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SELF-ESTEEM, FAILURE FEEDBACK AND PHYSIOLOGICAL REACTIVITY: IMPLICATIONS FOR WORKING MEMORY AND AGGRESSION

by

JOHN PATRICK RYAN

Under the Direction of Tricia Z. King

ABSTRACT

Research has recently begun to focus on separable conscious and subconscious aspects of self-esteem. Meanwhile, research on aggressive behavior has found that some individuals with high self-esteem are more prone to aggressive behavior. Based on a biopsychosocial approach, research has shown that appraisals of threat/challenge are marked by distinct physiological responses – threat appraisals are marked by activation of the hypothalamic-pituitary-adrenal axis, whereas challenge appraisals are marked by activation of the sympathetic adrenal-medullary axis. The present study examines the relationship between failure feedback, implicit and explicit self-esteem, appraisals, working memory and aggression in a series of three experiments. Experiment 1 examined the impact of failure feedback on stress physiology and found that individuals who displayed a physiological response to failure feedback consistent with a

challenge response, as indicated by an increase in blood pressure without a concurrent increase in salivary cortisol, were the most likely group to become aggressive. Experiment 2 examined the relationships between implicit and explicit self-esteem in predicting aggressive behavior. Implicit self-esteem predicted behavioral inhibition in response to negative feedback such that higher implicit self-esteem was associated with fewer behavioral inhibition errors. In Experiment 3, threat/challenge motivations were manipulated to determine their impact on working memory performance. Increases in feelings of threat were associated with greater working memory performance, whereas increases in feelings of challenge were associated with decreases in working memory performance. The present study is the first to examine aggression in the context of threat/challenge appraisal responses. Overall, this study suggests that appraisals and physiology can assist in predicting aggressive behavior, although the cognitive mechanism by which this occurs remains elusive.

INDEX WORDS: Self-Esteem, Social Psychology, Psychophysiology, Aggression, Working Memory

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JOHN PATRICK RYAN

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Composing a dedication to all of the individuals who have provided me social support over the past 30 years is an impossible task as they are too numerous to mention. First and foremost, I dedicate this dissertation to my parents and grandparents who instilled in me an intellectual curiosity and fostered my education. I also wish to acknowledge Cyma van Petten, Ph.D. and Tricia King, Ph.D. – two professors who have served as academic mentors and challenged me to apply myself and expand my goals. Finally, a special dedication to my lab mates – Jackie Micklewright, Matthew Mumaw, Emily Papazoglou, and Alex Kohl – who have helped me keep my (in)sanity over these past two years.

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CHAPTER ONE: REVIEW

How do our feelings about our self affect how we react to events in our lives? For more than one hundred years, a key concept in Psychology has been *self-esteem*, first defined by William James (1890a) as the ratio of our successes to our pretensions. Nearly a century later, this concept experienced a golden age when it was suggested as a panacea for activities ranging from academic performance (Lane, Lane, & Kyprianou, 2004) to schizophrenia (Knight, Wykes, & Hayward, 2006). As research has focused on self-esteem, it has become better understood as a multi-faceted phenomenon that plays a central role in day-to-day experiences (Baumeister, Campbell, Krueger, & Vohs, 2003). The present study examines how self-esteem may serve as a buffer from ego-threatening criticism, and how insufficient levels of implicit self-esteem may deplete working memory, making individuals more prone to aggressive behavior.

The Self

At the heart of the issue is the self, a concept that has been present in Psychology and Philosophy since the time of the ancient Greeks. In modern Psychology, the self is seen as a multi-faceted construct at the center of all conscious psychological processes. This self consists of three main aspects (for a review, see Baumeister, 1998). First, there is the act of reflexive consciousness, which involves self-awareness and recognizing the interior being that makes us who we are. Second, the self contains an interpersonal aspect. Who we are can depend on context and the people that surround us. Third, the self acts as an active agent, controlling our actions, making decisions and interacting with the world in a purposeful manner.

Theoretical Conceptions of the Self

Self-esteem is a byproduct of the reflexive aspect of the self. It is the act of one looking at oneself and deciding how one feels toward the characteristics that are present (Coopersmith, 1959; Rosenberg, 1965). As we proceed through life, our concept of our self may change based on our situation. Similarly, the way we feel about our self may vary based on how we feel we are currently meeting the demands of life. The fluctuations in self-esteem that accompany life events have helped define self-esteem as a multidimensional construct. Short-term changes in how we evaluate our self reflect *state self-esteem*. This is the original conception of self-esteem theorized by James (1890a): the ratio of our successes to pretensions. Success or failure can impact our feelings about ourselves at a given moment. These short-term fluctuations are only temporary – after time, we move on to other tasks and have the opportunity to redeem our worth. Because of the way state self-esteem is strongly tied to the environment, it tends to be relatively unstable.

But underlying these ripples in self-evaluation is an overall level of *trait* (or global) *self-esteem*. Global self-esteem is a more stable resource that represents the overall evaluation one has of one self across different situations. Global self-esteem is only moderately correlated with aggression (Baumeister, et al., 2003) and "adaptive" behaviors (O'Brien, Baroletti, Jeffrey, Leitzel, & O'Brien, 2006), such as school performance, but is strongly related to life satisfaction (r = .47, Diener & Diener, 1995), and depression (r = -.66, O'Brien et al., 2006). Twin studies suggest global self-esteem may even be genetically based (Neiss, Sedikides, & Stevenson, 2002).

In an attempt to maximize self-esteem we may make our feelings about our self more contingent upon events with which we identify and are likely to succeed (Crocker, Luhtanen, Cooper, & Bouvrette, 2003; Deci & Ryan, 1995). However, this strategy can be risky:

individuals who have highly contingent self-esteem are especially prone to anger and hostility following an insult (Paradise & Kernis, 2002). Alternately, an individual can see him or herself as intrinsically “good” (or bad), and this attitude is not necessarily tied to external events. This type of self-esteem is referred to as *true self-esteem*. The difference between true and contingent self-esteem and the consequences for each type have been enveloped in “self-determination theory” (Deci & Ryan, 2000; Ryan & Deci, 2004; Ryan & Brown, 2006).

With all the aspects of psychology that self-esteem can influence, the overarching purpose of self-esteem is still debated. Today, two theories have emerged that seem to encapsulate the causes and consequences of self-esteem (Baumeister, 1998): as an anxiety buffer (Terror Management Theory), or as an internal measure of how we are succeeding (or failing) in our interpersonal relationships (the Sociometer Hypothesis). Terror Management Theory (TMT) proposes that one unfortunate side-effect of a more developed sense of consciousness in humans is that we are aware of our own mortality. This awareness engenders a certain degree of existential anxiety for which we develop various symbolic coping mechanisms (e.g. culture, religion). These institutions allow us to adopt a particular worldview and feel that we are “part of something larger, more significant, and more eternal” than ourselves (Pyszczynski, Greenberg, Solomon, Arndt, & Schimel, 2004). Pyszczynski et al. (2004) propose that self-esteem arises in two ways from this worldview: First, we have to believe our worldview is valid, and second, that we are fulfilling the expectations of the culture around us. Through fulfilling these two criteria, we are able to deflect our death anxiety by knowing we are part of something bigger.

There is experimental evidence for TMT (for an extended review, see Pysczinsky et al., 2004; Solomon, Greenberg, & Pysczinsky, 1991). Greenberg, Simon, Pyszczynski, Solomon,

and Chatel (1992) found that elevating individuals' self-esteem lowered their feelings of state anxiety after they watched a video of deadly accidents. Harmon-Jones et al. (1997) examined the effects that self-esteem could have on information processing in response to mortality salience inductions. They found that as self-esteem was experimentally increased, the accessibility of death-related words decreased (Experiment 3). Terror Management Theory does have its critics: Because self-esteem (in the TMT view) is an accrual of various aspects of the self (i.e. contingent self-esteem), some authors claim that the self-esteem the Terror Management theorists examine is not a *global* self-esteem, but rather many different self-esteem contingencies (Moller, Friedman, & Deci, 2006).

A second theory regarding the function of self-esteem is the *Sociometer Theory* (Leary & Baumeister, 2000; Leary, Tambor, Terdal, & Downs, 1995). This theory proposes that self-esteem serves less of a defensive mechanism and more of an internal gauge of how we are succeeding (or failing) in our interpersonal relationships. Low self-esteem, therefore, reflects the perception of possible exclusion and this is an evolutionarily precarious position. In support of this theory, inclusion and exclusion feedback do influence self-esteem (Leary et al., 2003), but only when the group is meaningful to the individual (Leary et al., 1995, Study 3). Furthermore, retrospective reports of self-esteem do correlate with how included or excluded the person felt in the given situation (Leary et al., 1995, Study 2). However, subsequent studies have uncovered evidence that is contrary to the predictions of Sociometer Theory. In a series of studies, Twenge, Baumeister, Tice & Stucke (2001) showed that exclusion feedback could increase aggression – something that seems to make the possibility of inclusion less likely (Pyszczynski et al., 2004). Further studies have shown that self-esteem can sometimes be uncorrelated with valenced-

ratings of how people feel about their interpersonal relationships (Endo, Heine, & Lehman, 2000, cited in Pyszczynski et al., 2004).

Although there are many findings that seem to discredit -- or, at least, draw support away from -- Sociometer Theory, both Terror Management and Sociometer Theory have the common characteristic of an individual's perception of how effectively he or she relates to others and his or her satisfaction with their self. In subsequent sections, this paper will examine the effects of when the self-esteem buffer is lacking, and the effects this would have on the ability to manage executive resources, such as working memory and inhibiting behavior.

Measuring the Self

With the value society and researchers place on self-esteem, there has been a significant amount of attention devoted to issues of measurement. Explicit self-esteem (how one consciously feels about oneself) is usually measured with self-report questionnaires that are high in face validity. One of the oldest and most reliable measures of explicit self-esteem is the Rosenberg Self-Esteem Scale (RSES; Rosenberg, 1965). The RSES consists of ten questions that ask the participant about their feelings toward their self (e.g. "I feel I have a number of good qualities" and "On the whole, I am satisfied with myself"). The scale has shown strong internal consistency (Cronbach α = .88) and test-retest reliability (r = .82, Fleming and Courtney, 1984). The RSES has repeatedly been shown to be negatively correlated with neuroticism (r = -.7; Watson, Suls, & Haig, 2002) and depression (r = -.8; Watson et al., 2002) and positively correlated with extraversion (r = .5; Judge, Erez, & Bono, 1998).

Many other measures have been developed for measuring not only global aspects of self-esteem, but various aspects of self-esteem ranging from its relationship to interpersonal interactions (e.g. The Texas Social Behavior Inventory; Helmreich, Stapp, & Ervin, 1974) to

measuring the various sub-components of the self (e.g., Tennessee Self-Concept Scale, Roid & Fitts, 1988; The Body Esteem Scale, Franzoi & Shields, 1984). For a review of the many measures of explicit self-esteem, see Blascovich and Tomaka (1991).

In recent years, the idea of subconscious attitudes has gained acceptance in Social Psychology (Bargh, 1989, 1990; Fazio, Sanbonmatzu, Powell & Kardes, 1986). Whereas explicit measures reflect conscious reflection and awareness of internal states (Epstein & Morling, 1995), explicit measures also are prone to conscious control and censorship (e.g., to control for social desirability concerns). Implicit attitudes, however, are thought to reflect automatic processes (Teglasi & Epstein, 1998) and are more reflective of associations between the object and its affective associations. Several methods have been proposed for measurement of implicit attitudes toward the self. Many have been borrowed from cognitive psychology, and are based on associative models of knowledge structure (e.g. spreading activation theory; Anderson & Bower, 1973; Collins & Loftus, 1975).

Two common measures of implicit attitudes toward the self most directly influenced by Cognitive Psychology are sequential priming (Hetts, Sakuma, & Pelham, 1999) and the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998). Supraliminal sequential priming measures the reaction time of a participant during a word categorization task. Participants categorize words as *good* or *bad*, and each word is preceded by primes that are either self-relevant or not. Although this measure closely mirrors sequential semantic priming methods (Bargh, Chaiken, Govender, & Pratto, 1992; Fazio et al., 1986), as a measure of self-esteem it has questionable psychometric properties (test-retest reliability = .08; Bosson, Swann, & Pennebaker, 2000).

The IAT is another reaction time task that asks the participant to categorize words as quickly as possible. It consists of seven blocks of trials. In the first block, participants categorize adjectives as *good* or *bad*. Category labels are displayed at the upper left and right of the computer screen and stimuli appear in the center. The second block involves a similar categorization task, but this time words are categorized as *self* or *other* indicative (e.g. "me" "myself" "I" vs. "you" "them" "they"). The next two blocks add the first two tasks together – self and good words are sorted to one side of the screen, whereas bad and other are sorted to the opposing side. After completing a practice block, the participant completes the categorization task as quickly as possible. The subsequent two blocks switch the category labels: now *self* and *bad* are to one side, while *other* and *good* are to the opposing side. By comparing reaction time latencies of the *self-good* to the *self-bad* tasks, the IAT supposedly measures how well-associated the self is with good characteristics and objects compared to bad. The IAT has demonstrated low but reliable test-retest reliability, usually ranging around $r = .56$ (Greenwald & Farnham, 2000; Nosek, Greenwald, & Banaji, 2006).

