could be expected to temporarily drop. After the number was given, HR would be expected to temporarily increase as the participant calculates the sum. For work periods with little latency between number presentations there would be considerably less time spent attending to stimuli and more in active coping phases. Also for individuals with fewer resources available, more time might be spent in active coping even when latency between number presentations remains the same. This increase in time spent in active coping could help explain the HR response pattern observed in this experiment. This, however, is purely speculative and could only be demonstrated by a change in CV measurement. By recording heart beats in real time it would be possible to map them to the specific number stimuli. This measurement strategy could detect changes in HR during the mental arithmetic task that would have occurred too frequently for our current method of measurement to detect.
Four additional points concerning the CV data might be noted.

1. First, whereas HR responses for Low Fatigue participants rose with difficulty to the high condition and then fell sharply in the impossible condition, SBP and DBP responses for these participants tended weakly to peak in the moderate condition and slope gradually to a minimum in the impossible condition. This difference in CV response patterns could reflect something meaningful physiologically and say something important about effort levels in the mid-range difficulty conditions (such as whether they fall sharply or gradually after reaching a peak). However, it would be premature to draw a firm conclusion based on these data alone. The difference in response patterns for the three CV measures is not dramatic and could be a result of chance. Indeed, looking at the data for the Low Fatigue participants alone, the patterns are remarkably similar.

2. Related to the above, it also is of note that slightly different fatigue effects were observed in the impossible condition. Whereas SBP and HR responses were low and equivalent for both fatigue groups, DBP responses were somewhat higher among Low- as compared to High Fatigue participants. This difference also might reflect chance influence and, thus, best be considered guardedly. To the degree the effect is “real” one could speculate that it had to do with the rate of vascular recovery following engagement in the possible conditions. There is evidence that vascular recovery following stress is more extended than cardiac recovery following stress (Kelsey, Soderlund, & Arthur, 2004). Since DBP varies chiefly with vascular resistance, it follows that it may have remained elevated longer after participants disengaged than SBP (resistance x myocardial contractility) or HR (no vascular influence).
3. It is of note that High Fatigue participants showed consistent CV response declines across difficulty levels. There are many possible interpretations of this. However, one that seems reasonable in retrospect is that the participants became increasingly adapted to the experimental situation over time and were most comfortable being disengaged in the impossible condition in which success plainly was out of reach.

4. Finally, fourth, the discrepancy between the second versus first half CV response results was not predicted, but is explicable in light of more recent research (Richter & Gendolla, 2006, 2007; Wright & Kirby, 2001). Since participants were not told specifically how difficult a given task was expected to be, it is possible that it took them awhile to gauge the difficulty. This is important, because previous studies have found that when task difficulty is uncertain, expended effort is maximal. Other studies have addressed this issue by stating the exact likelihood of success. On the other hand, pre-statements of the likelihood of success may influence perceived ability and could confound fatigue effects. A clear solution to this, for future studies, would be to provide participants with a brief practice period before each session so that they can acclimatize themselves to the task and presumably determine task difficulty. Ideally this would be followed by a 3-minute waiting period to avoid carry-over effects before the actual task begins.

Subjective and Performance Findings

Subjective and performance results were generally in-line with expectations. Self-report questionnaire data confirmed that the two fatigue groups differed in levels of fatigue on the day of testing. As expected, individuals’ subjective difficulty increased as objective difficulty increased. Level of fatigue was also related to subjective difficulty,
with difficulty appraisals being greater among High- than Low Fatigue participants. Performance differences were found between the two fatigue groups, with the Low Fatigue group demonstrating better maintenance of performance as difficulty increased. Subjective expended effort, however, did not significantly differ between groups.

Considerations for Self-Report and Performance Findings

The modified FSS was useful in identifying individuals experiencing relatively consistent fatigue during the time of the experiment. This provides support for use of our modified FSS in future research with non-clinical High- and Low Fatigue populations. It could be, however, that the modified FSS also selected individuals who purposefully amplify their fatigue levels in order to provide an excuse for failure or even to avoid engaging in them (Hirt, Deppe, & Gordon, 1991). Possible considerations for future changes to the modified FSS include: 1) removal of the time period limitations, 2) inclusion of an actual fatigue rating, and 3) inclusion of a definition of fatigue. Removal of the two-week reference period would allow for the use of the modified FSS as a measure of a trait that indicates susceptibility to fatigue and its effects. Inclusion of a fatigue rating at the point in time that the questionnaire was completed would provide useful comparison levels of fatigue on the day of testing. While providing participants with a definition of fatigue, would reduce the amount of subjectivity regarding differing views of what constitutes fatigue.

Refining measures of fatigue is important because fatigue levels influence self-reported difficulty. Individuals who are fatigued should have lower levels of perceived ability and thus view possible tasks as more difficult than individuals who are not fa-
tigued. When tasks are easy, however, even if someone experiences high levels of fatigue, the change in perceived difficulty should be negligible. The individual’s perceived abilities are high enough that compensation with increased effort would not be as drastic. As tasks increase in difficulty, but remain possible, the discordance between task demands and perceived ability increases, and thus a higher increase in perceived difficulty and the effort required for success. Once the task becomes impossible, all individuals view the task as extraordinarily difficult, since the impossible task is far beyond anyone’s perceived ability level.

But self-reported measures of how much effort an individual expends on a task are prone to influence from confounding variables. For instance, individuals may wish to present themselves as “good participants” who try their hardest, even when it is apparent they will not succeed. Other individuals may lowball their expended effort levels since it reflects upon their abilities. In addition, individuals may have difficulty estimating their total level of effort across a given time period since their level of effort may fluctuate across time. Finally, it may be that individuals, who regularly have to expend more effort to succeed, have a different baseline than those for whom success comes relatively easily. Efforts were made to ameliorate these confounding factors by have respondents place their answers in sealed envelopes and not having the examiner present in the testing room. However, analysis of these data indicate that self-report continues to be an unreliable measure of expended effort, as there was no significant difference between fatigue groups.

