COGNITIVE APPRAISAL, ANXIETY, AND COPING STRATEGIES IN MEDIATING SAM ACTIVATION TO A PSYCHOLOGICAL STRESSOR

THESIS

Presented to the Graduate Council of the University of North Texas in Partial Fulfillment of the Requirements For the Degree of

MASTER OF ARTS

By

Michael Ennis, B.A.

Denton, Texas

August, 1998

The purpose of this study was to examine Dienstbier’s (1989) hypothesis that SAM elicitation is prompted by subject's cognitive expectations of an acute stressor (‘challenge’ or ‘threat’ appraisal). Reported anxiety was also measured.

At all three time points the threat group had higher SAM activation than the challenge group. During the exam (assessed at time 3), overall SAM activation dropped regardless of cognitive appraisal group. There was a robust positive correlation between anxiety and SAM activation at baseline (time 1) and pre-exam (time 2). Post-exam (time 3), this correlation continued for the challenge appraisal group, but not for the threat group. Results demonstrate that cognitive appraisal and anxiety are significant mediators of SAM activation.
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Recent psychophysiological literature has well documented that excess stress in human subjects can produce significant negative neuroendocrine, immune and health consequences (Glaser, Rice, Sheridan, & Fertel, 1987; Kiecolt-Glaser, Dura, Speicher, & Trask, 1991). Perhaps this data has been too persuasive, producing an implicit tendency to regard stress as a uniformly negative event (Dienstbier, 1989), precluding research that could allow a different effect of stress to manifest itself. This supposition is particularly relevant in light of cognitive research which has long maintained that there is no single stress response, but rather a variety of responses dependant on each individual’s cognitions toward the stressor (Lazarus, 1966). Physiologically, differing beliefs about a stressor may lead to qualitatively different outcome measures.

The hypothalamus and pituitary are the main effectors of the neuroendocrine system; they link the brain and endocrine system by converting nerve impulses into hormonal responses. When an organism perceives a stressor in its environment, a
neuroendocrine response appropriate for that stressor will occur. The
neuroendocrine response allows the organism to adequately deal with stressors as
they occur. Having more than one neuroendocrine response provides the organism
flexibility in dealing with environmental stressors, allowing a different response to
be adopted if a previous one fails in a particular situation.

Two neuroendocrine pathways are activated in response to environmental
stressors: the sympathetic-adrenal-medullary (SAM) pathway and the
hypothalamic-pituitary-adrenal (HPA) axis. Henry and Stephens (1977) posit that
these pathways respond selectively to different environmental demands placed on
the organism. An organism facing a stressor may seek to overcome the situation by
perseverance and aggressive action, a response Henry and Stephens propose is
characteristic of SAM activation. In mammals, for example, this might include
behaviors such as defending one's territory, actively competing for resources, and
gaining reproductive access to mates. These traits are typically found in the
dominant members of the social hierarchy. Conversely, an organism may respond
to a stressor by initially withdrawing from it, reorganizing a new behavior later.
This is characteristic of HPA activation which may be typified by an animal that
concedes territory to another or adopts a submissive pose in competing for
resources. This type of behavior is common in subordinate members of a social
hierarchy. This differential neuroendocrine pathway activation by an organism’s social status has been very well documented by Fuchs, Johen, and Flugge (1993).

Henry and Stephens (1977) propose that an organism’s neuroendocrine response relates to the amount of control that it perceives it has over a stressor; that an organism’s perception of a stressor can be separated into “threat to control” or “loss of control.” An organism that perceives it has a “loss of control” will exhibit activation of the HPA axis. Behaviorally, this may be seen as an organism submitting to a more dominant animal or withdrawing from competition. In this pathway, the hypothalamus releases corticotropin releasing factor (CRF). CRF stimulates the pituitary to release adrenal corticotropic hormone (ACTH). ACTH, in turn, stimulates the adrenal cortex to produce corticosteroids such as prolactin, growth hormone, and in humans, cortisol. These corticosteroids disseminate throughout the organism and have many peripheral effects. Cortisol, as the classic “stress hormone” is an excellent index of HPA activation. It has been shown to produce immunosuppression by impairing the function of lymphoid cells (Landmann, Muller, & Perine, 1984; Maes, Bosmans, Suy, & Minner, 1991). Chronic elevated levels of corticosterone (equivalent to cortisol in humans) also
depress neural functioning in animals (Barnes, 1986) and can lead to hippocampal cell deterioration (Uno, Eisele, Sakai, & DeJesus, 1994).