These implicit measures tend to weakly correlate with explicit measures, and most researchers have concluded that explicit and implicit measures are tapping different latent constructs. Greenwald et al. (2000) used a confirmatory factor analysis technique to examine the factor structure of implicit and explicit measures of self-esteem. Overall, the best model fit occurred with a two factor (implicit, explicit) solution with the implicit measures loading onto an implicit factor and the explicit measures loading on an explicit factor. The two factors were only weakly correlated ($r = .28$). Implicit self-esteem is usually considered to be relatively static in a laboratory setting, but recently investigators have found ways to manipulate implicit self-esteem

through classical conditioning (Baccus, Baldwin, & Packer, 2004) and subliminal association priming (Dijksterhuis, 2004).

With implicit and explicit self-esteem measures tapping different underlying constructs, the possibility arises that an individual could have high levels of one type of self-esteem while harboring low levels of the other. In the case where implicit and explicit self-esteem "match" (i.e. both are high, or both are low), this is usually referred to as *secure* self-esteem (Jordan, Spencer, Zanna, Hoshino-Browne, & Correll, 2003). If there is a mismatch between explicit and implicit, it is referred to as *discrepant*, *insecure,* or *fragile* self-esteem (Bosson, Brown, & Zeigler-Hill, 2003). The situation is usually one in which the individual reports having high self-esteem on explicit measures, but scores below average on measures of implicit self-esteem. This discrepancy between explicit and implicit measures has shown many interesting relationships to various phenomena. Individuals who are high in explicit self-esteem, but low in implicit self-esteem, score higher on measures of narcissism (Jordan et al., 2003; Zeigler-Hill, 2006), fail to self-regulate after negative feedback (Lambird & Mann, 2006), are more negative to outgroup members (Jordan, Spencer, & Zanna, 2005; Kernis et al., 2005), and show more unrealistic optimism than individuals with secure self-esteem (Bosson, et al., 2003).

The converse situation also can occur when an individual has high implicit, but low explicit, self-esteem. This condition is less common, and seems to be more associated with depression rather than defensiveness (Jordan, Logel, Spencer, & Zanna, 2006). Logel, Jordan, Spencer and Zanna (2005) found that students who scored low in implicit and explicit self-esteem were significantly more depressed than individuals who were low explicit/high-implicit. Individuals with high explicit self-esteem were also more optimistic (Bosson et al., 2003) leading

Jordan et al. to hypothesize that implicit self-esteem may provide a buffer against depression for individuals with low explicit self-esteem.

Consequences of Self-Esteem

When there are discrepancies between implicit and explicit self-esteem, what mechanism could detect this discrepancy and cause the individual to behave differently than someone with secure self-esteem? One possibility is that a mismatch between implicit and explicit appraisals of the self could lead to a sort of cognitive dissonance (Cooper & Fazio, 1984; Festinger, 1957; Festinger & Carlsmith, 1959). Cognitive dissonance is a phenomenon that occurs when an individual holds two inconsistent attitudes. Currently research is lacking on the relationship between implicit and explicit attitudes and how they may relate to dissonance, but some research has found that explicit attitudes – not implicit – are subject to dissonance-related attitude change (Gawronski & Strack, 2004).

Dissonance is induced in laboratory settings by asking participants to choose to write a counter-attitudinal essay (e.g. "Why the Board of Regents should authorize a tuition increase for next semester"). The result of performing this behavior is an arousal of dissonance in the individual – a general feeling of discomfort associated with a negative affective state (Elliot & Devine, 1994; Harmon-Jones, 2001). Croyle and Cooper (1983) found that participants who were in a highly-dissonant position maintained an elevated arousal state (as measured by electrodermal activity) after the task was completed.

The existence of dissonance between attitudes can have consequences for information processing. In a series of experiments, Briñol, Petty and Wheeler (2006) found that when discrepancies between implicit and explicit attitudes were made salient, participants engaged in more elaborative processing. The authors hypothesize that the reason for this more attentive

processing was an attempt to resolve the discrepancy between the implicit and explicit attitude states in order to reduce the negative affect and arousal that is a result of the dissonance. Tesser, Crepaz, Beach, Cornell, and Collins, (2000) manipulated dissonance and measured the effect it had on self-evaluation maintenance (SEM) processes. The SEM model (Tesser, 1999) hypothesizes that self-esteem threat is a confluence of one's performance on a task, the level of closeness one feels with others who are being used for comparison, and how relevant the task is for one's self-esteem. Therefore, to increase self-esteem after poor performance on a task, an individual can alter the amount of closeness they feel with someone who is a better performer on such a task, or they can alter the amount of relevance they place on the task (e.g. "Well I don't like math anyway.") Tesser and colleagues found that individuals who had dissonance aroused engaged in more SEM behaviors, indicated by feeling closer to a friend who outperformed them on a low self-relevant task. Previous work (Achee, Tesser, & Pilkington, 1994) had found that arousal and SEM behaviors are causally related, such that participants in a high arousal condition performed more behaviors in line with the predictions of SEM than did individuals in a low arousal condition.

Recently, neurobiology has begun to investigate the neural underpinnings for self-consciousness. With the advent of fMRI, researchers have begun to use creative methods to activate self-relevant thought and examine the neurobiological activation that co-occurs. Thus far, the primary area that correlates with self-related thoughts and activities is the medial prefrontal cortex (MPFC; D'Argembeau, et al., 2007; Gusnard, Akbudak, Shulman, Raichle, 2001; for review see Schmitz & Johnson, 2007). Specifically, across a variety of studies, the ventral MPFC shows activation during tasks requiring self-relevant thoughts, ranging from activities with anticipated reward (Knutson, Fong, Bennett, Adams, & Hommer, 2003) to studies

of pain management (Salomons, Johnstone, Backonja, & Davidson, 2004). The ventral MPFC (which includes the orbitofrontal cortex) is also involved in the control of aggressive behavior, which will be discussed in a later section.

The present study will aim to examine how differences in implicit and explicit attitudes shape how an individual responds to failure feedback. It is hypothesized that individuals with discrepant self-esteem (high explicit, low implicit) will experience an increase in dissonance-related arousal, and this arousal will have a deleterious effect on their ability to perform on subsequent tasks.

Executive Functions

The ability to engage in self-monitoring and response inhibition are maintained by frontal lobe systems, and constitute processes defined as *executive functions*. "Executive function" is an umbrella term of sorts for a wide variety of abilities including choosing goals, inhibiting impulsive behavior, self-monitoring, and switching tasks when the need arises. Given the importance of these abilities in daily life, Alexander Luria went as far as to call the frontal lobes "the organ of civilization" (cited in Goldberg, 2001).

In order to maintain a sense of order in controlled cognition, the mind uses working memory to coordinate the assignment of attentional resources to different cognitive tasks. Humans do not have an unlimited amount of attention available to devote to an infinite number of tasks; instead, working memory allows individuals to devote attention to the task on which they wish to focus. Alan Baddeley and colleagues have proposed that working memory has four components: (1) the visuospatial sketchpad, (2) the phonological loop, (3) the episodic buffer, and (4) the central executive (Baddeley, 1992; Baddeley & Hitch, 1974, Baddeley, 2000; Baddeley, 2003). The visuospatial sketchpad and phonological loop are responsible for holding

visual images and inner speech, respectively, in short-term memory for immediate processing. The episodic buffer provides a means for the phonological and visuospatial systems to interact, thereby creating coherent episodes to encode into memory. The central executive is the aspect of working memory that decides how to allocate attentional resources and governs behavior, and is the most relevant to the current discussion.

The Central Executive

Although the central executive is the most important component of Baddeley's model, it is also the least understood. In an effort to further understand the role of the central executive in terms of guiding attention to relevant stimuli and processes, Baddeley (1986) divided the system into two processes. The first process is mostly automatic, allowing an individual to react to the environment by using previously learned habits and schemas. The second process is the supervisory activating system (SAS), which is more controlled and intentional. Whereas Baddeley resigns himself to admit that the "controller" of the controlled processes may be nothing more than a homunculus, Baumeister has proposed that the self is at the center of controlled processes (Baumeister, Muraven & Tice, 2000). Baumeister et al. proposed

> "There exists a resource that the self uses for a broad variety of volitional activities. These activities include overriding response tendencies such as habits or impulses, making a conscious or deliberate choice, and initiation of action (as opposed to being passive). In broad terms, the self's executive function, including all acts of controlling or altering the self and all acts of decision making and initiative, depends heavily on this resource." (p. 131)

The concept of executive function as a resource has several consequences. First, like any resource, executive functions are limited. Baumeister et al. proposed that this same resource is responsible for all of the abilities listed above, and therefore if one activity depletes the resource, the ability to perform other activities (such as inhibiting a response) becomes reduced. Second,

if the resource becomes depleted, it takes time to replenish. This proposal is supported by a number of experiments that show that performing behaviors that deplete the executive resource (such as regulating emotions) will impair performance on a subsequent unrelated task, such as physical endurance (Muraven, Tice, & Baumeister, 1998).

Depletion of the executive resource can occur because of several different mechanisms. One of the earliest methods examined for depletion of executive resources was the induction of negative mood states (Ellis & Ashbrook, 1988). In a series of experiments, Ellis, Thomas, and Rodriguez (1984) induced negative mood states in participants and recorded their abilities to encode memories. Sentence difficulty was manipulated such that some sentences required more effort than others to encode. The researchers found that those participants who were induced to feel depressed were impaired at encoding sentences that required greater amounts of effort or elaborative encoding. Ellis et al. proposed that this decrease in encoding is due to a reduction in attention resources due to negative affect.

Cognitive Psychology has developed several methods for measuring working memory, most of which involve attempting to actively retain information for a short period of time through rehearsal, or perform two tasks concurrently. In nonhuman primates, the task that is most often used is a delayed matching to sample task in which the animal has to hold an item's location in memory in order to successfully identify the item on a subsequent trial. In humans, one task that has gained widespread use for measuring working memory is the operation span task (OST; Turner & Engle, 1989). In this task, the participant is shown a math problem and asked to indicate whether the provided answer is correct (e.g. "Is (9/3) – 2 = 1?"). At the end of the problem, the participant is given a word to remember and then presented with another problem to solve and another word to remember. At the end of a set of two to seven items, the

participant is asked to recall the words in order they were presented. Working memory is quantified as the number of words successfully recalled at the end of each set. In addition to the OST, tasks have also been developed for reading span (reading a sentence and being asked to remember the last word), and spatial span (remembering the location of a cue while performing a subsequent task; for a general review of span tasks, see Conway, et al., 2005).

Because working memory seems to reflect the ability of an individual to devote attention to particular tasks, some authors have even referred to working memory capacity as *executive attention* (Redick, Heitz, & Engle, 2007). Since attention is generally understood to be a limited resource (Baddeley & Hitch, 1974), differences in working memory capacity should be reflected in an individual's ability to perform various tasks that require different amounts of attention. Indeed, this is the case: OST scores predict the ability of an individual to successfully shadow a voice in a dichotic listening task (Conway, Cowan & Bunting, 2001), the amount of interference that occurs in a list-learning task (Rosen & Engle, 1998), and the ability to suppress unwanted thoughts (Brewin & Beaton, 2002).

Although working memory has been a staple in the cognitive literature for over a quarter century, cognitive neuroscience has struggled to define the neurological mechanisms by which attention can be actively distributed to different tasks depending on the goals of the organism. Hazy, Frank, and O'Reilly (2006) have recently proposed a Prefrontal Cortex, Basal Ganglia Working Memory (PBWM) model, which suggests that executive functioning is maintained through the interaction of three areas: the posterior cortex, the hippocampus, and a prefrontal-basal ganglia system which is responsible for "active maintenance of internal contextual information (PFC) which can be dynamically updated by the basal ganglia" (p 106). In their model, Hazy et al. propose that working memory is an emergent phenomenon that occurs as a

result of the interactions between these three networks. The prefrontal cortex and basal ganglia communicate in such a way that the basal ganglia can either allow information to enter the working memory system, or close off external stimuli such that the working memory module becomes a closed loop. The majority of the work with this model has been done using neural network models, and thus far the system is able to replicate task performance on tasks such as Stroop interference and the Wisconsin Card Sorting Task.

Mapping working memory in the brain has not been an easy task (for review, see Curtis & D'Esposito, 2006). Initial ablation studies in nonhuman primates indicated that the prefrontal cortex was a critical component for working memory tasks (Jacobsen, 1936; Fuster, 1997), and real-time recordings in nonhuman primates from the dorsolateral prefrontal cortex showed activation that was believed to encode representations that were being "held" in memory for the task being performed (Goldman-Rakic, 1987).

Functional imaging studies and invasive electrophysiological recordings in nonhuman primates have found that working memory is not a "frontal lobe only" phenomenon. In addition to the activation of the prefrontal cortex during working memory tasks, regions that are involved in the selection and processing of the particular type of stimuli the task involves also show an increased level of activation (Curtis, Rao, & D'Esposito, 2004; D'Esposito, 2007; Kastner & Ungerleider, 2001). One theory is that the prefrontal cortex is providing top-down modulation to maintain activity in processing areas, but this theory has proven difficult to test in humans (but see Fuster, Bauer, & Jervey, 1985, cited in D'Esposito, 2007).