All these complications taken into account, in general, Low Fatigue participants had better performance than High Fatigue participants. Given the complex relationships
between effort and performance; however, these results should only be viewed in the context of these arithmetic tasks. For these challenges, it appears that increasing levels of effort were required to be successful, up to the point that the tasks became impossible.

Health and Social Implications

One of the assumptions of Wright's integrative analysis is that highly fatigued individuals should have elevated levels of effort and CV response compared to less fatigued individuals so long as the task at hand appears possible and the available benefit worthwhile. Chronically exaggerated CV responses, as opposed to chronically diminished responses, have been implicated in the development of negative health outcomes, including hypertension and heart disease (Blascovich & Katkin, 1993; Contrada, Cather, & O’Leary, 1999; Dembroski, Schmidt, & Blümchen, 1983; Forsyth, 1969; Herd et al. 1969). This would place individuals who were chronically fatigued at higher risk for developing CV disease if they were placed in situations that require constant levels of elevated effort.

The results of this research suggest that highly fatigued participants conserved effort during all task periods and, as a result, had lower CV responses. The benefit from successfully meeting the challenge, however, was very modest in this experiment. If the benefit had been high, such as a large sum of money or the protection of a child, potential motivation presumably would have been increased enough to justify effort even among the High Fatigue participants. One real life example of this type of effect would be a caregiver of a child diagnosed with Autism who is willing to commit to taking the child to multiple therapists and doctors in order to ensure the child has the best prognosis.
Another would be a vice-president of a corporation willing to put in 80 hour work weeks to ensure that the company remains viable. Still another would be a soldier willing to continue fighting in extremely adverse circumstances with no sleep.

All people in the preceding examples would have highly motivating benefits available for putting forth effort, both rewards and punishment. Individuals who are placed in situations that require constant levels of elevated effort would be expected to have chronically elevated CV responses. Individuals who are highly fatigued and placed in highly motivating situations with a demand for high effort are the most likely to be at risk for developing CV disease. The risk would be further exacerbated by a predisposition for CV disease, such as through family history. Scheduling or services that provide predictable breaks in the need for sustained effort, such as respite care for parents of special needs children, would likely serve as a protective factor against negative health effects. For those individuals who are in situations where benefits are not so extreme, it is likely that they adjust to high fatigue by putting forth less effort. The diminished CV response would thus not place them at increased risk for health complications.

The lowered CV response for high fatigued individuals also indicates that they would be less likely to engage in tasks in real world settings. People who are fatigued would be more likely to cancel appointments, have poor attendance, not keep deadlines, and complete only the bare minimum work required, if at all. In the workplace these individuals would likely be at greatest risk for being terminated, while in school settings poor academic achievement would be highly likely. Remediation programs that manipulate success importance will likely show greater levels of success, such as providing clear and higher levels of consequences than typically given for success or failure. Future re-
search could address the diminished CV response issue by providing varying extremes of benefit for successful performance, such as $20 per correct response versus $2.

Limitations

There were some limitations to this study, which have been fully addressed elsewhere, but are reiterated here for convenience. The sample population had disproportionately higher amounts of females than males in the High Fatigue group. While analyses indicated no significant effects for gender, future researchers may wish to consider using stratified randomized sampling to ensure equal distributions of gender. Another limitation was that tasks were presented in a fixed order and thus could have been subjected to order effects. While this was an \textit{a priori} decision based upon concerns of fatigue effects it is also possible that individuals did not feel comfortable disengaging until they were presented with an obviously impossible task. Also, it appears that the incentive used was not sufficient to produce expected effort levels in highly fatigued individuals. A solution might be to provide obviously high levels of reward. Finally, the method of CV measurement used in this study, while providing relatively frequent data, was not sufficient enough to answer questions \textit{post-hoc} regarding HR values. The suggestion for this is to utilize measurement, such as ECG, that will provide real-time values or to also measure heart rate variability.

Conclusions

Participants were identified as having high and low levels of fatigue, as measured by a modified version of the Fatigue Severity Scale. Those meeting fatigue criteria were
randomly offered the opportunity to win a modest monetary reward by calculating mentally the sum of increasingly difficult series of audible numbers. Four levels of difficulty were presented (easy, moderate, hard, and impossible); they were manipulated by decreasing latency between numbers presented and by increasing the range of numbers presented. Blood pressure responses rose and then fell with difficulty among Low Fatigue participants, but were low and steadily diminished with difficulty among High Fatigue participants. The latter effect does not fit the interactional pattern first expected. However, it might be interpreted in terms of the originating fatigue analysis. Specifically, High Fatigue participants may have been so depleted that even the easy challenge required more effort than they were willing to expend.

HR responses were minimal for both fatigue groups at all difficulty levels. This could reflect a strong parasympathetic influence. A difficulty effect corresponded to similar effects observed on the blood pressure measures. An obtained interaction reflected a wholly unexpected response pattern that is difficult to explain post hoc. This should be viewed guardedly pending replication.

The main findings replicate previous fatigue results and extend them by 1) providing further evidence that CV responsiveness should be low across levels of difficulty for possible tasks if fatigue levels are so high as to make the effort required to be successful appear less worthwhile, 2) provide further confirmation that naturally occurring fatigue effects are similar to manipulated fatigue effects, and 3) documenting fatigue effects across a range of difficulty levels. The findings also suggest multiple additional lines of research.
Individuals who are highly fatigued appear to conserve energy, rather than put forth more effort, when the benefits from success are modest. This suggests that in the general population, high fatigue individuals will typically conserve energy so that changes in CV measures will be relatively low. This still places them at risk for CV events; however, when situations arise where benefits from success are great and sustained elevated effort is required. In those situations, CV response could elevate to unhealthy and unsustainable levels. In contrast, individuals with low fatigue would in theory have higher perceived ability levels and have lower CV response during the same situations.