In contrast, an organism that perceives a stressor as a “threat to control” will exhibit activation of the SAM system. A “threat to control” may be seen behaviorally as an organism actively confronting a specific stressor, such as defending territory or fighting for resources. The end result of this pathway is an increase in testosterone and the catecholamines epinephrine and norepinephrine. Central norepinephrine has been shown to inhibit the synthesis of serotonin and acetylcholine, which in turn are capable of stimulating the hypothalamic production of corticotropin releasing hormone (CRF) (Brady, 1994; Jones, Hillhouse, & Burden, 1976). It is CRH that stimulates the production of ACTH which produces cortisol and its immunosuppressive effects. ACTH production also appears to be inhibited in brain regions where norepinephrine is the primary neurotransmitter (Ganong, Kramer, Reid, Boryczka, & Shackelford, 1976). Peripheral hormones released by the immune system are thought to be able to cross the blood-brain barrier to cause the release of norepinephrine (Besedovsky, et al., 1983) with the effect of allaying immunosuppression (Schedlowski, Horsch, Oberbeck, & Schmidt, 1994).
Research with Non-Human Subjects

There has been a substantial amount of animal literature to support Henry and Stephen's premise that perceived controllability of a stressor is an important factor in determining the type of neuroendocrine response. Yoked-design experiments using rats, primates, and dogs have yielded similar results; subjects allowed control over an aversive stimuli have lower glucocorticoid levels than their no-control counterparts (Dess et al., 1983; Hanson, Larson, & Snowden, 1976; Henry, 1986). The health significance of higher HPA activation can be demonstrated by two yoked-design experiments using induced tumors in rodents. Tumor growth was accelerated in mice exposed to one session of inescapable shock, whereas mice exposed to controllable shock did not differ from non-shocked mice in tumor size and time of tumor appearance (Sklar & Anisman, 1979). Additionally, in rats, a single session of inescapable shock, but not of escapable shock, significantly impaired tumor rejection (Visintainer, Volpecilli, & Seligman, 1982). The possibility that these effects are mediated by immune suppression is suggested by studies showing that inescapable shock, but not escapable shock decreases specific immune functions (Sieber et al., 1992).

Research concerning learned helplessness also provides a great deal of illumination in this area. In a seminal study (Overmier & Seligman, 1967), two
groups of dogs received electric shocks in a yoked-design experiment. While both groups received the same amount of shock, one group had some control over it, while the other group did not possess any control over the stressor. By Henry and Stephen’s definition, the first group perceived a “threat to control” and the second perceived a “loss of control” over the stressor. After several trials, all subjects were then exposed to a controllable shock. The dogs that did not perceive having control over the previous shock exhibited “learned helplessness” during the subsequent, controllable shock, meaning they had the ability to stop the shocks, but they simply failed to do so. This can be seen as the passive behavioral response associated with “loss of control.”

One important discovery arising from this experiment is that learned helplessness only occurs soon after the uncontrollable stressor. With the passage of time, the subjects increasingly cease their learned helpless behavior. In 1970, Weiss, Stone and Harrell found that animals who exhibit learned helplessness had decreased central norepinephrine. They also found that as the norepinephrine accumulation increased with the passage of time, the subjects exhibited less helplessness. This strongly suggested that norepinephrine was the factor that produced active coping to an environmental stressor, and that absence of norepinephrine resulted in the passive, learned helpless behavior.
This hypothesis was aptly confirmed by Glazer, Weiss, Pohorecky and Miller (1975). These researchers gave subjects a monoamine oxidase inhibitor, which prevents the depletion of norepinephrine. Subjects who received this inhibitor did not exhibit learned helplessness when exposed to uncontrollable shock. This strongly supports Henry and Stephen's contention that catecholamines, at least norepinephrine, are essential in producing the active coping associated with an organism's perceived "threat to control."

Research with Human Subjects

While the Henry and Stephens model has a high predictive value in animals, attempts to apply the model to humans has produced mixed results. The disparate results can be characterized along two distinct lines: biochemical research and experimental social research. The biochemical research in humans is closely related to the animal research already cited, in that the dependent variables are typically familiar neurohormones such as catecholamines and corticosteroids, which have been well documented in animal research. Not surprisingly, results of this type of human research tallies well with the Henry and Stephens model. However, human experimental social research has produced data that appears contrary to the predictions of the Henry and Stephens model. These experiments use dependent variables such as internal cognition and self report. While these
Biochemical Human Research

Two studies (Rodin, 1980; Rodin & Langer, 1977) allowed nursing home residents to participate in decision making at their facility. They found that under this program, subjects' cortisol levels dropped below the established baseline. By allowing these residents greater control over their environment, activation of the HPA axis was decreased. After 18 months of this program, residents showed significantly greater improvements in health than a control group of residents. Compared to a 25% mortality rate in the nursing home in the 18 months before intervention, only 15% of the subjects in the intervention group died. In the same period, 30% in the control group died.

Croes, Merz and Netter (1993) had subjects engage in a false feedback number addition task. One group perceived that they were able to adequately perform the task as they were told their additions were accurate. The other group, in contrast, perceived that they were unable to adequately perform the task since they were told their additions were inaccurate. Subjects who perceived an inability
to exhibit proficiency at this had significantly increased cortisol
compared to baseline levels. Interestingly, these authors report a significant
decrease in cortisol relative to baseline in subjects who did perceive themselves as
proficient at the task. Thus, subjects who perceived they could exhibit control over
the stressor had decreased HPA activation, while those who perceived they could
not exhibit control had increased HPA activation.