Behavioral Inhibition

Working memory is also seen as one factor that contributes to a person's ability to inhibit unwanted thoughts and behaviors (Kane & Engle, 2003). In a series of experiments, Kane and

Engle examined differences in performance on a Stroop task. The authors found that individuals with low span (i.e. lower working memory capacity) made more errors, and, as the task goal changed, low span participants had more difficulty maintaining the task goal, which resulted in a slower reaction time. The authors concluded that working memory capacity is an important resource when an individual is attempting to maintain a goal in the face of distracting information. It should be noted, however, that in all of the experiments, participants were divided by pre-existing working memory capacity abilities – working memory was not experimentally manipulated.

Neuropsychology and Psychiatry also have relied extensively on the Go/No-go task when attempting to measure an individual's ability to inhibit behavior. The Go/No-go task requires a participant (human or nonhuman primate) to respond to certain stimuli, but not others. This can be accomplished using various types of stimuli such as pressing a button when a green (but not red) square appears, or when any letter of the alphabet (but not X) is shown. Iversen and Mishkin (1970) found that Go/No-go performance was significantly impaired in macaques after lesioning of the inferior convexity (homologous to the right inferofrontal gyrus (IFG) in humans). Later studies in humans confirmed the role of the right IFG in inhibiting the response tendency (Konishi, Nakajima, Uchida, Sekihara, & Miyashita, 1998), in concert with the presupplementary motor area and indirect pathway of the basal ganglia (Aron & Poldrack, 2006). This role of the indirect pathway in stopping behavior is central to the model of working memory proposed by Hazy et al. (2006) in which the basal ganglia "gates" information.

Social Psychology has attempted to experimentally manipulate behavioral inhibition, often in experiments that require the participant to exercise some level of self-regulation (Baumeister et al., 2000). Baumeister, Bratslavsky, Muraven and Tice (1998) examined the

extent to which impulse control can also deplete executive resources. Hungry participants were exposed to plates of chocolate chip cookies and candy, but told not to consume the snacks – instead they would get to eat from a bowl of radishes. A control group was allowed to eat from the more appetizing snacks. Following the self-control manipulation, participants were asked to complete a figure-tracing task. Individuals who were forced to exhibit self-control by not eating the delicious treats gave up on the figure-tracing task faster than participants who were allowed to eat from the tempting dishes.

In addition to self-control depleting the executive resources, the converse is also true: completing other tasks that deplete resources can reduce the ability to inhibit undesirable behavior. Muraven, Collins and Neinhaus (2002) tested the idea that exhibiting cognitive inhibition could deplete executive resources and thereby reduce the ability to self-regulate. Male drinkers were brought into the lab and asked to suppress thoughts of a white bear, or perform mental arithmetic (a control group did not perform this part of the task). They were then told they would perform on a driving simulator and would be rewarded for high scores. Before the driving simulator, they were given the opportunity to drink beer. Those who had performed the tasks that drained the executive resource consumed more alcohol (possibly indicative of a loss of self-control) compared to control participants.

Although these studies provide evidence of a loss of behavioral self-control, they do not examine the mediating cognitive mechanisms that may be the cause of behavior. In the current proposed study, executive control will be measured and the relationship to behavioral inhibition will be examined. Furthermore, the influence of a personality/individual difference variable (self-esteem) will be examined for its ability to predict an individual's cognitive functioning after

negative feedback. This understanding of how feedback affects cognition will be essential for predicting how the cognitions then guide behavior.

Aggression

Self-esteem and self-control are phenomena that occur within the individual, but humans are especially social creatures, and changes in information processing can have consequences for how we interact with others around us. In some situations, individuals can be more prone to behave in prosocial ways (Batson, Ahmad, Lishner, 1998; Garcia, Weaver, Moskowitz, & Darley, 2002), while in other situations they can be driven to act out aggressively. Aggressive behavior has significant societal implications that have created an impetus for research on the causes of aggression and possible ways to reduce the number of aggressive acts.

Historical Perspectives

One of the first individuals to ponder the causes and control of aggression was Aristotle (350 BCE). In his *Nichomachean Ethics*, he pointed out "any one can get angry- that is easy. . .but to do this to the right person, to the right extent, at the right time, with the right motive, and in the right way, that is not for every one, nor is it easy" (Book II, Chapter 9 – Translated by W. D. Ross). Aristotle did not directly address the causes of anger, but recognized it as one of the passions that, if used in excess, was contrary to a virtuous existence.

Two millennia after Aristotle, Freud developed psychoanalytic theory, which placed emphasis on the subconscious and ways it could drive behavior. Freud believed there were several innate drives in humans that motivated individuals to behave in particular ways. For example, the *libido* was the sexual drive that motivated individuals to pursue sexual activities and interests. If any of these drives were not given an outlet, they would begin to build up in the

individual who would need to find a way of releasing the energy. If an appropriate outlet was not available, the psyche could use sublimation to channel the energy into some other form of behavior to give it an outlet. Freud believed aggression was the result of built-up sexual energy that needed to find a release. In other words, individuals who did not have appropriate ways to release their sexual energy were prone to aggression. Furthermore, Freud saw this aggressive instinct as something that was natural "instinctive endowment" (Freud, 1930/1969, p. 68). Normally the aggressive impulse is kept in check, but Freud recognized that certain situations can disarm the "mental counter-forces which ordinarily inhibit it" (Freud, 1930/1969, p. 69).

Although Freud addressed innate drives that could be the cause of aggressive behavior, a group of psychologists led by John Dollard applied Freud's psychoanalytic theories of aggression to behaviorism and developed the Frustration-Aggression Hypothesis (Dollard, Doob, Miller, Mowrer & Sears, 1939). Briefly stated, frustration-aggression theory suggests that when an organism is prevented from achieving a goal, this results in frustration, which in turn produces aggressive energy and behavior (Tedeschi & Felson, 1994). As this aggressive energy builds up in the organism, the aggressive outburst will become more intense. Normally the organism may be able to inhibit this aggressive impulse out of fear of consequences (e.g. attacking a more dominant member of the social hierarchy could have deadly consequences), but Miller (1948) proposed that if the energy becomes great enough it can override the inhibiting mechanisms (cited in Tedeschi & Felson, 1994).

The idea of aggression being a result of frustration spurred decades of research on the topic (for review, see Berkowitz, 1993; Tedeschi & Felson, 1994). As research progressed, disagreement on terminology began to arise. Dollard et al. (1939) limited their definition of aggression to that which causes injury to another organism (p. 11), but researchers limited to

ethical practices in the laboratory developed numerous methods that did not necessarily cause a direct injury to another individual. Similarly, researchers disagreed on the causes of frustration. Whereas Dollard et al. defined frustration as the inability to achieve a goal, Buss (1961) saw personal attack as instigation to aggression that does not necessarily block a goal.

Categories of Aggression

In an attempt to explain the various findings engendered by frustration-aggression theory, Berkowitz (1981, 1988, 1999) developed a theory of aggression that relied more on the affective experience of the organism and less on goals and behaviorism. Berkowitz agreed that frustration can cause aggression, but only if the organism experiences the frustration as aversive. It is the aversive experience itself, Berkowitz proposed, that activates the aggressive response of the organism. Furthermore, Berkowitz divided aggression into two types: reactive and instrumental.

Reactive, or emotional, aggression is the traditional form of behavior that aims at directly harming an individual. According to Berkowitz, reactive aggression is the result of a confluence of many different psychological states, but primarily involves negative affect paired with heightened arousal. Experimental evidence for this hypothesis has been obtained through both animal and human studies. Azrin, Hutchinson, Ulrich and Norman (1964) demonstrated that administering electrical shocks to rats could induce fighting between the animals, and the probability of fighting could be predicted by the duration of the shocks. This aggressive response was also subject to modification through the principles of instrumental learning: if attacking another animal caused the shocking to stop (negative reinforcement), next time the animal was shocked it was more likely to become aggressive (Knutson, Fordyce, & Anderson, 1980).

In humans there is substantial support for the theory that unpleasant affect increases reactive aggression. A long-standing theory in social psychology has liked increases in aggressive behavior to increases in temperature (the heat-aggression hypothesis). Baron and Bell (1975) showed that if a participant was in a hot room (over 90 degrees Fahrenheit), they were more aggressive towards a peer during an interaction where they were given the opportunity to punish the individual. Berkowitz, Cochran and Embree (1981) had research participants place an arm in a bath of water that was either a neutral temperature or uncomfortably cold. Participants whose arm was in the cold water were significantly more aggressive and less rewarding toward a confederate than those whose arm was in the neutral temperature water. One interesting aspect to both of these situations is that the other person bore no responsibility for the uncomfortable situation (the temperature of the room or the water), yet was the target of the aggressive behavior. Berkowitz (1983) points out that situations other than uncomfortable temperatures increase aggressive behavior, including irritable cigarette smoke (Jones & Bogat, 1978) and disgusting scenes (White, 1979).

Additional evidence for aggression being caused by negative affect has been found using clinically depressed individuals, and participants who underwent a depressive mood induction. Berkowitz (1983) cites numerous studies where the researcher's primary interest was other than aggression (for example, Seligman's learned helplessness studies, 1975), but aggressive behavior was frequently observed in the studies. Further support for this hypothesis comes from findings that show individuals with depression often show an increase in hostility and emotional aggression (Bonime, 1966; Poznanski & Zrull, 1970; Miller & Norman, 1979).

In the Velten Procedure (Velten, 1968), healthy participants read a series of statements aloud. These statements are all either positive ("This is great – I really do feel good – I *am*

elated about things") or negative ("I have too many bad things in my life"). After reading these statements, the participants are usually induced into the mood (elation or depression) congruent with the valence of the statements. Hynan and Grush (1986) induced depressed affect in healthy participants using the Velten procedure and found that men who were highly impulsive and induced to have a depressed mood were more aggressive than those who did not undergo a mood induction.

The second type of aggression, according to Berkowtiz, is instrumental aggression. Instrumental aggression is aggressive behavior that is not directed at harming an individual as the end goal, but uses the aggression as a means to achieving another end. Bullies are an excellent example of instrumental aggressors. Berkowitz (1993) cites data from Olweus (1978) where teachers of over one-thousand adolescent males were surveyed regarding the aggressive tendencies of their students. Olweus found that those characterized as bullies (about 5% of the sample) acted intentionally, carefully choosing their aggressive interactions in a bid to achieve power and dominance.

Psychopaths potentially provide an extreme example of instrumental aggressors. Williamson, Hare and Wong (1987) examined the case files of hundreds of nonpsychotic male inmates in the Canadian criminal system and selected a group of psychopathic (N = 68) and nonpsychopathic inmates (N = 52) based on their scores on the Psychopathy Checklist (Hare, 1980). One of the most striking differences between the groups was the absence of "affective colouring" that accompanied the violent behavior.

Case studies of well-known "serial killers" also provide insights into the instrumental flavor of their aggressive acts. Jeffrey Dahmer, who killed more than fifteen men and boys during the 1980s, did so with the intention of fulfilling his necrophilic desires (Bennett, 1993;

Schwartz, 1992). Although Dahmer had feelings of loss after killing his victims, the feelings did not last long and he recognized upon reflection that his moral compass was "so off" (Schwartz, 1992). Most serial killing is associated with a sexual motive, although it is unclear how many murders each year are associated with sexual motives due to the absence of classification in the FBI reporting system (Ressler, Burgess, & Douglas, 1995).

Recently, there have been calls to move past the hostile/instrumental distinction in order better understand and predict aggressive behavior. Bushman and Anderson (2001) have integrated the study of aggression with findings from social cognition and proposed using a framework of knowledge structures (such as scripts and schemas) to better understand how aggressive behavior is learned and enacted. This move away from a dichotomization of aggression and towards a social-cognition perspective has begun to produce new ways of analyzing aggressive behavior in the past decade (see Douglas, et al., 2008; Fontaine, 2008).

One of the primary sources Bushman and Anderson use for arguing for a rejection of the hostile/instrumental dichotomy is the difficulty the legal system has had in drawing the distinction. Interestingly, in the past, the concept of executive control has been closely linked to aggressive behavior in the United States and British justice systems (Vronsky, 2004). In contemplating a definition for what constitutes "insane" behavior, the defense relied on what was termed "The M'Naghten Rule." Originally, this rule stated that in order to qualify as "insane" at trial, a defendant had to be unable to discern between right and wrong behavior (Queen v. M'Naghten, 1843). In subsequent decisions, the rule was revised to include individuals who "lost the power to choose between the right and wrong, and to avoid doing the act in question, as that his free agency was at the time destroyed" (*State of Alabama v. Parsons, 1887,* cited in Vronsky, 2004). This definition has since been rejected in favor of the more parsimonious

"knowledge of right or wrong" rule, but demonstrates that the idea of being able to control aggressive impulses has been an important criterion at times in determining culpability.