In comparison to William James's sailor (1890) who was responsible for the lives of his fellow sailors and his own, the sailor appeared to put forth the greatest level of effort possible regardless of fatigue. However, the same tired and wearied sailor might scoff at the idea of intensive and prolonged labor for a small sum of money. He would likely view the benefit as not being worth the effort required for the highest chance of success. The fatigued sailor could choose to put forth a minimal amount effort in order to obtain a reasonable chance of success, while also conserving energy. For a well-rested sailor, the modest sum of money may be a large enough draw for him to put forth a higher level of effort to have the highest chance for success.
REFERENCES


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152-160.


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APPENDIX A

SCREENING PACKET
Participant Number: ____________________

**Effects of Task Performance**

Please complete the following questionnaires. It is important that you complete all of the items even if you are unsure. We will contact you by phone if you qualify for this study.

Name: ____________________________________________

Phone #: _________________________________________
Age: 

Class (circle one):

- Freshman
- Sophomore
- Junior
- Senior
- Other

Gender (circle one):

- Male
- Female

Race (circle one):

- White
- Black
- American Indian
- Asian
- Pacific Islander
- Other

Do you consider yourself Hispanic (circle one)?

Yes  No
We are interested in how fatigue has affected you within the past two weeks. Please think about each item carefully. Circle how much you agree or disagree with the statement.

**Examples:**

<table>
<thead>
<tr>
<th>I like to eat chocolate.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>Strongly Disagree</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>I like to eat raw onions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>Strongly Disagree</td>
</tr>
</tbody>
</table>

Below is a list of items that describe how fatigue affects people. For each item, circle how much you agree or disagree with the statement. Answer all items as well as you can, even if you are unsure. Remember to think only about how you have felt for the past two weeks for each item.

**For the past two weeks, I have felt that...**

<table>
<thead>
<tr>
<th>I am easily fatigued.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>Strongly Disagree</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fatigue interferes with my daily functioning.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>Strongly Disagree</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fatigue causes frequent problems for me.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>Strongly Disagree</td>
</tr>
</tbody>
</table>
For the past two weeks, I have felt that...

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fatigue prevents sustained functioning in my daily life.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Strongly Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Somewhat Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Undecided</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Somewhat Agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Strongly Agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Fatigue makes it hard for me to carry out certain duties and responsibilities.</strong></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Strongly Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Somewhat Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Undecided</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>5 Somewhat Agree</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Agree</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Strongly Agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>For me, fatigue is disabling.</strong></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Strongly Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Disagree</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Somewhat Disagree</td>
<td></td>
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<td></td>
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<tr>
<td>4 Undecided</td>
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<tr>
<td>5 Somewhat Agree</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>6 Agree</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>7 Strongly Agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Fatigue interferes with my work, family, and/or social life.</strong></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Strongly Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3 Somewhat Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Undecided</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Somewhat Agree</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Strongly Agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
We are interested in how sleep problems have affected you for the past two weeks. For each item, circle the rating that best describes how your sleep has affected you. Answer each item even if you are unsure.

1. Please rate the current (i.e., last 2 weeks) severity of your sleep problems.

<table>
<thead>
<tr>
<th>Difficulty falling asleep:</th>
<th>None</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>Very Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficulty staying asleep:</td>
<td>None</td>
<td>Mild</td>
<td>Moderate</td>
<td>Severe</td>
<td>Very Severe</td>
</tr>
<tr>
<td>Problem waking up too early:</td>
<td>None</td>
<td>Mild</td>
<td>Moderate</td>
<td>Severe</td>
<td>Very Severe</td>
</tr>
</tbody>
</table>

2. How satisfied/dissatisfied are you with your current sleep pattern?

<table>
<thead>
<tr>
<th>Very Satisfied</th>
<th>Satisfied</th>
<th>Undecided</th>
<th>Dissatisfied</th>
<th>Very Dissatisfied</th>
</tr>
</thead>
</table>

3. To what extent do you consider your sleep problem to interfere with your daily functioning (e.g., daytime fatigue, ability to function at work/daily chores, concentration, memory, mood, etc.)?

<table>
<thead>
<tr>
<th>Not at all Interfering</th>
<th>Barely</th>
<th>Somewhat</th>
<th>Much</th>
<th>Very Much Interfering</th>
</tr>
</thead>
</table>

4. How noticeable to others do you think your sleeping problem is in terms of impairing your quality of life?

<table>
<thead>
<tr>
<th>Not at all Noticeable</th>
<th>Barely</th>
<th>Somewhat</th>
<th>Much</th>
<th>Very Much Noticeable</th>
</tr>
</thead>
</table>

5. How worried/distressed are you about your current sleep problems?

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Barely</th>
<th>Somewhat</th>
<th>Much</th>
<th>Very Much</th>
</tr>
</thead>
</table>
APPENDIX B

ORIGINAL FATIGUE SEVERITY SCALE AND INSOMNIA SEVERITY INDEX
FATIGUE SEVERITY SCALE

For Krupp’s (1989) FSS, participants are asked to chose a number from 1-7 that shows how much they agree with the following statements (1= strongly disagree, 7= strongly agree):

1. My motivation is lower when I am fatigued.
2. Exercise brings on my fatigue
3. I am easily fatigued.
4. Fatigue interferes with my physical functioning.
5. Fatigue causes frequent problems for me.
6. My fatigue prevents sustained physical functioning.
7. Fatigue interferes with my carrying out certain duties and responsibilities.
8. Fatigue is among my three most disabling symptoms.
9. Fatigue interferes with my work, family, or social life.