In a similar manner, Hyyppa (1983) had subjects engage in a cognitive task
which was paced so that effort was required to perform the task well, but without it
being overwhelming. In these subjects the psychological stressor produced a
decrease in prolactin and cortisol, attributable to the fact that subjects were
allowed to adjust the pace to a controllable level. By allowing subjects control in
performing the task, HPA axis activation was reduced.

Experimental Social Human Research

Research that is cognitively oriented, however, has produced data that
appears to contradict the Henry and Stephens model. These studies include
examples in which subjects report more distress and anxiety when they are given
more control over their environment. Unfortunately, there is some difficulty in
comparing the human biochemical research and the experimental social research
because they both tend to be limited in their scope in inquiry. The biochemical
studies largely ignore self-report by subjects, thereby giving no idea of their affective state at the time. Conversely, the experimental social research does not provide any physiological measures that would allow comparisons with animal and human neuroendocrine studies.

Mills and Krantz (1979) performed an experiment using blood donors as subjects. Donors were given information to increase perceived control over the blood draw. They were instructed how to increase their self-control and behavioral control. Subjects who were given both forms of control reported more distress than subjects who were only given one form of control. The authors conclude that subjects were given a larger executive part in their blood draw than they would have liked. Similarly, patients undergoing medical procedures who received pre-admission interventions to enhance their sense of control over the operation failed to have better outcomes than patients who did not receive these interventions (Fuller & Endress, 1978; Hill, 1982; Johnson & Levanthal, 1974). In their review of the literature, Miller, Combs and Stoddard (1989) conclude that patient information and control in these situations, "can sometimes facilitate patient adjustment, [and] can also have the reverse effect" (p. 125).

In addition, control over a stressor may be disruptive to a subject whose preferred style of dealing with the world is avoidance rather than confrontation.
Averill, O'Brien and DeWitt (1977) performed a shock-avoidance experiment in which subjects could choose whether or not to listen to a warning that signaled an upcoming shock. The warning gave subjects potential control over the aversive stimulus by allowing them to avoid the shock by a switch. In each of the 12 trials, subjects were informed as to how effective the switch was likely to be in preventing the shock. The response effectiveness ranged from 0% to 100%. Subjects who preferred having some control over the situation by choosing to listen for the warning period reported less distress as their effectiveness of stopping the shock increased. In contrast, subjects who preferred not to listen for the warning reported more distress as effectiveness of stopping the shock increased. Subjects whose preferred style was avoidance of a stressor reported more distress as their control over the aversive stimuli increased.

Theory of Human Stress and Coping

The disparity that appears to be present in these experiments can be reconciled by looking at the cognitive theory of stress and coping in humans, espoused by Richard Lazarus and his colleagues. Folkman (1984) describes stress as “a particular relationship between the person and the environment” (p. 840). This is a bidirectional relationship with the person and the environment constantly acting upon each other. In order to understand the stress experienced by a
particular individual, the significance of the event to that individual must be known. Stress arises only when a particular transaction is viewed by the individual as relevant to his or her well-being (Folkman & Lazarus, 1985). An exam, for example, may be stressful for a student because it threatens his or her grade for the class. In turn, the grade in the class may be relevant for admission to graduate school, which, in turn, may be important for realizing long term career goals. The student who values these things is likely to experience the exam as a stressor, while someone who does not value these particular goals will not perceive the exam as a stressor since it is impertinent to his or her well-being (Folkman & Lazarus, 1985).

**Challenge vs. Threat Appraisal of a Stressor**

Once ego involvement in the stressor at hand has been determined, the individual must now make an appraisal of his or her ability to handle the demand. A threat appraisal refers to a perceived potential for harm or loss, while a challenge appraisal refers to a perceived potential for growth, mastery or gain (Folkman, 1984). A subject makes an appraisal based on his or her coping resources in dealing with the demand. For example, a student facing an exam would evaluate his or her resources to cope with this stressor by considering such things as: have I studied for this exam? have I attended classes regularly? do I
consider myself skilled in this subject? how have I performed on previous exams? Based on these considerations, the individual will make an assessment concerning his or her performance on the exam. In one case, subjects may evaluate their coping resources for the exam and feel that it will probably exceed their ability to do well. This group would be making a threat appraisal of the environmental stressor. Conversely, a different group may evaluate their coping resources for the exam and conclude that they expect to perform well. These individuals would be making a challenge appraisal of the stressor. In this case, two groups are facing the exact same stressor with very different expectations of the outcome. One group feels unable to meet the demand (threat appraisal), while the other group does feel able to meet the demand (challenge appraisal).

As Folkman (1984) describes, a threat appraisal refers to a perceived potential for harm or loss, while a challenge appraisal refers to a perceived potential for growth, mastery or gain. Particularly with a fairly routine stressor, such as an exam would be to a student, subjects have some kind of expectation of what will be happening to them and how well they expect to perform, based on evaluations of one’s personal abilities and how past events transpired.
This implicit cognitive appraisal of a stressor must be taken into account in human cognitive research. Experiments in the area of stressor research which use animal methodologies cannot be accurately applied to human subjects. Asking a rat how it expects to perform in a stressful situation is clearly inappropriate. Conversely, asking a person how he or she expects to perform on a stressor is obviously quite relevant. Differences in how humans and non-humans cognitively evaluate stressors has probably caused the disparity in human research where the Henry and Stephens model has been applied. By using constructs that are better suited to human experience, the Henry and Stephens model will be tested to confirm its predictive value in human subjects.