The Neurobiology of Aggression

Recently, research has begun to examine the cognitive and neural relationships between executive functioning and aggressive behavior. Differentiating between reactive and instrumental aggressors, Raine et al. (1998) examined glucose metabolism using positron emission tomography (PET) in samples of affective (reactive) murderers, predatory (instrumental) murderers, and healthy controls. Participants completed a continuous performance task while undergoing a PET scan. The continuous performance task increases frontal lobe activity in normal controls (Buchsbaum et al., 1990), and the authors replicated this result. There was no difference in prefrontal activity in predatory (instrumental) aggressors, compared to controls, but affective (reactive) aggressors showed a reduced level of activity in both the left and right prefrontal regions.

In a study of impulsive murderers, Amen, Hanks, Prunella and Green (2007) compared the blood perfusion levels in murderers and healthy controls. The authors found no difference in regional blood flow between the two groups at a resting level, but when the participants were asked to perform a Go/No-go task, murderers showed a lower level of perfusion in the anterior cingulate and orbitofrontal cortex compared to control participants. These results hint at differences in ability to inhibit unwanted responses, although the authors did not present any performance data in their results.

Similar to the model proposed by Berkowitz (1993) in which aggression is one possible outcome of anger, Panksepp (1998) has proposed the existence of a "RAGE" circuit that underlies aggressive behavior in animals. It is important to note that in this model, aggression

does not necessarily follow from anger; there are different types of behavior, such as predation and territoriality, which can be characterized as "aggressive" but may not mean the aggressor is "angry" at the target. This RAGE circuit encompasses the medial amygdala (MeA), hypothalamus, and periaqueductal grey (PAG) matter. These three regions communicate hierarchically such that the MeA is dependent on the functioning of both the hypothalamus and PAG, the hypothalamus is only dependent on the PAG, and the PAG can still evoke anger even if the hypothalamus and MeA have been ablated (Panksepp, 1998). Modulation of the RAGE pathways comes from higher cortical areas, including the orbitofrontal cortex which innervates the MeA, PAG, lateral and posterior hypothalamus (Barbas, 1988; Kringelbach & Rolls, 2004; Rempel-Clower & Barbas, 1998). Many of these connections with the OFC are reciprocal, and a large amount of communication occurs between the amygdala and OFC.

Neuroimaging of structural and functional differences in aggressive individuals, compared to controls, have consistently found some level of dysfunction in the frontal cortices. In a study of 40 psychiatric patients with histories of aggressive behavior, Amen, Stubblefield, Carmichael, and Thisted (1996) found decreased activity in the frontal lobe, and increased activity in the left limbic regions. This is interesting when put into the context of EEG asymmetry research which considers the left hemisphere dominant for "approach-related" behaviors and the right hemisphere dominant for withdrawal motivations (Davidson, 1992; Harmon-Jones & Allen, 1998). Many studies have not differentiated between specific regions of the frontal cortex, but subsequent studies have identified a prominent role for the orbitofrontal cortex (OFC) in the control of aggressive behavior.

Evidence for the involvement of the OFC in aggressive behavior has come from more specific neuroimaging studies and from neuropsychological case studies. In a landmark study by

Grafman et al. (1996), survivors of the Vietnam War who suffered frontal lobe injuries were compared to individuals who experienced other head injuries, and healthy controls. The authors found that if the OFC was involved in the injury, the individual was significantly more aggressive (as measured by self-report of previous aggressive acts, and by report of a family member) than controls and individuals who had other lesions.

Other studies have examined the result of injury to the OFC and the resulting 'acquired sociopathy' that can occur as a result (Blair & Cipolotti, 2000; Damasio, 1994; Eslinger & Damasio, 1985). Many theories have attempted to account for the cause of the increase in aggression that occurs as a result in OFC injury. Damasio (1994) has proposed that individuals with ventromedial prefrontal cortex damage have a faulty somatic marker system such that they are unable to monitor their body's changes in response to the environment and attend to internal 'alarm signals' (Blair et al., 2000). Evidence for this hypothesis has included findings that these patients are often impaired in a gambling task, and show an absent or decreased level of physiological arousal in response to visual stimuli (Bechara, Damasio, Damasio, & Anderson, 1994; Bechara, Damasio, Tranel, & Damasio, 1997; Damasio, Tranel, & Damasio, 1990).

The somatic marker hypothesis is not without its critics. Experimental evidence that is counter to the predictions of the hypothesis is beginning to accumulate. In one case of acquired sociopathy, resulting from damage to the OFC, the individual did not show any impairment in somatic marker responses or gambling task performance (Blair et al., 2000). In a clever study by Ishikawa, Raine, Lencz, Bihrle, and Lacasse (2001), it was found that individuals who did have a history of psychopathic behavior but had never been caught showed greater physiological reactivity to writing an essay describing their faults and weaknesses and then delivering the

speech. These "successful psychopaths" also did not show a difference in WCST performance when compared to psychopathic individuals who had been caught and incarcerated.

A second theory for the role of the OFC has been proposed by Rolls (1996). In opposition to Damasio's Somatic Marker Hypothesis, Rolls has proposed that the circuitry of the OFC lends it more to a role of monitoring representations of reward and punishment relationships. One of the primary inputs into the OFC is from the insula/gustatory pathways and this establishes a direct path for primary reinforcement input into the frontal lobe. In addition to these and other sensory pathways, the OFC receives input from the object pathways for visual perception. Rolls hypothesizes that the OFC forms representations of reward and punishment and integrates the incoming sensory information to form relationships between objects and reward. Evidence for the role of OFC in reward contingencies in humans comes from studies that have found deficits in task switching when reward conditions switch during a modified Wisconsin card sorting task (Rolls, Hornak, Wade, & McGrath, 1994).

Another theory that has been proposed as a mechanism for aggression is that aggressive behavior occurs as a result of a reduced ability to inhibit aggressive impulses (Blair, 2005; Coccaro, 1998). Evidence for this idea comes from findings that executive function deficits are often associated with increases in aggressive behavior (Giancola & Zeichner, 1994; Giancola, Moss, Martin, Kirisci, & Tarter, 1996; Lau, Pihl, & Peterson, 1995, for review see Brower & Price, 2001). Additional evidence has been found in the research on the relationship between alcohol and aggression. For many years, alcohol has been known to cause a disinhibition of behavior, and researchers have theorized that this may result in an increase in aggressive tendencies while under the influence of alcohol (Muehlberger, 1956, cited in Bushman & Cooper, 1990). In a meta-analysis of the literature at the time, Bushman et al. determined that

alcohol does, in fact, facilitate aggressive tendencies. Interestingly, in subsequent work, Giancola (2004) has found that this relationship between alcohol and aggression is strongest for men with low executive functioning scores, but not for men with preexisting high levels of executive functioning.

Aggression Towards the Self

Whereas social psychologists and criminologists are interested in how aggressive behavior can be directed at other individuals, clinical psychology has historically been interested in how an individual can direct aggression at his or her self. In his object relations theory, Freud proposed that as a normal part of development, an individual directs his or her inner drives towards individuals in the environment. For example, as a person grows out of childhood, he or she develops a libidinal drive that is directed towards a particular object – ideally one's spouse. However, if the relationship is broken, the drive can be redirected at the individual's ego, resulting in narcissism (Freud, 1914). Freud proposed that this same redirection of drives holds true for aggression: "murderous impulses" against others can lead an individual to an ego attempting to commit suicide.

This theory of suicide as aggression directed toward oneself was advanced by Karl Menninger (1938). Menninger elaborated on Freud's concepts of a death instinct that was normally kept under control by a reciprocal life instinct, and hypothesized that suicide was the result of this death instinct either being turned against oneself, or an insufficient "erotic impulse" to suppress the destructive urge. Thus, the psychoanalytic tradition has a strong history of associating self-destructive and outward-directed aggressive behavior.

Recent research has expanded on the potential relationship between suicidality and aggressive behavior. Multiple studies have identified a link between aggressiveness and suicide,

such that aggression increases the risk of suicidal behavior (Duberstein & Conwell, 1997; Nock & Marzuk, 2000). In a review of the literature, Conner, Duberstein, Conwell, & Caine (2003) proposed that, specifically, reactively aggressive individuals who are especially prone to suicidal tendencies. In their theory, the authors propose that because suicidal individuals show dysfunctional serotonin transmission (Mann, Brent, & Arango, 2001), they are more impulsive and therefore more prone to aggression. The authors note correlations between prisoner suicide likelihood and level of aggressiveness in the offense they are imprisoned for, such that those convicted of murder or manslaughter are more likely to attempt suicide (DuRand, Burtka, Federman, Haycox, & Smith, 1995; Kerkhof & Bernasco, 1990). Subsequent studies have found a link between means of suicide and history of aggression, such that individuals who die by more violent means (e.g. hanging, gunshot) have a higher lifetime history of aggression than those who died of less violent means (e.g. drug ingestion, carbon monoxide asphyxiation; Dumais et al., 2005a).

One motif in the aggression and suicide literatures is that of impulsivitiy. Impulsiveness is thought to have three underlying factors: motor, attentional, and nonplanning (Patton, Stanford, & Barratt, 1995). Overall, these three factors attempt to measure the lack of ability an individual has to control thoughts and behaviors (e.g. "I am restless at the theatre or lectures," "I act on the spur of the moment," "I say things without thinking"). Prison inmates and those with substance abuse problems tend to score higher on the Barratt Impulsiveness Scale (BIS; Patton et al., 1995), as do individuals with a family history of suicidal behavior (Roy, 2006), and those who die by violent means (Dumais, Lesage, Lalovic, et al., 2005). This involvement of impulsiveness in aggression has been identified as an independent predictor of suicide among clinically depressed individuals (Dumais, Lesage, Aida, et al., 2005).

The ability to inhibit impulses, as discussed above, is one of the roles of the executive functioning system. Therefore, one of the aims of the present study is to further examine the relationship between the ability to inhibit behaviors, and how this may be affected by the level of implicit self-esteem. To date, no studies have investigated the relationship between discrepant self-esteem and executive functioning. Given that a heightened level of impulsivity (i.e. lowered inhibition ability) makes individuals more prone to aggression, it is plausible that if the ability to inhibit impulses is depleted, this could make those individuals more prone to aggress, against either themselves or others.

Emotion, Arousal & Aggression

Although psychopathic killings grab national headlines, the majority of killings occur because of arguments, money, or jealousy (Berkowitz, 1993; Wolfgang, 1967). According to Berkowitz, activation of the emotional response system – specifically anger – leads to aggressive impulses, and a significant amount of research has focused on what cognitive mechanisms can lead an individual to become angry. But many people go through the same types of experiences without becoming aggressive, or even angry. In his pioneering studies of arousal and emotion, Stanley Schachter (1959; Schacter & Singer, 1962) examined the contextual and cognitive conditions that could cause a person to experience different types of emotions. Central to his theory of emotional lability was the idea that emotions are the result of two factors: First, the bodily experience of emotion – increased heartbeat, sweating, general arousal – and second, how an individual interprets this change in physiology.

In a series of experiments, Schachter and Singer (1962) injected research participants with epinephrine or placebo. A control group received no injection. In addition to receiving the injection, half of the participants were told of the effects of epinephrine would have on their

body – increased heart rate, feeling warm, sweating – and the other half were told false side effects, such as dizziness (Fiske & Taylor, 1991). Following administration of the injection, participants were exposed to a confederate who behaved in a particular way. In one condition, the confederate acted foolish, and in another condition the confederate was very hostile and angry. Participants were then asked to infer their own feelings. If they had been correctly informed of the effects of epinephrine (i.e. increased arousal), participants attributed their arousal to the injection and were not affected by the behavior of the confederate. But if they were given false information regarding the effects of the injection, participants attributed their arousal to the behavior of the confederate. Those exposed to a silly-acting confederate indicated that they felt silly, and those exposed to an angry confederate became angry. What is remarkable about this experiment is that the emotional experience of the participant depended on their cognitive appraisal of the arousal they were experiencing, and the context to which they were exposed.

The idea of misattributed arousal and how it could relate to aggressive behavior was extended by Dolph Zillmann (1978, 1979, 1983) in Excitation Transfer Theory. According to Zillmann, aggressive behavior relies on three processes: arousal, disposition of the individual, and cognitive appraisal (Tedeschi & Felson, 1994). Zillman proposed that high levels of arousal impair cognitive processing of information, causing the individual to behave more habitually. Therefore, if an individual is predisposed to behave aggressively, under high arousal the individual will begin to act in such a way. The process of excitation transfer occurs when the arousal from one situation is misattributed to another cause, which in turn causes the person to behave more aggressively towards the person wrongly accused of the arousal.

Measuring Aggression

Measuring aggression in the laboratory with human participants presents specific challenges to the researcher. One difficulty is that many of the techniques that have been developed rely on deception and/or concealment of the focus and methods of the study from the participant. Another difficulty is that the experimenter (or confederate) cannot be subjected to physical or emotional harm over the course of the experiment. In an effort to overcome these challenges and minimize the risk and harm done to the participant, researchers have developed clever ways to measure aggression in the lab.

One of the earliest methods used to elicit aggression from participants was devised by Arnold Buss (1961): the Buss Aggression Machine. In this experimental method, the participant signs up for a “teaching-learning” experiment. Upon arrival, the participant is assigned to the role of “teacher” and is instructed to correct the mistakes of another participant (a confederate) using electric shocks (in reality, no shocks are administered to the confederate). The participant is allowed to choose the magnitude of the shocks, either a low amperage (less painful) or higher amperage (more painful) shock. The magnitude the participant chooses is considered a measurement of their level of aggression. The procedure has been modified by subsequent researchers to use various stimuli in place of electrical shocks, such as blasts of loud noise, or measuring how long they hold down the button to administer the punishing stimulus (Berkowitz, 1993).