An average score of 4 or higher is indicated as being "severe fatigue".
INSOMNIA SEVERITY INDEX

Morin's (1993) ISI asks participants to rate seven sleep related items on a scale from 0-4, with increasing numbers indicating greater complications from sleep problems. Scores of 15 and above indicate clinical levels of insomnia. Below are the items from the ISI:

1. Please rate the current (i.e., last 2 weeks) SEVERITY of your insomnia problem(s):
   (a) Difficulty falling asleep
   (b) Difficulty staying asleep
   (c) Problem waking up too early

2. How SATISFIED/DISSATISFIED are you with your current sleep pattern?

3. To what extent do you consider your sleep problem to INTERFERE with your daily functioning (e.g., daytime fatigue, ability to function at work/daily chores, concentration, memory, mood, etc.)?

4. How NOTICEABLE to others do you think your sleeping problem is in terms of impairing the quality of your life?

5. How WORRIED/DISTRESSED are you about your current sleep problem?
APPENDIX C

EXAMINER PROTOCOL
Protocol for Study

1. Experimenter (E) places the Informed Consent in lab, meets the participant (P) and escorts the P to the lab. E asks P to review the Informed Consent Statement. E informs P that it contains some general details about the study and their rights as a participant. E asks P to place their initials at the bottom of each page and to sign the last page if they agree to participate.

2. P reviews the Informed Consent Statement in private, and signs. E observes to see when the statement is signed, and returns to the room when it has been. E answers any questions about the consent statement P may have. E has P sign another copy and gives one to P.

3. E describes briefly the study as being concerned with how people respond psychologically and physiologically when they are presented different tasks under different conditions. E indicates that the physiological responses being studied are heart rate and blood pressure, describes how these will be assessed, and places the wrist cuff on the P’s non-dominant arm. E notes that the session will begin with a 15 minute baseline. Before leaving the room, E places in front of P magazines to read while baseline measures are being taken. E asks P to limit motion during baseline. E asks P if they have a cell phone and to please turn it off or silent (no vibrate) as this may affect the their CV measures.

“We are interested in how people respond psychologically and physiologically when they are presented different tasks under different conditions. Your basic cardiovascular measures, such as blood pressure and heart rate, will be recorded by this wrist cuff while you perform the tasks. Since this is a sensitive instrument it is important to stay as still as you can during the tasks and not to place anything on the monitor. Also try to keep your hand resting face up as this provides more accurate results.

We will begin with a 15-minute baseline session. Please turn off any cell phone or pagers you may have. Feel free to look through these magazines if you like, but do not read any additional reading materials you may have brought with you. Remember to stay as still as you can until I tell you the session is over.”

3. E returns to the control room and begins the baseline period. Although the baseline has been described as lasting 15 minutes, it actually will last about 8 minutes. Six minutes 20 seconds into the baseline E will begin recording CV data every 20 seconds. E will press stop once all 8 baseline measurements have been taken.

4. Once the baseline period is over, E returns to the experimental chamber and places in front of P a preliminary affect questionnaire. E also places magazines back into the tray. E shows P the intercom CALL button and says:
“Here is an affect checklist. I would like you to begin by completing the checklist, indicating how you feel right now. Once you have responded to all items, please press CALL.”

5. E returns to the control room and places pen back into cup. When the P presses the CALL button (indicating that P is finished), E returns to the experimental chamber and places in front of P five envelopes (Instructions and Questionnaires A-D). E says:

“Here are five envelopes. Once I leave the room I want you to open the envelope marked Instructions and review the contents carefully. Once you have finished reading the instructions and are ready to begin the first task please press CALL. Please do not open the other envelopes until I instruct you to do so.”

6. E returns to the control room. When P presses the CALL button E starts the Vasotrac and says:

“Please place the instructions back into the envelope. In approximately 30 seconds we will begin the first task period. You will hear a series of numbers presented orally in sequence. Your goal in the task period is to mentally determine the sum of the numbers presented.”

7. Once 30 seconds has elapsed, E starts Set A. P begins adding. E begins monitoring CV responses and records samples at 20 s intervals.

8. Once the track ends, E presses stop on the Vasotrac. E comes over the PA system and says:

“OK, now please open the envelope marked Questionnaire Set A and remove the contents. Please respond to all of the questions in the packet. When you have responded to all of the questions return the questionnaire to its envelope and place the pen back into its container. Then press the CALL button and we will continue.”

9. P completes the questionnaire and presses CALL. At this point, the E says:

“You will now have a three minute rest period to relax. Please sit quietly, but feel free to look through the magazines provided to you. “

10. After 3 minutes has passed, E starts the Vasotrac and says over the intercom:
“Please place the magazines back into the tray. In approximately 30 seconds we will start number presentations for the second task period. Once again, your goal is to mentally determine the sum of the numbers presented.”

11. Once 30 seconds has elapsed, E starts Set A. P begins adding. E begins monitoring CV responses and records samples at 20 s intervals.

12. Once the track ends, E presses stop on the Vasotrac. E comes over the PA system and says:

“OK, now please open the envelope marked Questionnaire Set B and remove the contents. Please respond to all of the questions in the packet. When you have responded to all of the questions return the questionnaire to its envelope and place the pen back into its container. Then press the CALL button and we will continue.”

13. P completes the questionnaire and presses CALL. At this point, the E says:

“You will now have a three minute rest period to relax. Please sit quietly, but feel free to look through the magazines provided to you.”

14. After 3 minutes has passed, E starts the Vasotrac and says over the intercom:

“Please place the magazines back into the tray. In approximately 30 seconds we will start number presentations for the third task period. As before, your goal is to mentally determine the sum of the numbers presented.”

15. Once 30 seconds has elapsed, E starts Set C. P begins adding. E begins monitoring CV responses and records samples at 20 s intervals.

16. Once the track ends, E presses stop on the Vasotrac. E comes over the PA system and says:

“OK, now please open the envelope marked Questionnaire Set C and remove the contents. Please respond to all of the questions in the packet. When you have responded to all of the questions return the questionnaire to its envelope and place the pen back into its container. Then press the CALL button and we will continue.”