**Problem-focused vs. Emotion-focused Coping**

Coping refers to an individual’s cognitive and behavioral efforts to manage an environmental demand. This may be done by mastering the stressor, reducing it in some way, or simply tolerating it. Coping has two major functions: the regulation of distressing emotions (emotion-focused coping) and manipulating the environment to reduce the stressor that is causing the emotional distress (problem-focused coping) (Folkman & Lazarus, 1980). Problem-focused coping, with the subject’s energy directed externally at changing the environmental demand, is usually more indicative of a challenge appraisal. Emotion-focused coping is more
often associated with a threat appraisal, with the subject's energy
directed more internally at regulating the emotional distress of an environmental
demand that cannot be mitigated (Folkman & Lazarus, 1985).

This cognitive approach to understanding stress has advantages in human
research that the “threat to control” and “loss of control” perceptions of Henry and
Stephens do not. For example, in an animal study, the subjects will manifest
control or loss of control by how they manipulate their external environment.
However, for humans the scenario is more complex. In addition to the ability to
manipulate their external environment as animals can, humans can also manipulate
their internal environment. This is the distinction between problem-focused coping
and emotion-focused coping (Folkman, 1984). Problem-focused coping is solving
or adjusting to an environmental demand, while emotion-focused coping is
regulating the psychological distress engendered by the demand (Folkman &
Lazarus, 1980). An example of problem-focused coping in humans may be a
student actively concentrating as much as possible on an exam in order to attain
the highest grade possible. In contrast, emotion-focused coping may be a subject
that rationalizes to him or herself that the exam at hand is not very important and
will have little effect on his or her future. While both of these means of coping are
attempts to control the immediate stressor, they are likely to produce markedly
different objective results on the exam score. The subject using problem-focused coping will likely have a higher score than the subject using emotion-focused coping. However, in both cases subjects were actively working to control the situation, but the different coping strategies produce different objective results. Even subjects who entirely give up may be using emotion-focused coping to control their disappointment.

Based on Dienstbier’s early work (1979), it is hypothesized that subjects making a challenge appraisal of a stressor are likely to use more problem-focused coping strategies, while subjects making a threat appraisal are likely to use more emotion-focused coping. For example, a student making a challenge appraisal of an exam expects to do well on it. Since the student expects to do well, the psychological distress engendered by the demand is neutralized because the student expects to show mastery, gain or growth by the experience. Conversely, a student making a threat appraisal of the exam expects to perform poorly on it. Since this student feels that he or she simply does not have the resources to do well on the exam, problem-focused coping cannot be achieved. Therefore, emotion-focused coping is expected to be predominant. With emotion-focused coping, the student may rationalize that the test is unimportant, engage in wishful thinking or denial, or assign blame for the poor grade on someone else, etc. When problem-
focused coping can be done, the need to use emotion-focused coping, while not eliminated, is minimized. When problem-focused coping is not available, emotion-focused coping is expected to increase (Folkman & Lazarus, 1985).

**Synthesis of Neuroendocrine and Cognitive Theories of Human Stress and Coping**

This approach to stress emphasizes that neuroendocrine responses to a psychosocial environment reflect its emotional impact on the individual. The emotional impact, in turn, is determined by the person's cognitive appraisal of the demand in relation to his or her coping resources (Frankenhaeuser, 1986). The Henry and Stephens model successfully demonstrates the value of this approach in animal subjects. The task at hand is to adapt it so it can be equally successful in human research. In animals, Henry and Stephens predict "threat to control" to result in SAM activation, and "loss of control" to result in HPA activation. Based on Lazarus' theory of human stress and coping, this model can be adapted for humans by restating it: a challenge appraisal is predicted to result in SAM activation, and a threat appraisal is predicted to result in HPA activation. It is important to note that "threat to control" (Henry and Stephens) is proposed to elicit SAM activation, while "threat appraisal" (Lazarus) is conversely predicted to elicit HPA activation. This is a common source of confusion since the same word is
being used in these two different models to denote the opposing type of neuroendocrine activation.

Challenge appraisal vs. threat are constructs that allow operational definitions that are more testable in a human population. Human subjects can self-report their anxiety upon engaging a stressor, with less anxiety (more positive affect) indicating a challenge appraisal, and higher anxiety (more negative affect) indicating a threat appraisal (Dienstbier, 1979). As previously stated, these appraisals allow for the (presumably) unique human characteristic of speculating about what the future will hold, and how adequately one feels prepared in dealing with these impending demands. This type of implicit appraisal, inevitable in humans is presumably absent in animals, and as such, is not addressed by the Henry and Stephens model.