Another commonly used procedure is the Taylor Aggression Paradigm (Taylor, 1967). In this method, participants are informed they are competing against another participant in a competitive reaction time game. If they “win” the trial, they get to administer a shock to the other participant (who does not actually exist). If they lose the trial, they receive a shock

(supposedly administered from the other participant). As with the Buss aggression procedure, aggression is operationalized as the magnitude of shock the participant chooses to administer to the competitor.

Although both of these procedures are the most widely-used, they are often criticized for lacking face validity (Ritter & Eslea, 2005; Tedeschi & Quigley, 1996; but also see Giancola & Chermack, 1998). Several other procedures have been used to measure aggression in laboratory settings. These have included giving participants an opportunity to subtract points from an opponent's score (Cherek, 1981), asking participants to designate a quantity of hot sauce for another person to eat (Lieberman et al., 1999) and more "real-world" tasks such as suggesting a trainee be hired or fired after interacting with the person during the experiment (Kulik & Brown, 1979; Stucke & Baumeister, 2006; Zillman & Cantor, 1976).

However, as noted by Berkowitz (1993) just because physiological arousal and anger occur does not necessitate an aggressive outburst. Various situational factors can cause us to restrain our aggressive impulses. If a person is able to remain anonymous, and therefore avoid any punishment or social disgrace that could result from acting aggressively, oftentimes they will behave more aggressively than if they were individuated. Zimbardo (1969) had participants interact with an obnoxious confederate and gave the participant an opportunity to punish the confederate by administering electrical shocks. In one condition, the women wore lab coats with hoods, thereby masking their identity. In the other condition, the women were "individuated" – they did not wear cloaks, but instead wore large nametags and were told the experimenter was interested in their individual responses. Participants who were given the cloak of anonymity shocked the confederate twice as long as those who were individuated.

Duval and Wicklund (1972) proposed that self-awareness motivates individuals to behave more in line with their personal standards. If individuals oppose aggressive behavior, drawing attention to their self (e.g. having them look in a mirror while performing the experiment) can reduce aggressive impulses; but if participants are inherently disposed to aggression, the self-awareness can actually increase aggressive behavior (Carver, 1975).

Much of the experimental evidence seems to indicate that executive functioning and self-awareness can influence the aggressive behavior of a person, but very little research explicitly examines the connection between the self, executive functioning, and aggressive behavior. The purpose of the proposed experiments is to examine these relationships; specifically, when an individual has discrepant self-esteem, how does an ego threat affect their executive functioning? If it is the case that a threat depletes executive resources, this may potentially decrease the individual's ability to inhibit aggressive impulses, thereby increasing the aggressiveness of the individual toward the source of the insult.

Psychophysiology

Basic Principles and Methods

Questionnaires, surveys and observing outward behavior are common methods for quantifying variables of interest to psychologists, but recently Psychology has begun to overlap more with Biology in attempts to explain and predict behavior. Molecular and invasive techniques are available for use on animals, but ethical standards usually preclude their use on human participants. Attempts to measure biological and physiological variables have been undertaken by a branch of psychology called psychophysiology. Through measuring changes in somatic states, such as electrodermal activity (sweating), heart rate, electromyography, brain waves (electroencephalography), hormones, and most recently functional magnetic resonance

imaging (fMRI), psychophysiologists attempt to infer changes in mental state from changes in bodily responses. For the purposes of this paper, cardiovascular responses and circulating hormone levels will be discussed.

Cardiovascular Reactivity

The cardiovascular system consists of the heart, the blood and the intricate system of veins, arteries and capillaries that carry blood to every organ of the body.

As physical demands necessitate, blood flow to particular regions can increase or decrease, and, of interest to psychologists, changes in the cardiovascular system can also occur as the result of psychological processes. As a fluid system, the most obvious changes that occur are often reflected in changes in hydrostatic pressure within the system. Blood pressure is a complex phenomenon; a combination of the rate and pressure at which the heart is pumping, and the resistance that is occurring within the veins and arteries (Martini, Ober, Garrison, Welch, & Hutchings, 1998). Measuring arterial pressure results in two readings. The first, *systolic pressure*, is a point of high pressure; the result of constriction of the ventricle pushing the blood into the arteries. The second, *diastolic pressure,* occurs when the ventricle has relaxed before starting the cycle once again.

The cardiovascular system receives innervation from both the sympathetic (SNS) and parasympathetic (PNS) branches of the autonomic nervous system. The overall heart rate is the result of a combination of both branches of innervation, each working against the other. Both systems originate in the cardiac centers of the medulla oblongata, but take different routes and have different levels of influence on cardiac activity. Sympathetic innervation is accomplished through ganglia in the lower cervical and thoracic level, whereas parasympathetic innervation is

carried via the vagus nerve (CN X). Although PNS may have the more direct route, the heart receives significantly greater innervation from the SNS (Martini et al., 1998).

Cortisol

Traditional measures of psychophysiology (heart rate, skin conductance, electromyography) are adept at recording changes in physiology that can occur in seconds, but there are also changes that can occur over the course of minutes. When an organism experiences stress, one of the most robust physiological changes that can occur is activation of the hypothalamic-pituitary adrenal (HPA) axis. The HPA axis involves a cascade of hormone events that culminate in the release of cortisol from the adrenal cortex. Following release of cortisol from the adrenal cortex, it then circulates through the bloodstream and can be monitored through blood or saliva assay. The average time from perception of a stressful event to peak cortisol levels ranges from 20 to 40 minutes (Dickerson & Kemeney, 2002).

In addition to the slower time course of cortisol reactivity, the baseline levels of cortisol also vary with circadian rhythms (Kirschbaum & Hellhammer, 1989; Weitzmann et al., 1971). Generally, cortisol levels tend to be highest in the morning upon waking and steadily decrease during the day. Because levels are higher in the morning and therefore closer to the ceiling, some studies have reported greater cortisol reactivity (i.e. changes in response to some stimulus – stress, corticotropin releasing hormone, insulin injection) in the morning than in the afternoon (Copinschi et al., 1983; DeCherney et al., 1985; Schulte et al., 1985), but more recent studies have not been able to find any differences in reliability of the cortisol response based on time of day (Galliven et al., 1997; Kudielka, Schommer, Hellhammer, & Kirschbaum, 2004).

Since cortisol was first recognized by Hans Selye (1956) as an important contributor to the stress response, multiple theories have been advanced that suggest different contexts where

the HPA axis may become activated (for an extensive review, see Dickerson & Kemeney, 2004). Whereas the eliciting stimuli may be debatable, the physiological role of cortisol is better understood. When activated for short periods of time, cortisol fulfills a role of energy release: it stimulates gluconeogenesis in the liver and fatty tissue, mobilizing energy for immediate use in a stressful environment. However, if the HPA axis remains chronically activated it can have deleterious effects, including immunosupression (Cohen, 1989, Schwarttzman & Cidlowski, 1993; McEwen et al., 1997), hippocampal deterioration (Diamond, Bennet, Flshner, & Rose, 1992; Pavlides, Watanabe, & McEwen, 1993), and the health and memory deficits that accompany such changes in the body (Sapolsky, 1996; Sapolsky, Romero, & Munck, 2000).

Central to many theories of HPA activation is the presence of a threat to the organism (Dickerson et al., 2004; Blascovitch & Tomaka, 1996; Sapolsky, et al., 2000). Dickerson and colleagues have proposed that the HPA axis is part of a *self-preservation system*, the role of which is to “[monitor] the environment, for threats to one’s social esteem or social status and [coordinate] psychological, physiological and behavioral responses to cope with such threats.” Indeed, the relationship between social-evaluative threat conditions and cortisol responding is a large effect ($d = 0.67$; Dickerson et al., 2004).

Although self-esteem plays a central role in the self-preservation theory proposed by Dickerson *et al.*, there is a small amount of research on the relationship between self-esteem and cortisol reactivity in humans. In one study, Pruessner, Hellhammer, & Kirschbaum (1999) presented participants with a difficult task and gave them success or failure feedback. There was no relationship between self-esteem and cortisol levels, except in the condition where participants were told they had failed at the experimental task. When failure feedback was administered, participants with lower self-esteem experienced a lower sense of control resulting

in a heightened cortisol response. One important aspect to note is that self-esteem was only measured with an explicit measure. The present study will examine the role that implicit self-esteem could play in predicting a heightened cortisol response, and how this response can affect an individual's working memory capabilities.

In a study of depressed individuals, Scarpa & Luscher (2002) had participants complete an uncontrollable laboratory task – participants were exposed to bursts of white noise and told they could stop the noises if they pressed the correct button sequence...which did not exist. The authors found that individuals with low explicit self-esteem, cortisol reactivity did not predict depressive severity, but for individuals with higher self-esteem, cortisol reactivity was positively correlated with depressive symptoms. This interaction was mediated by perceptions of controllability: the less controllable the task was perceived as, the greater was the cortisol response. This relationship of cortisol reactivity and feeling a lack of control over the situation fits nicely with the theory of threat vs. challenge appraisal, presented below.

Threat vs. Challenge Responses

In recent years, some interesting work has been done by Blascovich and Tomaka (1996) on how cognitive appraisals can differentially affect physiological responses to events. The authors propose a *biopsychosocial model* that considers not only the affect an individual experiences in a given situation, but how that affect interacts with the individual's cognitive processes. Central to their theory is the concept of resource demands: if an individual perceives that he or she does not possess the ability to meet the demands of a task, they will experience this situation as threatening and will show activation of the HPA axis. However, if the individual does appraise the situation as one for which they possess the ability to meet demands, they will show activation of the sympathetic adrenal-medullary (SAM) axis. Physiologically, threat and

challenge show a different pattern of responding. Threat increases cardiac contractility, but because the HPA activation blocks release of epinephrine from the adrenal medulla, there is no change in blood pressure or heart rate (Blascovitch & Mendes, 2000). Because the HPA axis becomes activated, this should result in an increase in salivary cortisol levels, although no published studies have yet examined this effect. Challenge, by activating the SAM axis, shows a different physiological response, which is marked by an increase in blood pressure and heart rate (Esler, Jennings, & Lambert, 1989; Tomaka, Blascovich, Kibler, & Ernst, 1997). Again, no studies to date have examined the effect this response may have on salivary cortisol, but due to the lack of activation of the HPA axis, there should not be a noticeable increase in salivary cortisol levels.

In a series of studies, Tomaka et al. (1997) tested the cognitive appraisal theory against the peripheralist idea that attributions rely on physiological responses. In the first experiment, the authors presented participants with sets of mental arithmetic problems. Half of the participants received instructions that emphasized the task as a challenge – “do your best” – and the remaining subjects received instructions that presented the task as a threat – “responses will be scored for speed and accuracy.” Psychophysiological responses (heart rate, blood pressure, impedance cardiography and electrocardiographic responses) were recorded during the task. Participants who received challenge instructions and reported seeing the task as a challenge experienced physiological reactions indicative of a challenge response, marked by increased sympathetic activation but decreased (or unchanged) peripheral resistance. Participants who received threat instructions also showed activation of the sympathetic nervous system, but showed increased peripheral resistance. In a second experiment, the authors manipulated the physiological activity of participants to make it resemble that of a challenge or threat response

(e.g., riding a stationary bike, or performing a cold-pressor task). They found that physiological activity itself was not sufficient to cause the individual to appraise a situation as threatening or challenging. However, in each of these experiments, circulating cortisol levels were not measured and were merely inferred through the use of cardiography measures.

Subsequent studies have shown that these challenge and threat physiological reactions are sensitive to social interactions. When interacting with a stigmatized individual, participants showed an increase in threat physiology (i.e. increase in heart rate coupled with an increase in blood pressure), which in turn decreased performance on a word-finding task. Alternately, participants interacting with a nonstigmatized individual exhibited challenge physiology (i.e., increase in heart rate without an increase in blood pressure), which did not interfere with performance on a word-finding task (Blascovich, Mendes, Hunter, Lickel, & Kowai-Bell, 2001). To date, no studies have examined potential relationships between threat vs. challenge physiology and aggression. Additionally, a literature review did not identify any studies to date that have examined the relationship between appraisals of threat or challenge and cortisol reactivity in humans.

A separate line of research has studied the relationship between anxiety and working memory using the framework of processing efficiency theory (Eysenck & Calvo, 1992; Eysenck, Derakshan, Santos & Calvo, 2007). Processing efficiency is conceptualized as the level of performance a participant performs at relative to the amount of mental resources the participant has to devote to the task at hand (i.e. a participant who can perform well while using very few cognitive resources is said to be cognitively efficient). The theory uses Baddeley's (1986) model of working memory as a foundation and assumes that the cognitive resources that are influenced by anxiety are limited primarily to the central executive (Eysenck et al., 2007). The primary

effects of anxiety, the authors propose, are a decrease in performance on attentional control – the ability to focus on a desired task – because the threatening situation of stimuli begin to drain attentional resources. Evidence for these theories come from studies showing that anxious participants use additional effort to boost performance in the face of decreased processing efficiency, and these decreases in performance become more pronounced as they increasingly rely on the central executive (for review, see Eysenck et al., 2007). The anxiety experienced by a participant also can be detrimental to their ability to inhibit unwanted responses. Increased anxiety and stress impair performance on the Stroop task (Pallak, Pittman, Heller, & Munson, 1975; Hochman, 1969).