17. P completes the questionnaire and presses CALL. At this point, the E says:
“You will now have a three minute rest period to relax. Please sit quietly, but feel free to look through the magazines provided to you.”

18. After 3 minutes has passed, E starts the Vasotrac and says over the intercom:

“Please place the magazines back into the tray. In approximately 30 seconds we will start number presentations for the fourth and final task period. As before, your goal is to mentally determine the sum of the numbers presented.”

19. Once 30 seconds has elapsed, E starts Set D. P begins adding. E begins monitoring CV responses and records samples at 20 s intervals.

20. Once the track ends, E presses stop on the Vasotrac. E comes over the PA system and says:

“OK, now please open the envelope marked Questionnaire Set D and remove the contents. Please respond to all of the questions in the packet. When you have responded to all of the questions return the questionnaire to its envelope and place the pen back into its container. Then press the CALL button.”

21. P completes the questionnaire and presses CALL. At this point, the E says:

“Very good. Now please sit back and relax. I will be back in the room in a few minutes.”

22. E returns for the debriefing. Following the debriefing, E asks P if s/he would like to have his or her response sheet scored for the purpose of receiving a prize. If the P says “yes”, E will examine the responses and give P the appropriate payment (as indicated in instructions). All Ps will receive course credit. All Ps will be urged to keep details of the study confidential.
APPENDIX D

PARTICIPANT MATERIALS
Affect Checklist

*Instructions:* Please rate your current feelings on the following dimensions. Please circle only numbers and not the scale labels.

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- Please press CALL when you are finished -
EFFECTS OF TASK PERFORMANCE: INSTRUCTIONS
AND RESPONSE SHEETS
UNIVERSITY OF ALABAMA AT BIRMINGHAM
PSYCHOLOGY DEPARTMENT
Study Overview

For a number of years, studies in this laboratory have examined how people respond psychologically and physiologically when they are presented different tasks under different conditions. The study in which you will participate today continues work on this theme. In today's session, you will be presented a series of four mental addition tasks. Measures of your blood pressure and heart rate will be taken at points in the task periods. In addition, you will be asked at points to report on questionnaires your feelings and perceptions of the situation.

- Please continue to the next page -
Mental Counting Tasks

The mental counting tasks in this study are designed to test a person’s ability to concentrate. They all will involve your adding together in your head (in other words, without a writing instrument or calculator) a list of numbers that will be presented orally to you. Your goal in each of the four task periods will be to determine the sum of the numbers presented in the period. Thus, for example, if you were presented in a task period the numbers “1…4…3…2…7…5”, your aim would be to determine the sum of 22 (1+4+3+2+7+5 = 22).

A variable of interest in our research is difficulty. Consequently, we will increase difficulty steadily as we move from one task period to the next. This means that the second adding task will be more difficult than the first, the third adding task will be more difficult than the second, and the fourth adding task will be most difficult of all.

Incentive

In each task period, we offer an incentive for good performance. Specifically, if the sum you come up with at the end of a task period is the actual sum, then we will pay you $2 (two dollars) for that period. On the other hand, if the sum you come up with is not the actual sum, then you will receive no payment for the period. Performances in the different task periods will be evaluated independently. Thus, depending on how you do in each task period, you could earn as little as $0.00 (nothing) and as much as $8 (eight dollars) across the four periods.

- Please continue to the next page -
Getting Started

It is critical that you understand the instructions on the previous page. If they are unclear to you, please turn back and re-examine them. Once you fully understand, you should press the CALL button on the intercom in front of you. Shortly afterwards, the experimenter will come over the public address system and tell you how to start your first task period (Set A). Be sure to sit quietly while numbers are being presented to you in the period. This way we will not obtain false blood pressure and heart rate readings.

After numbers have been presented for approximately three minutes you will hear “End Set A”. This will indicate that the first task period is over. Shortly after you hear “End Set A”, the experimenter will tell you to turn to the page that follows this one and respond to the questions on the page and the following page. Among the questions on the pages will be one that asks you to indicate the sum of the numbers that were presented in the first task period. You should write the sum you computed in the space provided. If you have no sum in mind, then write “no sum”. Once you have responded to all questions on the page, press the CALL button. You will then have a three minute break to rest and look through some magazines. The experimenter will inform you when the break is over and the next task period is about to begin.

Final Points

There are two final instruction points of note. First, understand that you are free to exert as much or as little effort as you choose during the upcoming task periods. Second, also understand that you retain the right to keep your responses private. At the end of the full session, the experimenter will ask you if you wish to have your responses scored. If you prefer not to have them scored, say so and the experimenter will place your packet of materials in an envelope without looking at them. Later on, a member of our investigation team will record your data for statistical analysis, but without any information that would allow you to be identified personally.

-PLEASE PRESS “CALL” WHEN YOU ARE READY TO BEGIN-
Questions for Task Period 1 (Set A)

1. To the best of your knowledge, what is the sum of the numbers that were presented in the first task period? (If you have no idea, please write “no sum.”)

2. How difficult was the Set A addition task?

3. How much effort did you exert on the Set A addition task?

4. How much effort would be required to consistently succeed on this task?

-PLEASE PRESS “CALL” WHEN YOU HAVE RESPONDED TO THE QUESTIONS-
Questions for Task Period 2 (Set B)

1. To the best of your knowledge, what is the sum of the numbers that were presented in the second task period (Set B)? (If you have no idea, please write “no sum”.)

__________________________

For the following items, please circle the number that best reflects your opinion.

5. How difficult was the Set B addition task?

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6. How much effort did you exert on the Set B addition task?

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<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very little</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Very much</td>
</tr>
</tbody>
</table>

7. How much effort would be required to consistently succeed on this task?

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very little</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Very much</td>
</tr>
</tbody>
</table>

-PLEASE PRESS “CALL” WHEN YOU HAVE RESPONDED TO THE QUESTIONS -
Questions for Task Period 3 (Set C)

1. To the best of your knowledge, what is the sum of the numbers that were presented in the third task period (Set C)? (If you have no idea, please write “no sum”.)