In an influential article, Dienstbier (1989) combined the neuroendocrine animal model of Henry and Stephens with the human cognitive theory of Lazarus and his colleagues. He cites data suggesting that the two neuroendocrine pathways respond differentially to a psychological stressor perceived as a challenge vs. threat. For example, increased SAM activation correlates with higher scores on academic tests and vigilance tasks (Johansson & Frankenhaeuser, 1973; Johansson, Frankenhaeuser & Magnusson, 1973; O’Hanlon & Beatty, 1976;
Rauste-von Wright, von Wright & Frankenhaeuser, 1981). Presumably, subjects who performed well on these measures were making a challenge appraisal of the stressor with concomitant SAM activation. This conclusion is bolstered by cognitive measures which associate SAM activation with higher reported school satisfaction, emotional stability, lower psychosomatic symptomology and, in males, with lower anxiety, neuroticism, lower day-to-day reported stress, and increased ego strength (Forsman, 1981; Frankenhaeuser & Magnusson, 1973; Johansson, Rauste-von Wright, von Wright & Frankenhaeuser, 1981; Roessler, Burch & Mefferd, 1967).

The intensity of the stressors that Dienstbier reviews range from the fairly mild (i.e. vigilance tasks) to the extreme (i.e. skydiving), and from this gradation he concludes that SAM activation is never too high for optimal performance (Dienstbier, 1989, p. 86). However, other approaches suggest the relationship between SAM activation and challenge appraisal may not be unilateral when dealing with a routine, daily psychological stressor. For example, in a 1979 experiment, Marshall and Zimbardo injected subjects with epinephrine and placed them in different environments to determine the role social attribution plays in the subjective experience of emotions. Contrary to Dienstbier's prediction that subjects would experience emotions indicative of a challenge appraisal, subjects
were instead biased toward negative emotions, such as anxiety and anger, independent of environment. Other research supports this intuitive conclusion that the increased heart rate, tremor and sweaty palms associated with sympathetic activation are perceived negatively under conditions that do not require such excessive arousal to adequately cope (Maslach, 1979).

In fact, as early as 1962 in her review of the literature, Duffy concluded that a moderate degree of physiological arousal produces optimal performance in human subjects. An increase in arousal from baseline facilitates attention to task-relevant cues, thereby enhancing cognitive performance (Matthews, Davies, & Holley, 1990; Matthews & Margetts, 1991), but only to a point. In contrast to Dienstbier, she posits that further arousal impairs performance by increasing attention to irrelevant cues, resulting in anxiety and further distractions. Subsequent research has shown this effect to be particularly true of complex stressors, such as an exam, in which a lower level of arousal produces optimal cognitive performance (Anderson, 1994).

Research stemming from Dienstbier’s hypothesis has produced mixed results. A 1993 experiment assessed challenge vs. threat appraisals to a mental arithmetic task with cardiac reactivity (Tomarka, Blascovich, Kelsey & Leitten, 1993). One parameter these researchers used was heart pre-ejection period, which is
considered a relatively pure index of central sympathetic activation (Cacioppo, Uchino & Berntson, 1994). Consistent with Dienstbier's predictions, challenge appraisals to the stressor produced more initial cardiac reactivity, explained by these authors as increased mobilization of energy to effectively deal with the stressor. While this seems a reasonable conclusion, there is a point of contention in that this effect was found only during the first task exposure of four minutes. When subjects again experienced a highly similar stressor for another four minutes, the same physiological activation failed to occur. The brevity of the effect may be reflecting subject's response to the novelty of the laboratory environment or apprehension of being evaluated by others, rather than energy mobilization.

Additionally, research from the field of psychoneuroimmunology sheds light on the role the neuroendocrine system plays in response to a stressor. That stressors can produce impairments in immune function is well documented (Dantzer & Mormede, 1995); however, research also indicates that acute stressors can produce transitory enhancement of several immunological parameters (Bachen et al., 1992; Bosch et al., 1996; Brosschot et al., 1994). Maes et al. (1997) address this disparity by dividing subjects facing an exam into high and low perceived stress. They found that subjects reporting high perceived stress to the exam also
had increased levels of serum immunoglobulins (IgA, IgG and IgM) compared to the low stress group. This finding is relevant to the present discussion since immunoglobulin production results from increased SAM activation (Madden & Felten, 1995). This suggests that, contrary to Dienstbier’s predictions, students reporting high perceived stress, indicative of a threat appraisal, had elevated SAM elicitation from baseline significantly higher than the low stress group.

**Hypotheses and Operational Definitions**

The present experiment investigated the relationship between an individual’s subjective experience and objective physiological response to a naturalistic, routine exam stressor. Specifically, Dienstbier’s 1989 hypothesis that challenge appraisals would be related to an increase in SAM activation, while threat appraisals would be related to its decrease, was examined. Additionally, it was predicted that lower anxiety would be related to challenge appraisals and higher problem-focused coping, and that higher anxiety would be related to threat appraisals with higher emotion-focused coping. To operationalize challenge vs. threat appraisal, participants were asked immediately before the exam (time 2), what grade on the upcoming test each would consider to be personally “just good enough.” Also at this time each participant was asked to predict as accurately as possible what grade he or she expected to make on the exam. Subjects predicting a
grade equal to, or higher than their “just good enough” grade were assessed as making a challenge appraisal of the exam. Conversely, subjects predicting a grade below their “just good enough” grade were assessed as making a threat appraisal.