The neural substrate associated with this anxiety-performance relationship has been hypothesized to be in the right prefrontal cortex (Shackman, et al., 2006). Processing of approach and withdrawal-related emotions is thought to occur in the left and right prefrontal cortices, respectively (Coan & Allen, 2003, 2004; Davidson, 1994). Given that anxiety is largely a negative emotional state, Shackman and colleagues (2006) hypothesized that anxiety would more significantly impair executive processes involving the right (withdrawal) hemisphere. The authors asked participants to complete two three-item *n*-back tasks (the participant was shown a series of stimuli and asked to press a button if a stimulus matched a stimulus three back in the series). One of the tasks used a verbal (left hemisphere) format in which the participant was asked to identify if the same letter had appeared three back. The other task used a spatial (right hemisphere) task, composed of a box that appeared at different locations on the screen. The participant was asked to identify if it appeared at the same location as it had three back in the series. In addition to performing the tasks, the researchers recorded acoustic startle EMG and corrugator activity, and, to invoke a state of anxiety, participants were told they would receive

electric shocks at various times throughout the experiment. The results revealed a dissociation in task performance: verbal working memory remained intact, regardless of how much anxiety the participant experienced – but spatial working memory was significantly impaired during states of anxiety. While the results are impressive, in reality participants are not often exposed to situations where they may be subjected to electric shocks. Therefore, the present study will attempt to examine the effect ego-threatening feedback has on the anxiety/threat response of a participant without the use or suggestion of electric shock.

The present study will use cardiovascular recording and cortisol assays to attempt to assess the level of anxiety/threat a participant experiences when presented with failure feedback. No studies to date have examined the role that implicit self-esteem may play in predicting the response an individual has to a challenging versus threatening environment. Assuming that participants with discrepant (high explicit, low implicit) self-esteem have a heightened threat response (increased blood pressure and heart rate, and cortisol reactivity), the present study will also examine the effects this has on subsequent working memory and response inhibition tasks.

The Present Study

Given that negative feelings make an individual more prone to aggressive outbursts, it seems intuitive that if an individual feels badly about himself or herself (low self-esteem), this would make the person more prone to aggress. Indeed, this was the dominant theory for a potential link between self-esteem and aggression for nearly a decade (Oates & Forrest, 1985; Schoenfeld, 1988; Baumeister, Smart, & Boden, 1996). After reviewing the literature on self-esteem and aggression, however, Baumeister et al. (1996) proposed that it is *high* self-esteem individuals who are prone to aggressive outbursts. The reason for this, the authors propose, is that individuals with high self-esteem have more of an opportunity for threats to the ego. Kernis

(1993) has been particularly interested in how levels of self-esteem can change over time, and proposed that individuals who have highly variable levels of self-esteem may be especially sensitive to feedback. Consistent with this hypothesis, Kernis, Cornell, Sun, Berry, and Harlow (1993) found that negative feedback caused defensive reactions in individuals with high self-esteem, if the esteem was unstable over time.

Bushman and Baumeister (1998) examined the self-esteem-aggression relationship and found no relationship between self-esteem and aggression in response to an ego challenge. However, individuals who scored high on a scale of narcissism did react more aggressively toward the individual who provided the insult. In the experiment, self-esteem was only measured using an explicit measure (the Rosenberg scale), and modern conceptions of self-esteem suggest that self-esteem can either be secure or fragile (Zeigler-Hill, 2006). Insecure self-esteem, as discussed above, can be measured in different ways, such as measuring self-esteem stability (Kernis et al., 1993), or discrepancies between implicit and explicit self-esteem (for review see Kernis & Paradise, 2002). In a second experiment, the authors investigated the role of perceived threat (as indicated by self-report) and found that threat mediated the relationship between narcissism and aggression. The present study will assess insecure self-esteem by utilizing a measure of implicit self-esteem.

Interestingly, as noted earlier, implicit self-esteem can have significant effects on individuals who are high in explicit self-esteem: they score higher on measures of narcissism (Jordan et al., 2003; Zeigler-Hill, 2006), fail to self-regulate after negative feedback (Lambird & Mann, 2006), are more negative to outgroup members (Jordan, et al., 2005; Kernis et al., 2005), and show more unrealistic optimism than individuals with secure self-esteem (Bosson, et al, 2003). To date, no studies have examined defensive self-esteem (high explicit, low implicit) as it

may relate to aggression. However, if negative mood states and threatening cognitive appraisals can reduce mental resources, and those are the same resources that are needed to inhibit an aggressive response, it would seem that individuals with fragile self-esteem may be more prone to an aggressive response if negative affect is aroused.

Therefore, the present study will examine the relationships between self-esteem (implicit vs. explicit) and aggression when an individual is presented with an ego threat. The relationship between self-esteem and aggression has consistently been shown to be small, and possibly nonexistent, but this relationship has only been examined with explicit self-esteem measures. Recent findings on the importance of implicit attitudes highlight the impact they may have on narcissism (Zeigler-Hill, 2006), prejudice (Jordan, Spencer, & Zanna, 2005), and anger suppression (Schroder-Abe, Rudolph, & Schuz, 2007). Therefore, it is possible that the absence of a link between self-esteem and aggression thus far has been because experiments have failed to distinguish between secure and insecure self-esteem. The proposed experiment will attempt to circumvent this outcome through the perspective of self-esteem as a heterogeneous phenomenon.

The primary hypothesis of this proposal is that individuals with insecure self-esteem will respond to an ego threat with a physiological threat response (increased blood pressure/heart rate and a larger level of cortisol reactivity), and this will have the result of diminishing working memory. This depletion of executive resources will make the individual less able to inhibit aggressive impulses, thereby resulting in increased aggression. Individuals with secure self-esteem, however, will not experience a threat so much as a threat because implicitly they do not harbor self-doubt. Therefore, threatening feedback will not make their implicit attitude salient and will not deplete working memory, nor increase aggression.

CHAPTER TWO: METHOD

A series of three experiments will be conducted, each testing separate relationships within the model (Figure 1). Experiment 1 will examine how discrepancies between implicit and explicit self-esteem affect physiological threat/challenge responses, and the impact physiological changes have on working memory capacity. Experiment 2 will examine the relationship between self-esteem, ego threat and inhibitory ability, and the role these constructs play in preventing aggressive behavior. Experiment 3 will examine the relationship between threat physiology, working memory capacity and inhibitory control. Specifically, does a physiological threat response deplete working memory capacity, thereby making an individual less able to inhibit responses?

Experiment 1

Previous research (e.g. Schmader et al., 2003) has attempted to examine how perceived threat can affect working memory, but no studies to date have examined the physiological responses and individual differences that may mediate this relationship. This experiment will examine how failure feedback may interact with self-esteem discrepancies to predict physiological threat responses (Figure 2). Additionally, the effect these responses have on working memory will be examined. It is predicted that individuals with discrepant self-esteem will show physiological responses congruent with threat responses to failure feedback, and this physiology will be associated with lower working memory capacity.

Participants

A review of previous literature identified the relationship between negative feedback and physiological reactivity was the smallest effect in the model (Gruenewald, Kemeny, Aziz, &

Fahey, 2004; Cohen's d = .65, a large effect). A power analysis of this effect determined that 94 participants would be required to detect the effect (Soper, 2009). The present study included 116 individuals (47 men) enrolled in an introductory Psychology course at Georgia State University (ages 18-30, mean = 20.2 years old). Participants were asked not to eat, smoke, exercise, or consume low pH beverages for at least one hour prior to the beginning of the experiment. Compliance was assessed by asking participants to report the last time they ate, drank or smoked after obtaining informed consent. At the end of the study, participants were asked to guess the motive of the experiment. One participant was excluded for correctly guessing the experiment was attempting to measure reactions to feedback. Three individuals reported having recently ate, and therefore did not supply saliva. Eight participants did not supply sufficient saliva at either baseline or at the end of the experiment and therefore cortisol levels were unable to be quantified. One participant aborted the experiment early due to equipment failure and therefore her data were not included. In total, the final number of participants in the experiment was 103 (49 in the threat condition, 54 in the challenge condition). However, this was primarily due to loss of saliva data. For analyses that did not include cortisol, 114 participants were included (116 minus the participant who suspected the purpose of the experiment, and the participant lost due to equipment failure).

Procedure

Personality Questionnaires. Explicit self-esteem was measured using the Rosenberg Self-Esteem Scale (α = .88, Dobson, Goudy, Keith, & Powers, 1979; test-retest reliability = .85, Silber & Tippett, 1965) (RSES; Rosenberg, 1965). The RSES is a ten-item questionnaire that asks participants how much they agree with statements such as "I take a positive attitude towards

myself" and "At times I feel like I am no good at all" (reverse scored). Participants respond with one of four responses (strongly agree to strongly disagree).

Psychophysiology. Following the completion of the questionnaires, the experimenter returned to the room and the participant was given a small Salivette swab (Sartstedt, Rommelsdorf, Germany) in which to collect a saliva sample. The cotton sampling device was kept in the mouth for approximately 2 minutes. During this time, the experimenter administered a blood pressure and heart rate reading from the participant's left brachial artery using an automated sphygnomanometer (Omron Healthcare, Bannockburn, Illinois) while the participant remained seated. The participant was instructed to place the cotton saliva collection gauze directly into the test tube without using their fingers, and all samples were frozen (approximately -20 C°) until analysis.

Baseline Working Memory. Following completion of the physiological measurements, participants completed the Operation Span Task (OST; La Pointe & Engle, 1991; Turner & Engle, 1989), which involves memorizing single-syllable words for later recall while concurrently evaluating whether mathematical equations are correct or incorrect. Each equation consists of (a) multiplication or division, (b) addition or subtraction, and (c) a solution (e.g. Is (5 x 2) – 3 = 7?). Participants are asked to indicate "yes" or "no" regarding whether or not the solution is correct, and are then shown a word for two seconds. Sets of equation-word pairs vary in length, between two and five stimuli per set. Following the conclusion of the set, the participant is shown "???" and they write down all the words they can remember from that set in the same order they were shown. Working memory capacity is quantified as the number of words the participant correctly recalls from each set divided by the total number of sets. This

measure has been widely used and demonstrates acceptable reliability and consistency (α = .78, test-retest = .83, Unsworth, Heitz, Schrock, & Engle, 2005).

Implicit Association Task. After completing the working memory task, the experimenter introduced the next computer task and explained that the computer would automatically run the task. The task consisted of the Implicit Association Task (IAT; test-retest reliability = .69; Bosson, Swann & Pennebaker, 2000; Greenwald, et al., 1998, α = .88, Bosson et al., 2000). Participants are shown words in the center of the screen and asked to respond as quickly as possible. Category labels appear in the upper left and right corners of the screen, and participants are instructed to use the "d" and "k" buttons to categorize stimuli into the two categories. There were seven blocks of trials, five of which (1, 2, 3, 5 and 6) were practice. The first block asks participants to categorize stimuli as *good* or *bad*. The second block asks them to categorize stimuli as *self* or *other*. Blocks 3 and 4 add the two categories together: if the stimuli is *good* or *self* it will be one side, if the stimulus is *bad* or *other* it will go to the other side. Blocks 6 and 7 are similar, but link *bad* and *self* on one side, with *good* and *other* on the right. IAT latencies are calculated using Blocks 4 and 7 only. At the end of the task, the computer automatically returned a screen that read "Score: 193. Please tell the experimenter you are finished."

Praise/Failure Feedback. The experimenter then returned to the room and delivered either positive or negative feedback, randomly assigned by a coin toss before the experiment began. Positive feedback consisted of the experimenter seeing the score and replying in a cheerful tone "Wow! Great job, that's a good score! Ok, let's go on to the next task." Negative feedback included the experimenter returning to the room, seeing the score and replying in a disgusted tone "Ugh, that's kind of a low score. Well, let's just go on to the next task."

Post-manipulation Working Memory. Following the feedback, the participant completed the automated version of the operation span (OPSPAN; LaPointe & Engle, 1990). In this version, the participant is shown a math problem without an answer at the end (e.g., 4 + 6 = ?) and asked to compute the answer to the problem. After thinking of the answer, the equation is removed from the screen and replaced by a number, along with a box marked "True" and a box marked "False." If the number is the answer to the problem, the participant clicks "True," but if it is not the correct answer, the participant clicks "False." When the box is clicked, the screen is cleared and a letter appears on the screen. That is the letter the participant is to remember for the recall portion of the experiment. After a number of equations and letters, a recall screen is shown which has a grid of 16 letters. The participant is asked to click on the letters he/she was shown, in the order they were presented, and to click "Exit" when he/she is finished. Following this, the participant is given immediate feedback by the computer on how many letters they correctly recalled, the number of math problems they correctly solved, and the overall percentage of math problems that were correct for the entire experiment. Participants were instructed to keep their overall math performance above 85% "because we only use the data for people who score above 85%."