________________________________________________________________________

For the following items, please circle the number that best reflects your opinion.

8. How difficult was the Set C addition task?

0 1 2 3 4 5 6 7 8 9 10
Not at all Extremely

9. How much effort did you exert on the Set C addition task?

0 1 2 3 4 5 6 7 8 9 10
Very little Very much

10. How much effort would be required to consistently succeed on this task?

0 1 2 3 4 5 6 7 8 9 10
Very little Very much

-PLEASE PRESS “CALL” WHEN YOU HAVE RESPONDED TO THE QUESTIONS -
Questions for Task Period 4 (Set D)

1. To the best of your knowledge, what is the sum of the numbers that were presented in the fourth task period (Set D)? (If you have no idea, please write “no sum”.)

   __________________________________________________________

For the following items, please circle the number that best reflects your opinion.

<table>
<thead>
<tr>
<th>Question</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. How difficult was the Set D addition task?</td>
<td>0-10</td>
</tr>
<tr>
<td>12. How much effort did you exert on the Set D addition task?</td>
<td>0-10</td>
</tr>
<tr>
<td>13. How much effort would be required to consistently succeed on this task?</td>
<td>0-10</td>
</tr>
</tbody>
</table>

-PLEASE PRESS “CALL” WHEN YOU HAVE RESPONDED TO THE QUESTIONS-
APPENDIX E

VALIDITY AND RELIABILITY FOR MODIFIED FSS AND ISI
Validity and Reliability Sample FSS and ISI scores

<table>
<thead>
<tr>
<th>Race</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FSS</td>
<td>ISI</td>
</tr>
<tr>
<td>White</td>
<td>n=155</td>
<td>n=155</td>
</tr>
<tr>
<td></td>
<td>M=19.30</td>
<td>M=13.07</td>
</tr>
<tr>
<td></td>
<td>SD=9.16</td>
<td>SD=4.58</td>
</tr>
<tr>
<td>Black</td>
<td>n=50</td>
<td>n=50</td>
</tr>
<tr>
<td></td>
<td>M=18.70</td>
<td>M=13.30</td>
</tr>
<tr>
<td></td>
<td>SD=9.01</td>
<td>SD=4.86</td>
</tr>
<tr>
<td>Asian</td>
<td>n=17</td>
<td>n=17</td>
</tr>
<tr>
<td></td>
<td>M=21.88</td>
<td>M=14.18</td>
</tr>
<tr>
<td></td>
<td>SD=10.47</td>
<td>SD=4.60</td>
</tr>
<tr>
<td>Other</td>
<td>n=7</td>
<td>n=7</td>
</tr>
<tr>
<td></td>
<td>SD=7.02</td>
<td>SD=4.63</td>
</tr>
</tbody>
</table>

Grand Mean FSS= 21.03 (N= 715, SD=9.22 )
Grand Mean ISI= 14.24 (N=712, SD=5.25 )
FSS= Fatigue Severity Scale
ISI= Insomnia Severity Index
APPENDIX F

FIRST VERSUS SECOND HALF CARDIOVASCULAR RESPONSE
A concern in developing the research procedure was how quickly participants would recognize the difficulty of their mental addition tasks. Difficulty recognition is crucial because effort and CV responsiveness can be influenced by difficulty only to the degree that performers perceive it. Where difficulty is unknown (e.g., due to lack of experience with a task), effort and associated CV responses should correspond to success importance and, thus, tend to be high (e.g., Richter & Gendolla, 2006, 2007; Wright & Kirby, 2001).

Preliminary ANOVAs were performed on the CV change scores including work period half as a factor. Means are presented in Figures 1F-6F. These revealed powerful effects for half ($F$s $\geq 16.80$, $p$s $\leq .001$) reflecting stronger responses in the first half than in the second. For SBP and DBP, half effects were especially pronounced in the easy conditions ($t$s $\geq 3.93$, $p$s $\leq .0001$). For SBP, half effects were also evident in the moderate and impossible conditions ($t$s $\geq 1.97$, $p$s $\leq .05$). For DBP, half effects were marginally present during the impossible condition, $t$ (237) $=1.78$, $p = .08$. For HR, they were present in the easy and hard conditions ($t$s $\geq 2.50$, $p$s $\leq .013$), but not the moderate and impossible conditions ($t$s $\leq 1$). A possible suggestion is that participants did not fully appreciate the difficulty of their challenge early in the work periods, but came to understand it later on. With this in mind, I chose to focus on data from the second half of the work periods.
Figure 1F. Mean SBP response (±SE) comparisons between first and second half responses in Low Fatigue Participants (n = 42) during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Figure 2F. Mean SBP response (±SE) comparisons between first and second half responses in High Fatigue Participants (n = 41) during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Figure 3F. Mean DBP response (±SE) comparisons between first and second half responses in Low Fatigue Participants (n = 41) during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Figure 4F. Mean DBP response (±SE) comparisons between first and second half responses in High Fatigue Participants (n = 40) during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Figure 5F. Mean HR response (±SE) comparisons between first and second half responses in Low Fatigue Participants (n = 33) during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Figure 6F. Mean HR response (±SE) comparisons between first and second half responses in Low Fatigue Participants (n = 33) during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
APPENDIX G