Anxiety was assessed by the State Anxiety Inventory (Spielberger, Gorsuch, Luschene, Vagg, & Jacobs, 1983) to operationalize experienced anxiety. This scale was altered for time 1, by changing the directions in asking participants to report how they have been feeling “generally, within the past week or so.” This was done so that subject’s reported general state anxiety at baseline could be discerned from the acute state anxiety evoked by the exam stressor. By using the same scale, it can be assured that any differences between the two time points reliably reflect subject’s anxiety to the stressor at hand, rather than an overall stable anxiety level.

Emotion-focused vs. problem-focused coping strategies were assessed by the COPE Inventory (Carver, Scheier & Weintraub, 1989). Items that were clearly inappropriate for an exam stressor were excised from this measure.

The experiment was divided into three time points: baseline (at least a week before the exam), time 2 (immediately before the exam), and time 3 (the sample taken immediately after the exam.) SAM activation was indexed by total urinary catecholamines (epinephrine, norepinephrine, and dopamine), assayed by low
pressure liquid chromatography. Urinary measures reflect each subject's neuroendocrine response of the previous hour or more (Frankenhaeuser, 1986), and subjects completed the exam stressor in an average of slightly over one hour.

Method

Subjects

Fifty-five female and 24 male University of North Texas undergraduates were recruited through class announcements. Participant’s ages ranged from 18 to 44, with a mean of 24 years. All were enrolled in a psychology class and received extra-credit points for participation; each had successfully passed at least one previous psychology class. A total of six classes were used; five used the second exam as the stressor, and the sixth used the third exam. The exam stressor was neither the midterm nor final in order to assess responses to a "typical" stressor.

Potential subjects were excluded from the experiment if they were on any medication, including birth control pills, or suffering from any illness (physical or mental) no matter how slight, or in remission, throughout the entire experiment. Additionally, pregnant females were excluded. Subjects who met the exclusionary criteria were then instructed to comply with pre-experimental requirements before giving each urine sample. Specifically, subjects affirmed they had abstained from
caffeine and nicotine for at least four hours and all other drugs and
alcohol for at least twelve hours prior to giving their sample. Subjects were also
required to have obtained adequate sleep the night before. All participating
individuals gave informed consent for the experiment. The study protocol was
approved by the Human Subjects Protection Committee of the University of North
Texas.

Materials

Urinary catecholamines were assayed using low pressure liquid
chromatography using a weak cation-exchange resin (BioRex-70, 150-200 mesh)
to selectively bind total catecholamines from each urine sample. Catecholamines
were eluted by reducing the column pH and were then measured at 210 nanometers
on an Iso-Data UV spectrophotometer. Light absorbance values were then
converted to ug/mL via linear regression (r = .95).

Procedure

All urine samples were taken between 7:45 a.m. and 11:15 a.m. on weekdays
to control for diurnal effects. Samples were acquired from the 1996 fall semester
and the 1997 spring semester at the University of North Texas.

**Time 1 (baseline).** Subjects were required to give the baseline sample on a
day when no exams or "stressful" appointments were scheduled. Upon arrival at
the laboratory, subjects were informed of the general purpose of the experiment, the procedure, and that participation was voluntary. Each participant was then asked to fill out a questionnaire surveying his or her present health status and answered questions confirming that all pre-experimental requirements had been met. Individuals were subsequently given a cup to collect their first urine sample and were asked to acquire the sample mid-stream if possible. All samples were labeled and refrigerated. Following sample collection, each subject was administered the State Anxiety Inventory (altered to assess general state anxiety), and asked, for the upcoming test what grade he or she would consider a "personal failure", "just good enough," and "the best grade that could reasonably be expected." To control for potentially confounding variables the participants also provided their cumulative g.p.a., satisfaction with their current class grade, predicted class grade, and how satisfied he or she would be with this grade using a five point Likert scale (1="very dissatisfied" to 5="very satisfied").

**Time 2 (pre-test).** The procedures for time 2 (pre-test) and time 3 (post-test) occurred on exam day. Subjects had received a handout at baseline reminding them to observe all pre-experimental restrictions, sleep a normal amount the night before, and drink at least 12 ounces of water about an hour before coming to the laboratory. Immediately before their scheduled exam, subjects came to the
laboratory and filled out the questionnaire surveying present health status, and signed the affidavit affirming all pre-experimental restrictions had been observed, and that they had no other exams that day. If any of these requirements was not met, the subject was not allowed to participate. Subjects were then given a urine collection cup and asked to completely empty their bladder, acquiring the sample from midstream if possible. Subjects were then administered the State Anxiety Inventory and a questionnaire asking them to predict as accurately as possible their grade on the impending test, and how satisfied they would be with this grade using a five-point Likert scale (1= "very dissatisfied" to 5= "very satisfied"). Participants provided their current class grade, and were asked again what grade they would personally consider a "personal failure," "just good enough," and the "best grade that could reasonably be expected," to determine if these parameters had changed since baseline. Subjects were provided with water and instructed to walk directly to the classroom to take the exam.