Post-Manipulation Physiology & Aggression Measures. Following the completion of the automated OPSPAN task (approximately 20 minutes), the experimenter obtained another blood pressure and heart rate reading from the participant's left brachial artery using an automated sphygmomanometer, and saliva sample using a new Salivette swab which was kept in the mouth for two minutes. Participants were then asked to complete an "experimenter evaluation form" (Appendix A). The feedback form is considered the measure of aggression, as low ratings of the experimenter could endanger the individual's job. To strengthen the cover story, participants

were asked to seal the evaluation in the envelope and place the envelope into a locked box labeled "Experimenter Evaluations." Before debriefing, participants were asked to guess what the experiment was measuring, and to rate the praise/failure feedback on a scale of 1 (not at all believable) to 4 (totally believable). Participants were then debriefed.

Results

Data Analysis Strategy. In the proposal for this series of experiments, it was hypothesized that a moderated mediation approach would be best-suited to analyzing the data. However, moderated mediation requires a series of significant pathways (either directly, or indirectly; Muller, Judd, & Yzerbyt, 2005) in order to test for mediation, and moderation of the mediation. Unfortunately in the experiments below, there were few significant relationships between the constructs of interest. Therefore, tests for mediation were unable to be performed. As a result, more appropriate statistical measures (MANOVA, hierarchical linear regression, logistic regression) were utilized to examine relationships between the variables.

Data Screening. Each variable was examined for normality and outliers by viewing box plots and q-q plots of the data. Baseline working memory was normally distributed (M = .74, SD = .09). One value was identified as an outlier (greater than 3 standard deviations lower than mean) and was removed from the dataset. Post-manipulation working memory exhibited negative skew and was therefore transformed by reflecting the distribution (multiplying by -1 and adding a constant) and taking the square root of each value.

Implicit Association Task reaction time data were processed according to the procedures outlined in Greenwald and Farnham (2000). All responses less than 300 ms were recoded to 300 ms and responses greater than 3,000 ms were recoded to 3,000 ms. Reaction time data were log transformed (Bosson, Swann, & Pennebaker, 2000) and the first two trials for each block were

deleted. Means were then calculated for each block, and the self-negative block was subtracted from the self-positive block yielding a latency score. Thus, positive scores indicate higher self-positive associations and higher implicit self-esteem whereas negative scores indicate stronger associations between self-words and negative adjectives (*M* = .07, *SD* = .06).

Saliva samples were stored in a chest freezer at approximately -20 C within 4 hours of collection, and were kept frozen until analysis (up to three months later). Cortisol levels were quantified by radioimmunoassay (Coat-a-Count Cortisol I125 immunoassay kit; Siemens Medical Solutions Diagnostics, Los Angeles, CA). All samples were run in the same assay (*M* = 7.88, *SD* = 3.75, intra-assay precision 2.28%, r = .99, sensitivity = 0.12-113.11 nmol/L, Specificity: Cortisol 100%, 11-Deoxycortisol 11.4% and less than 1% for all other related compounds). Time of day was controlled for by running all participants in the afternoon to account for circadian differences in baseline cortisol levels. Mean arterial pressure (MAP) was computed by the equation (2 x diastolic pressure + systolic pressure)/3) based on the blood pressure readings obtained from the sphymomanometer (*M* = 82.34, *SD* = 9.17). Descriptive statistics for each variable are shown in Table 1.

Manipulation check. In order to confirm that the experimental manipulation of negative vs. positive feedback had the desired effect on experimenter ratings, a Mann-Whitney *U* test was conducted to compare the ratings across groups. The Mann-Whitney *U* test was chosen due to the extreme skew in the data (transformations were unsuccessful at removing the skew). Therefore, parametric statistics were inappropriate to compare groups. Individuals who received failure feedback rated the experimenter lower (*M* = 34.62, n = 56) than individuals who received positive feedback (*M* = 35.22, n = 58), *U* = 1361, z = -2.33, $p < .05$, $r^2 = .04$ (4% of the variance, a medium effect, Cohen, 1988).

Hypothesis 1: Following negative feedback, discrepant self-esteem will be associated with physiological threat responses (i.e., increases in cortisol but not mean arterial pressure) whereas secure self-esteem will be associated with challenge responses (i.e., increases in blood pressure, but not cortisol levels).

Effect of feedback on physiological measures. A one-way between-groups multivariate analysis of covariance was performed to investigate differences in physiological reactivity between feedback conditions. Two dependent variables were used: post-task mean-arterial pressure (MAP; (2 x diastolic pressure + systolic pressure)/3) and post-task cortisol levels. Baseline MAP and cortisol levels were entered as covariates, and feedback was entered as the between-subject variable. Preliminary testing for the assumptions of normality, linearity, univarite and multivariate outliers, as well as homogeneity of variance-covariance matrices and multicollinearity were conducted. Two participants were identified as outliers (Mahalanobis distances > 13.82) and were therefore excluded from the analyses. There was a nonsignificant trend toward a difference between positive and negative feedback conditions on the composite physiological dependent variables, F (2, 97) = 2.84, p = .06; Wilks' Lambda = .95; pη^2 = .06 (6% of the variance, a medium effect). An inspection of the mean scores indicated that individuals in the negative feedback condition showed higher levels of post-manipulation cortisol (M = 8.62, SD = 4.45) than individuals who received positive feedback (M = 7.45, SD = 3.80), as well as higher MAP values (negative feedback: M = 85.63, SD = 10.41; positive feedback: M = 84.45, SD = 9.82).

Self-esteem as a predictor of physiological reactivity. Separate hierarchical regressions were performed to examine the effect of feedback and self-esteem on cortisol and MAP reactivity. Hierarchical regression was chosen in order to partition variance between main

effects and interactions between feedback and self-esteem in predicting physiology. Baseline values were entered in a preliminary step to act as a covariate. Regressing post-experiment cortisol values on feedback type, implicit and explicit self-esteem accounted for a significant portion of variance, F_{change} (3, 97) = 2.73, $p < .05$, $R^2_{change} = .05$ (5% of the variance, a medium effect; Table 2). One main-effect was present in the first step: individuals who received negative feedback had greater increases in cortisol levels than individuals who received positive feedback, $b = -.70$, t = -2.27, $p < .05$, $pr^2 = .03$ (3% of the variance, a small effect). There was also a trend such that higher explicit self-esteem was marginally associated with greater cortisol reactivity, $b = .64$, t = 1.80, $p = .07$, $pr^2 = .02$ (2% of the variance, a small effect). Implicit self-esteem was not related to cortisol reactivity, $b = .92$, t = .18, $p = .85$, $pr^2 = .00$. Second-order interactions did not account for any additional variance, F_{change} (3, 94) = .00, $p = 1.00$, $R^2_{change} = .00$, including the interaction between implicit self-esteem and feedback, $b = -.55$, t = -.10, $p = .91$, $pr^2 = .00$, and the interaction between implicit and explicit self-esteem, $b = -.20$, t = -.03, $p = .97$, $pr^2 = .00$. The three-way interaction term between implicit self-esteem, implicit self-esteem and feedback was insignificant, F_{change} (1, 93) = .03, $p = .87$, $R^2_{change} = .00$.

A separate hierarchical regression was conducted to examine the relationships between feedback, explicit and implicit self-esteem on mean arterial pressure reactivity (MAP; Table 3). Again, hierarchical regression was used to examine the effects of the variables on mean arterial pressure. There were no main effects nor interactions that significantly accounted for the variance in mean arterial pressure scores, although there was a trend towards individuals who received negative feedback exhibiting higher mean arterial pressure, $b = -.90$, t = -1.79, $p = .08$, $pr^2 = .01$ (a small effect). Implicit self-esteem did not predict MAP reactivity, $b = -8.40$, t = -.99, $p = .32$, $pr^2 = .00$, did not interact with explicit self-esteem, $b = -10.63$, t = -.18, $p = .34$, $pr^2 =$

.00, and did not interact with feedback when predicting MAP reactivity, $b = 2.71$, t = .31, p = .75, $pr^2 = .00$. The third step included the three-way interaction term between feedback, implicit self-esteem and explicit self-esteem, and was nonsignificant, F_{change} (1, 104) = .00, p = .96, $R^2_{change} = .00$.

Hypothesis 2: In response to negative feedback, physiological threat responses will predict decreases in working memory from baseline while physiological challenge responses will predict an increase in working memory capacity.

Effect of physiological changes on working memory. A hierarchical regression was conducted to examine the relationships between feedback, physiology and working memory (Table 4). Baseline working memory score, baseline cortisol level and baseline MAP were entered in the first step as covariates. In the following step, post-task MAP, cortisol levels and feedback type were entered and did not account for a significant portion of variance, F_{change} (3, 93) = .913, p = .44, $R^2_{change} = .02$. In a third step, two-way interaction terms were entered and again did not account for a significant portion of variance, F_{change} (3, 90) = .03, p = .99, R^2_{change} = .00, and the final step included the three-way interaction term between MAP, cortisol and feedback, F_{change} (1, 89) = .79, p = .38, $R^2_{change} = .01$.

Hypothesis 3: In response to negative feedback, physiological threat responses will be associated with aggression toward the experimenter.

Physiology and Aggression. There was an extreme amount of negative skew in the ratings of the experimenter such that the majority of participants rated the experimenter the maximum rating possible. Transformations were not successful at reducing the skew, and therefore experimenter ratings were binned into a binary variable for logistic regression analysis. Participants who did not penalize the experimenter on any rating item (i.e. giving the

experimenter a perfect score of 36) were coded as 0 ("no aggression"). Scores of 0-35 were recoded as 1 ("became aggressive").

Binary logistic regression was performed to assess the impact of cortisol, mean arterial pressure and feedback on the likelihood that participants would give the experimenter a less-than-perfect rating (SPSS 17.0, Chicago, IL; Tabachnick & Fiddell, 2007). The model contained the three variables, their two-way interactions, and the three-way interaction, which were entered in three steps in a hierarchical regression. Baseline mean arterial pressure and cortisol values were entered in a preliminary step to act as covariates. The full model containing all predictors was statistically significant, χ^2 (9, N = 115) = 21.62, $p < .01$, indicating that the model was able to distinguish between participants who penalized the experimenter from those who did not. The model as a whole explained between 18.9% (Cox and Snell R^2) and 27.4% (Nagelkerke R^2) of the variance in experimenter ratings and correctly classified 79.6% of the cases. As shown in Table 5, three variables made a unique significant contribution to the model: feedback condition, feedback x mean arterial pressure change, and the interaction between cortisol and mean arterial pressure. The strongest predictor of aggression was feedback type, recording an odds ratio of 3.40, such that individuals in the negative feedback condition were 3.4 times more likely to penalize the experimenter.

In order to examine the interaction between MAP and cortisol changes in predicting aggression, a separate logistic regression was conducted for only participants in the negative feedback condition. The full model containing all predictors (baseline MAP and cortisol values, post-manipulation MAP and cortisol values, and MAP x cortisol) was statistically significant, χ^2 (5, N = 49) = 18.34, $p < .01$, indicating that the model was able to distinguish between participants who penalized the experimenter from those who did not. The model as a whole

explained between 31.2% (Cox and Snell R^2) and 42.7% (Nagelkerke R^2) of the variance in experimenter ratings and correctly classified 77.6% of the cases.

Values +/- 1 SD of each variable were inserted into the regression equation in order to examine the interaction (Figure 3). Individuals with cortisol and MAP values that both increased one standard deviation above the mean had a 1% probability of being categorized as aggressive, as did individuals whose cortisol and MAP values both rose less than one standard deviation. Individuals whose cortisol values rose one standard deviation greater than the mean, but whose MAP values rose one standard deviation below the mean, were 52% likely to be categorized as aggressive. Individuals whose cortisol values rose one standard deviation less than the mean, but whose MAP values increased one standard deviation above the mean, had a 99% probability of being categorized as aggressive[1].

Threat and Challenge. PANAS items reflecting threat were selected to index measures of threat (see Appendix B; $\alpha = .90$), as were items to reflect challenge ($\alpha = .86$). In order to confirm that an increase in blood pressure without a concurrent increase in cortisol was evidence of a challenge appraisal, post-experiment ratings of challenge items on the PANAS were regressed on MAP and cortisol scores for individuals in the negative feedback condition. The interaction between cortisol and MAP showed a nonsignificant trend toward individuals' feelings of challenge (after controlling for baseline cortisol, MAP and challenge ratings; F_{change} (1, 42) = 3.91, $p = .06$, $R^2_{change} = .03$, 3% of the variance, a small effect).

Similarly, in order to confirm that an increase in cortisol without a concurrent increase in blood pressure was indicative of increased feelings of threat, post experiment ratings of threat

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[1] An alternative model was examined using only implicit self-esteem (without explicit self-esteem). Results are discussed in Appendix 3.

items on the PANAS were regressed on MAP and cortisol scores for individuals in the negative feedback condition, after controlling for baseline feelings of threat, MAP and cortisol levels. The interaction between cortisol and MAP did not predict feelings of threat: F_{change} (1, 42) = .29, p = .53, R^2_{change} = .01.

Self-Esteem, Working Memory and Aggression. The relationship between self-esteem, working memory and aggression is hypothesized to be a small effect. In order to maximize power to detect this effect, data from Experiment 1 will be pooled with data from Experiment 2 in order to examine this effect. Results are presented with Experiment 2.