MIXED MEASURES ANOVAS WITH RACE AND GENDER
Analysis for Race

Separate 4 (difficulty) x 2 (fatigue) x 2 (race, Black & White) mixed measures ANOVAs were performed on the SBP, DBP, and HR data. Means and standard errors are available in Figures 1G-6G. Although there were violations of sphericity, no corrections were made since there was relatively little difference between results calculated with a corrected $df$ versus results without a correction. Only findings relevant to race are reported here, please refer to previous sections for the main cardiovascular response findings. There were no significant effects for race or interactions with race for SBP and DBP ($F_s \leq 1.42, ps \geq .24$). When HR was entered as the DV, the difficulty * race interaction approached significance $F(3, 225) = 2.58, p = .054$. Blacks had lower HR response during the hard difficulty task compared to Whites, $t(225) = 3.22, p = .002$. On all other difficulty levels, Whites had similar HR response levels as Blacks, $t_s < 1$. The effects for race and other interactions with race on HR were non-significant ($F_s \leq 1.38, ps \geq .20$). Race did not appear to influence SBP or DBP response; however, there were effects for race on HR present during the hard difficulty task period. The HR results should be interpreted with caution given the non-significant differences for the ANOVAs, minimal HR response values, and that these were not predicted findings.
Figure 1G. Mean SBP response (±SE) comparisons for White, Low Fatigue (n = 23) and White, High Fatigue (n = 29) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Figure 2G. Mean SBP response (±SE) comparisons for Black, Low Fatigue \( (n = 22) \) and Black, High Fatigue \( (n = 11) \) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Figure 3G. Mean DBP response (±SE) comparisons for White, Low Fatigue (n = 23) and White, High Fatigue (n = 29) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Figure 4G. Mean DBP response (±SE) comparisons for Black, Low Fatigue (n = 21) and Black, High Fatigue (n = 9) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Figure 5G. Mean HR response (±SE) comparisons for White, Low Fatigue \( (n = 23) \) and White, High Fatigue \( (n = 27) \) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Figure 6G. Mean HR response (±SE) comparisons for Black, Low Fatigue (n = 18) and Black, High Fatigue (n = 11) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Analysis for Gender

Separate 4 (difficulty) x 2 (fatigue) x 2 (gender) mixed measures ANOVAs were performed on the SBP, DBP, and HR data. Means and standard errors are presented in Figures 7G-12G. Although there were violations of sphericity, no corrections were made since there was relatively little difference between results calculated with a corrected df versus results without a correction. Only findings relevant to gender are reported here, please refer to previous sections for the main cardiovascular response findings. There were no significant effects for gender or interactions with gender ($F$s $\leq$ 1.60, $p$s $\geq$ .19), when SBP and DBP were the DV. Gender did not appear to influence SBP or DBP response. For HR, the main effect of gender and the gender * fatigue group- and difficulty * gender * fatigue group interactions were not significant ($F$s $<$ 1). However, the difficulty * gender interaction did approach significance, $F$ (3, 237) = 2.31, $p$ = .08. During the moderate tasks, females tended to have higher HR responses values than males, $t$ (237) = 2.51, $p$ = .01. This tendency was also marginally present during the easy task as we $t$ (237) = 1.84, $p$ = .07. When the task was hard or impossible, males and females had equivalent HR response, $t$s $<$ 1. The HR results should be interpreted with caution given the non-significant differences for the ANOVAs, minimal HR response values, and that these were not predicted findings.
Figure 7G. Mean SBP response (±SE) comparisons for Male, Low Fatigue (n = 23) and Male, High Fatigue (n = 10) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted. SBP, Male participants
Figure 8G. Mean SBP response (±SE) comparisons for Female, Low Fatigue ($n = 19$) and Female, High Fatigue ($n = 33$) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Figure 9G. Mean DBP response (±SE) comparisons for Male, Low Fatigue (n = 23) and Male, High Fatigue (n = 10) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Figure 10G. Mean DBP response (±SE) comparisons for Female, Low Fatigue (n = 22) and Female, High Fatigue (n = 33) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Figure 11G. Mean HR response (±SE) comparisons for Male, Low Fatigue (n = 24) and Male, High Fatigue (n = 10) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 SD units from their group mean at any level of difficulty and half combination were omitted.
Figure 12G. Mean HR response (±SE) comparisons for Female, Low Fatigue ($n = 17$) and Female, High Fatigue ($n = 32$) groups during auditory mental addition tasks of increasing difficulty. Participants with scores that deviated ±2 $SD$ units from their group mean at any level of difficulty and half combination were omitted.
APPENDIX H

IRB FORMS
Protection of Human Subjects
Assurance Identification/IRB Certification/Declaration of Exemption
(Common Rule)

Policy: Research activities involving human subjects may not be conducted or supported by the Departments and Agencies adopting the Common Rule (5FAR2003, June 18, 1991) unless the activities are exempt from or approved in accordance with the Common Rule. See section 101(a) of the Common Rule for exemptions. Institutions submitting applications or proposals for support must submit certification of appropriate Institutional Review Board (IRB) review and approval to the Department or Agency in accordance with the Common Rule.

Institutions must have an assurance of compliance that applies to the research to be conducted and should submit certification of IRB review and approval with each application or proposal unless otherwise advised by the Department or Agency.

1. Request Type [ ] ORIGINAL [ ] GRANT [ ] CONTRACT [ ] FELLOWSHIP
   [ ] EXEMPTION [ ] COOPERATIVE AGREEMENT [ ] OTHER:

2. Type of Mechanism:

3. Name of Federal Department or Agency and, if known, Application or Proposal Identification No.:

4. Title of Application or Activity Effects of Task Performance:

5. Name of Principal Investigator; Program Director, Fellow, or Other:
   WRIGHT, REX ALTON

6. Assurance Status of this Project (Respond to one of the following)
   [ ] This Assurance, on file with Department of Health and Human Services, covers this activity:
   Assurance Identification No. FHA0005806, the expiration date 12/28/10, IRB Registration No. IRB0000196

   [ ] This Assurance, on file with [agency/department], Assurance No. , the expiration date , IRB Registration/Identification No. , if applicable

   [ ] No assurance has been filed for this institution. This institution declares that it will provide an Assurance and Certification of IRB review and approval upon request.