**Time 3 (post-exam).** Upon completing the exam, subjects were instructed to walk directly back to the laboratory. They were administered the State Anxiety Inventory, the COPE Inventory, and asked to predict as accurately as possible what grade they made on the test just taken, and how satisfied they were with this expected grade using a five-point Likert scale (1= "very dissatisfied" to 5= "very
satisfied”). Each subject’s actual exam grade was subsequently obtained. Subjects were given a collection cup and asked to give their final urine sample, from mid-stream if possible. After collecting the sample, participants were debriefed.

Results

While a total of 79 subjects participated in the experiment, not all of them contributed a urine sample at every time point. Due to subject attrition and experimenter error, there were 36 subjects in the data analyses who had urine samples at both times 1 and 2; 32 subjects who had urine samples at both times 2 and 3; and 24 subjects who had urine samples at all 3 time points. There were 58 individual samples at time 1, 45 samples at time 2, and 41 samples at time 3. All subsequent statistical procedures are denoted with the number of subjects used in each analysis, and all data analyses are two-tailed unless otherwise noted.

As a result of the missing data, original a priori statistical analyses planned were amended for optimal use of the data that was attained. Specifically, a repeated measures ANOVA of anxiety by catecholamine levels across all three time points was changed to correlations of anxiety and catecholamines at each time point, as well as an ANOVA across times 2 and 3. Each subject’s “just good enough” grade was ascertained at time 1 (baseline) and time 2 (pre-exam) to
determine cognitive appraisal. While these two measures were highly correlated (Pearson's $r (67) = .501, p = .001$) the time 2 “just good enough” grade was used to assess subjects’ challenge vs. threat appraisal in light of the fact that this more accurately reflected the appraisals of subjects actually taking the exam.

It was first established that potentially confounding factors did not impact the acute stressor examined. Cumulative g.p.a., current class grade, subject’s satisfaction with their current class grade, expected final grade, satisfaction with this expected final grade, and actual exam grade scored did not significantly correlate with catecholamine levels at any time point (all analyses, $p > .1$). Furthermore, basal catecholamine levels did not significantly correlate with catecholamine levels at the onset of the stressor, determined by correlating them at times 1 and 2, of subjects who had samples at both time points (Pearson’s $r (36) = .089, p = .603$). In addition, subjects with samples at all three time points did not have significant correlation between these two catecholamine levels (Pearson’s $r (24) = .021, p = .907$).

Challenge vs. threat appraisal in relation to the exam stressor was assessed independently from baseline using a repeated measures ANOVA pre and post-exam. The 36 subjects with samples at both times 2 and 3 were used in this analysis. Results indicated a main effect of group, $F (1,30) = 5.308, p = .028,$ and
time, $F(1,30) = 16.67, p = .001$; there was no interaction, $F(1,30) = 1.28, p = .267$. Catecholamines were significantly higher for subjects making a threat appraisal than those making a challenge appraisal. Subject’s predicted grade at time 2 was significantly correlated with their predicted grade at time 3 (Pearson’s $r(36) = .539, p = .001$), suggesting that cognitive appraisals were relatively stable throughout the stressor.

There was a significant difference in anxiety between the challenge and threat groups. The threat appraisal group reported more anxiety as determined by a repeated measures ANOVA across times 2 and 3, $F(1,30) = 5.814, p = .025$. General state anxiety was positively correlated with resting time 1 catecholamine levels (Pearson’s $r(58) = .364, p = .005$). Acute state anxiety in anticipation of the stressor was positively correlated with time 2 catecholamine levels (Pearson’s $r(45) = .380, p = .01$), while anxiety measured immediately after the exam was not significantly correlated with time 3 catecholamine levels (Pearson’s $r(41) = .230, p = .148$). However, post hoc analyses of challenge vs. threat groups independently produced interesting results. Subjects making a challenge appraisal had a significant correlation between time 3 catecholamines and anxiety (Pearson’s $r(27) = .512, p = .01$); subjects making a threat appraisal did not attain statistical significance between these two measures (Pearson’s $r(14) = -.216, p = .459$). The
two correlations were significantly different as assessed by Fisher's $r'$ to $z$ score transformation (obtained $z$ score = 2.15, $p = .046$).

Problem-focused coping was significantly correlated with time 2 anxiety (Pearson's $r$ (65) = -.283, $p = .022$), but not time 3 anxiety (Pearson's $r$ (65) = -.184, $p = .141$). Problem-focused coping was not significantly correlated with times 2 or 3 catecholamines (Pearson's $r$ (42) = -.134, $p = .398$; Pearson's $r$ (38) = .006, $p = .973$). There was no significant difference between the challenge and threat groups ($t = -.327, p = .746$).

Emotion-focused coping was not significantly correlated with times 2 or 3 anxiety (Pearson's $r$ (65) = .147, $p = .246$; Pearson's $r$ (65) = .083, $p = .512$). It was significantly correlated with time 2 catecholamines (Pearson's $r$ (42) = .337, $p = .029$), but not time 3 (Pearson's $r$ (38) = -.085, $p = .618$). There was no significant difference in emotion-focused coping between the challenge and threat groups ($t = -.066, p = .947$).

Discussion

Results demonstrate that cognitive appraisal of an acute psychological stressor determines urinary catecholamine output, which is a direct measure a SAM activation. Catecholamine levels were elevated in individuals making a threat appraisal of the exam relative to those making a challenge appraisal,
especially immediately prior to the exam (time 2). Although the interaction was not significant, it can be seen from the data that the catecholamine levels evidenced by those making a threat appraisal were much higher than those making a challenge appraisal pre-exam, in anticipation of the stressor. While a subject’s predicted grade throughout the exam remained relatively stable, overall catecholamine levels significantly dropped in slightly over one hour. Thus, in accordance with Duffy (1962), lower SAM activation was manifested in subjects performing a complex, psychological stressor, regardless of subject’s anticipatory appraisal of the stressor (i.e., challenge vs. threat).

Henry and Stephens (1977) provide a caveat to their hypothesis that is relevant to the present discussion. These authors state that their predicted neuroendocrine responses will occur only when the organism cannot deal with the stressor at a higher neural level. Presumably in this case, the highest level of dealing with the stressor would be self-perceived efficacy in answering the exam questions correctly. Subjects making a challenge appraisal apparently felt able to achieve this standard, thereby allaying the expected neuroendocrine arousal. Conversely, subjects unable to deal with the exam at this higher level default to the older limbic response resulting in SAM “fight or flight” activation (Henry & Stephens, 1977).
Catecholamine levels were positively correlated with anxiety pre-exam. It is important to note that basal catecholamine levels were not correlated with levels immediately prior to the exam, thus signifying that the responses seen were in anticipation of the exam, and not necessarily a resting *a priori* difference among subjects. It is also very interesting that basal catecholamines were correlated (positively) with general state anxiety. Highly anxious individuals had higher resting catecholamine levels, a result that, while expected, has not always been reported (see below). While the present results concerning anxiety to an acute stressor run counter to Dienstbier's expectations, one prediction of his is that resting SAM activation at baseline correlates with trait anxiety. He posits that subjects who have successfully faced past intermittent stressors become "physiologically toughened," resulting in lower resting sympathoadrenal levels and higher emotional stability. This idea supports previous data associating elevated resting sympathetic arousal with persons predisposed to hypertension and other health problems (Collins, Baum & Singer, 1983; Manuck & Krantz, 1986). This data is particularly important in that Peronnet (1986) did not find baseline SAM activation differences in high vs. low trait-anxious subjects. However, these researchers assessed plasma catecholamines, which provide a more "minute-to-minute" response to stressors, whereas by assessing urinary catecholamines, it was
possible to obtain a more “overall” picture of subjects’ resting physiological levels (Frankenhaeuser, 1986).

While anxiety and SAM activation have robust positive correlations at times 1 and 2, these two variables were not statistically significant at time 3. However, by assessing the challenge and threat groups independently, interesting results emerge unique to this time point. In the challenge group there is a strong positive relationship between anxiety and SAM activation, consistent with results found at times 1 and 2, but potentially more interesting is that the threat group has a negative correlation between these two variables. While the correlation of the threat group is not statistically significant in itself, it is significantly different from the correlation of the challenge group, suggesting a tangible difference in how these groups respond during the exam. The lack of correlation in the threat group may reflect subjects’ diverse strategies in dealing with their expected failure; i.e., some subjects may continue struggling with the exam, while others may simply give up. This variability in dealing with the stressor produces a weaker correlation than that found in the challenge group.

Overall, the present results suggest two possible amendments to Dienstbier’s (1989) hypothesis concerning physiological arousal to an acute stressor. First, his assertion that SAM activation is never too high to produce
optimal performance is not supported in subjects facing a complex, psychological stressor. Notably, some previous studies do support Dienstbier using fairly complex, psychological tasks, but these researchers may have been inadvertently been tapping subject's response to the novelty of the laboratory experience (Dienstbier, 1991), hesitation in being evaluated by others, or uncertainty of what the task would require of them (Tomaka, Blascovich, Kelsey, & Leitten, 1993), making accurate appraisals of the stressor difficult. The present study is unprecedented in explicitly testing challenge vs. threat appraisals to a naturalistic, real-world stressor, reducing these kinds of experimental artifacts, and under these conditions, both challenge and threat groups had markedly decreased catecholamine levels during the exam, as predicted by Duffy (1962).

Secondly, in anticipation of the stressor, there was a difference between the threat and challenge groups, although in the opposite directions predicted by Dienstbier. Present data supports the intuitive conclusion that the increased heart rate, tremor, and sweaty palms associated with sympathetic activation are perceived negatively under conditions that do not require such excessive arousal to adequately cope (Maslach, 1979). The difference in physiological arousal for subjects anticipating a stressor, and actually experiencing it, may suggest that two different activating mechanisms are at work. Anticipatory stress, which tends to be
more ambiguous and uncontrollable, may not be accurately predicted by Dienstbier’s hypothesis. Future research may benefit from clearly distinguishing anticipatory stressors from actual experienced stressors, which could at least potentially allow an active coping response.
REFERENCES


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