   [ ] Exemption Status: Human subjects are involved, but this activity qualifies for exemption under Section 101(a), paragraph

7. Certification of IRB Review (Respond to one of the following if you have an Assurance on file)
   [ ] This activity has been reviewed and approved by the IRB in accordance with the Common Rule and any other governing regulations.
   by: [ ] Full IRB Review on (date of IRB meeting) or [ ] Expedited Review on (date) 12-3-08

   [ ] This activity contains multiple projects, some of which have not been reviewed. The IRB has granted approval on condition that all projects covered by the Common Rule will be reviewed and approved before they are initiated and that appropriate further certification will be submitted.

8. Comments

   Protocol subject to Annual continuing review:
   Effects of Task Performance

   HIPAA Waiver Approved?: N/A

   IRB Approval Issued: 12-23-08

9. The official signing below certifies that the information provided above is correct and that, as required, future reviewers will be informed until study closure and certification will be provided.

10. Name and Address of Institution
    University of Alabama at Birmingham
    701 20th Street South
    Birmingham, AL 35294

11. Phone No. (with area code) (205) 934-3788
12. Fax No. (with area code) (205) 934-1301
13. Email: smoore@uab.edu

14. Name of Official
    Marilyn Dosier, M.A.

15. Title
    Vice Chair, IRB

16. Signature
    [Signature]

17. Date
    12-23-08

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Informed Consent  
Effects of Task Performance  
Department of Psychology, UAB  
Investigator: Rex A. Wright, Professor  
Sponsor: National Science Foundation  

Explanation of Procedures  

The Department of Psychology maintains an active concern for the well-being of students participating in research. The following is provided so that you can decide whether you wish to participate in this study.

This research is concerned with how people respond psychologically and physiologically when they are confronted with different tasks. In the session today, you will be asked to perform tasks involving mental concentration and minor physical activity. More specifically, depending on the condition to which you are assigned, you may be asked to perform a math task, a scanning task, a color identification task, a speaking task, and/or an emotion expression task. Cardiovascular (CV) measures (e.g., heart rate) will be taken at points throughout the procedure. You also will be asked at times to respond to questions asking how you perceive yourself and the situation. The session will last no more than an hour.

Risks and Discomforts  

There are no notable risks or discomforts associated with today’s procedure. Your physiological responses will be measured with a conventional blood pressure cuff. There may be some discomfort when the blood pressure cuff is inflated, but that should be slight and last no more than a few seconds. You also could experience some degree of fatigue and stress. The fatigue and stress should be no more than you experience in a regular day (e.g., studying, doing homework, or taking notes). If you have any reservations about participating, notify the experimenter in charge and you will be dismissed. Similarly, if you continue with the procedure and then find that you would like to stop, you should notify the experimenter.

Benefits  

You are not expected to benefit directly from this research. On the other hand, you will have the opportunity to examine your CV responses at the end of the session. In addition, your participation may provide valuable information about CV function. This information ultimately could tell us why some people are at greater risk for CV disease than others and suggest treatments for people who are at risk.

Confidentiality  

The information gathered in this study will be kept confidential to the extent of the law. Findings as a whole may be published for scientific purposes; however, your individual identity will not be revealed. The Office of the UAB Institutional Review Board and the Sponsor, the National Science Foundation may review records for auditing purposes.

Date: March 26, 2005  
Participant’s initials ___________
Withdrawal Without Prejudice

You are free to withdraw your consent and to discontinue participating at any time without penalty.

Cost for Participation

There will be no cost to you for participating in this research.

Payment for Participation

You may be offered the chance to win a modest prize by performing up to a certain standard. You will receive one research credit for each half hour that you participate.

Alternative

Please note that you are not required to participate in a research project to receive research credit. As an alternative, you can read and prepare a report on a research article. To learn more about the alternative credit option, contact your class instructor.

Payment for Research-Related Injuries

UAB and the National Science Foundation have made no provision for monetary compensation in the event of injury resulting from the research. In the event of such an injury, treatment is provided, but not provided free of charge.

Questions

If you have any questions about the research or research-related injuries, Dr. Rex A. Wright will be glad to answer them. Dr. Wright’s phone number is 205-934-8725. If you have any questions about your rights as a research participant, Ms. Sheila Moore, Director of the Office of the UAB Institutional Review Board for Human Use (IRB), will answer them. Ms. Moore’s telephone number is 205-934-3789 or 1(800) 822-8816 (press the option for the operator/attendant and ask for extension 4-3789) between 8:00am and 5:00pm, Central Time, Monday through Friday.

Legal rights

You are not waiving any of your legal rights by signing this consent form.

Date: March 26, 2005

Participant’s initials ________
Signatures

You will receive a signed copy of this informed consent agreement. Your signature below indicates that you agree to participate in this study.

____________________________________  _____________ _______________
Signature of Participant                Date

____________________________________  _______________
Signature of Investigator                Date

____________________________________  _______________
Signature of Witness                    Date

Date: March 26, 2005
August 5, 2009

MEMORANDUM

TO: The UAB Graduate School

FROM: Ferdinand Urthaler, M.D.
Chairman, IRB

RE: Dissertation Research of Jason LaGory

Dr. Rex Wright is the Principal Investigator of the IRB approved protocol entitled, “Effects of Task Performance” IRB Protocol number X050314014. Dr. Wright submitted an amendment to the protocol in August of 2006 describing changes to the protocol which were approved by the Vice-Chair of the IRB on August 8, 2006. The IRB has been informed that the changes described in the amendment were to reflect the work that was to be conducted by Mr. Jason LaGory toward his dissertation. Mr. LaGory’s name was not added to the protocol and the IRB has just learned that the work described was for his dissertation. The changes to the protocol were approved and had Mr. LaGory’s name been included on the amendment, that addition would have been approved as amendment to Dr. Wright’s original protocol or Mr. LaGory would have been asked to submit a separate protocol. However, in either case, the work described would have been approved by the IRB.