Discussion – Experiment 1

Feedback type had an effect on the physiological stress response of participants, such that individuals who received failure feedback showed an increase in cortisol levels and a trend toward an increase in mean arterial pressure. Of particular interest, individuals who had higher explicit self-esteem showed greater cortisol reactivity regardless of feedback condition. The relationship between self-esteem and reactivity has been found in numerous studies, although the relationship has been inconsistent (Preussner, Hellhammer, & Kirschbaum, 1999; Scarpa & Luscher, 2002). The present study adds to the literature by integrating a measure of implicit self-esteem to examine contributions of a heterogeneous model of self-esteem to understanding physiological reactions to feedback. The present study also is the first to examine the consequences of these changes in physiology and appraisals on aggressive behavior.

The finding that individuals with high explicit self-esteem are more physiological reactive to feedback, regardless of whether it is positive or negative, is puzzling. Modern theories of ego-threat and self-esteem would predict that high self-esteem would be associated with greater physiological reactivity in response to negative feedback (an ego-threat), but that this

reactivity is also present when given positive feedback is particularly perplexing. It could be that individuals with high self-esteem are just more sensitive to feedback, or possibly more open to the opinions of others, however these hypotheses would need to be addressed in future studies.

A significant finding in the present study is the interaction between mean arterial pressure, cortisol reactivity and aggression, such that individuals who received negative feedback and had high MAP reactivity, but low cortisol reactivity, were more aggressive toward the experimenter. Contrary to the hypothesis that individuals who exhibited a threat response would become aggressive, this data suggests that the *challenge* response (i.e., increased blood pressure without concurrent increase in cortisol levels) predicts aggressive behavior. Consistent with the psychological basis of this response, individuals who exhibited this response reported a nonsignificant trend toward feeling more challenged at the end of the experiment relative to baseline.

Low cortisol levels have been shown to be associated with aggressive individuals in clinical populations (Coccaro & Silver, 1995; McBurnett, Lahey, Rathouz, & Loeber, 2000). A possible conclusion from this finding is that HPA activation to failure feedback is actually a beneficial response. There is evidence in the clinical literature that possessing a hypoactive cortisol response to environmental stressors is associated with an increased fear of negative social evaluation (Tops, Riese, Oldehinkel, Rijsdijk, & Ormel, 2008), so it is possible that individuals with this blunted response (but with appropriate activation of the cardiovascular physiology) were more sensitive to the negative feedback and therefore more reactive to the experimenter on the evaluation form. Of course, further study to examine this hypothesis would be required. Should someone pursue this line of inquiry, they could measure cardiovascular and

cortisol reactivity and see if the physiological measures mediate the relationship between negative feedback and behavioral responses, or negative feelings.

There was no interaction between implicit and explicit self-esteem in predicting threat responding to failure feedback, which fails to replicate an earlier study (Seery, Blascovich, Weisbuch, & Vick, 2004). The difference in study outcomes could be due to several factors. In their study, Seery et al. did not measure implicit self-esteem – instead they used a measure of self-esteem stability by measuring participants' explicit self-esteem levels at various timepoints. The relationships between self-esteem stability and implicit self-esteem have not been examined, but this potentially provides evidence that stability and implicit attitudes are separate constructs (although an explicit test of this hypothesis would be required to confirm this, perhaps through the use of structural equation modeling to see if implicit and stability measures load on separate factors). A second difference is how the studies measured threat/challenge appraisals. Blascovich and colleagues (as well as other labs) have traditionally taken change in impedance cardiography (specifically total peripheral resistance) to serve as markers of the activation of the threat, and supposedly by definition, the HPA axis. In contrast, the present study measured HPA activation through endocrinology. This approach was chosen due to lack of access to impedance cardiography equipment, and because salivary cortisol should provide another measure of HPA activity. However, a literature search failed to find any studies that have concurrently measured cortisol activity to determine the amount of covariance between the measures. Future research should investigate the covariance of salivary cortisol levels and impedance cardiography measures to ensure they are measuring the same construct.

A second null finding was the relationship between cortisol and working memory. Previous studies in nonhuman animals have found a relationship between stress and working

memory (Arnsten & Goldman-Rakic, 1998; Diamond, Park, Heman, & Rose, 1999) and recently a relationship between cortisol and working memory has been found in human studies (Evans & Schamberg, 2009; Luethi, Meier, & Sandi, 2009). However, these human studies have some critical differences with each other and the present study. Evans and colleagues used a longitudinal design to study the relationship between chronic stress and adult working memory, finding that individuals from lower socioeconomic status experience greater chronic stress, which results in lower working memory as young adults. Luethi and colleagues experimentally manipulated acute stress using the Trier Social Stress Task (TSST) and found that individuals who were in the stress group had lower scores on a measure of working memory – the reading span task. Results were analyzed with a between-groups design, and the dose-response relationship between cortisol and working memory was not examined. These studies suggest a potential relationship between cortisol and working memory, but a causal relationship remains elusive.

Unfortunately, implicit self-esteem did not account for a significant portion of the variance, nor did it interact with any of the other independent variables when predicting physiological reactivity to feedback or working memory changes. This seems to argue against a role of heterogeneous self-esteem, at least in the current context of physiology and cognition, although prior studies have found a moderating influence of implicit self-esteem in buffering against criticism (Bosson, Brown, Zeigler-Hill, & Swann, 2003). However, these previous studies looked at self-enhancement tendencies and found that individuals with low implicit self-esteem (as measured by a letter-preference task) were more likely to engage in self-enhancement activities and have more unrealistic optimism. This may hint at a role of implicit self-esteem being more focused on guiding behavioral outcomes and less on cognitive resources.

An additional weakness in the present study is that physiological markers of appraisals failed to predict self-reported feelings. Although nonsignificant, there was a trend between the interaction of MAP and cortisol reactivity predicting challenge appraisals and this lack of significance could be due to a power issue (due to the loss of cortisol data, the sample size in the negative feedback condition was reduced to 43 individuals, and the power to detect an effect size of $R^2 = .03$ is only .12 – far short of the desired .80). However, the relationship between physiology and threat appraisals was much smaller ($R^2 = .01$) and nonsignificant. This lack of relationship is possibly due to the several factors. First, items chosen from the PANAS to reflect threat may not have adequately captured the construct for which they were chosen to measure. However, this seems unlikely as items were specifically chosen that were felt to reflect the constructs of interest. A more likely explanation for the null effects between physiology and self-report is that the self-report questionnaire may have been inadequate in assessing appraisals. Technically, an appraisal is a feeling about an object or situation (Lazarus & Folkman, 1984). The questionnaire that was utilized to assess emotion asked the participant to report how they were feeling at that particular moment. A more appropriate questionnaire would have asked how they felt retrospectively about the tasks while they were performing them, or how they were feeling about their performance on the tasks. By directing their attention to appraising the particular encounter which they had just performed, the questionnaire may have been a better measure of appraisals and may have been significantly related to the physiological variables. Furthermore, threat and challenge appraisals are, by definition, anticipatory experiences (Lazarus & Folkman, 1984) that engender emotional responses. In the present study, the questionnaires that asked the participant to self-report on their feelings were administered at the conclusion of the experiment, thereby missing the anticipatory period during which the threat/challenge

appraisals would have been present. A simple way to prevent this mistake in future studies would be to administer the self-report questionnaire immediately before the behavioral task, rather than at the conclusion of the task.

In summary, the first experiment suggests the importance of considering physiological markers of appraisal when attempting to predict aggressive behavior in response to failure feedback. Although no relationship between feedback and working memory was present, another cognitive component that is frequently cited in studies of aggression is impulsivity and behavioral inhibition. The first experiment also did not support a model of heterogeneous self-esteem, and the inclusion of implicit self-esteem did not contribute a significant portion of variance to the model. In order to examine the relationships between feedback, self-esteem and behavioral inhibition, a second experiment was conducted.

Experiment 2

Although there is a significant body of literature suggesting a relationship between executive functioning deficits and aggression, these studies often rely on psychopathic patient groups or alcohol intoxication rather than healthy controls. Furthermore, the relationship between self-esteem and aggression has been intensely studied, but a thorough literature review did not identify any studies to date that have examined the effect that implicit self-esteem may have on the relationship between explicit self-esteem and aggression. In an attempt to clarify the relationships between self-esteem, ego threat, inhibition and aggression, a second experiment was performed. It was predicted that individuals with discrepant self-esteem will show a lower ability to inhibit behavioral responses following an insult, and this lowered ability to inhibit behavior will be associated with an increase in aggression (Figure 4).

Participants

Examination of previous literature determined that the smallest effect size in the model was the relationship between feedback and aggression (Konrath, Bushman, & Campbell, 2006; Cohen's d = .48, a medium effect). A power analysis determined that 168 participants would be required to detect the effect (Soper, 2009). One-hundred ninety three participants (33 men) were recruited from the introductory Psychology research pool at Georgia State University (ages 18-45, mean age = 20.2 years old). Eleven participants in the negative feedback condition were excluded for reporting they did not believe the experimenter feedback. This resulted in a sample of 182 participants (32 men), of whom 54 were Caucasian, 80 were African-American and 47 reported other ethnicities.

Procedure

Upon arriving to the experiment, participants were asked to complete self-report questionnaires identical to Experiment 1. The participant then completed the IAT, which was followed with positive or negative feedback identical to experiment 1. Following feedback, participants completed a Go/No-go task. Finally, participants were asked to complete an evaluation of the experimenter. Following the evaluation of the experimenter, participants were debriefed as in Experiment 1, such that any suspicion of the purpose of the experiment or the validity of the feedback excluded the data from inclusion in the analyses.

Materials

Self-report measures and the "flexible thinking task" (IAT) will be identical to Experiment 1. Following feedback, participants will complete the Go/No-go task.

Response Inhibition. This task is a computer-administered task that presents participants with a series of letters of the alphabet, based on previous versions in other studies (Amodio, Master, Yee, & Taylor, 2008; Nieuwenhuis, Yeung, van den Wildenberg, & Ridderinkhof, 2003). The participant is instructed to press the space bar whenever they see a letter, *except* when they see the letter X (in which case they do not press any key). Letters are presented individually for 500 msec with a 1500 msec intertrial interval. Stimuli are separated into four blocks, containing 60 stimuli each. The first and third blocks contain the "GO" signal (i.e., X) 80% of the time, thereby training the participant to associate X with the GO signal. The second and fourth blocks contain the GO signal only 50% of the time – the other 50% are filled with filler letters (NO GO). There is no break between blocks. Differences in probability of target stimuli present changes in predictability of the stimuli for the participant. Inhibitory ability is operationalized as the number of correct rejections of the target stimulus (i.e., not pressing the space bar when an X is shown), after controlling for performance during the 80% training block. Unfortunately, although Go/No-go tasks are widely used in neuropsychology, they are poorly standardized across experiments and reliability data are seldom reported. However, in one study that did test reliability of a Go/No-go task, the measure did show a high level of test-retest reliability (r = .83) across a two-week span (Langenecker, Zubieta, Young, Akil, & Nielson, 2006). The task used in the present study was somewhat different from the task used in the test-retest reliability study, such that the current task manipulated the probability of the Go signal as a means to test behavioral inhibition. In the test-retest study cited above, a "Parametric Go/No-go" (PGNG) task was used. The PGNG task integrates a working memory component, asking the participant to only respond to the Go signal when it was preceded by a separate Go-signal (i.e.,

the Go signals are *x* and *y*, and the participant should only respond to *y* when it was preceded by *x* and vice versa).

Results

Data cleaning. All variables were checked for normality prior to completing analyses. Explicit self-esteem was negatively skewed (M = 32.67, SD = 4.88) and was transformed using a square root transformation. Implicit self-esteem data were normally distributed (M = .08, SD = .06). Go/No-go data were positively skewed and transformed using a Log_{10} transformation (50% condition M = *3.24,* SD = 3.30; 80% condition M = 3.99, SD = 3.14). The transformations had the effect of rendering the data closer to the normal distribution, although skew was still present. Given the size of the sample, linear regression methods were assumed to still be appropriate (Tabachnick & Fidell, 2007).

Manipulation check. In order to confirm that the experimental manipulation of negative vs. positive feedback had the desired effect on experimenter ratings, a Mann-Whitney *U* test was conducted to compare the ratings across groups. Individuals who received failure feedback rated the experimenter lower (M = 34.31, n = 87) than individuals who received positive feedback (M = 35.45, n = 95), U = 3467, z = -2.35, $p < .05$, r^2 = .03 (3% of the variance, a small effect).

Hypothesis 4: Following negative feedback, discrepancies in self-esteem will be associated with increased errors on a behavioral inhibition task.

Implicit and explicit self-esteem predicting behavioral inhibition. To examine the relationship between implicit and explicit self-esteem in predicting behavioral inhibition after different types of feedback, feedback was recoded into a contrast coded variable and all variables were entered in a hierarchical regression with the 50% Go/No-go performance variable as the criterion (Table 7). In step one, performance during 80% training, explicit self-esteem, implicit

self-esteem and feedback were entered, F_{change} (4, 174) = 26.90, $p < .001$, $R^2_{change} = .38$. In the second step, the two-way interaction variables were entered (F_{change} (3, 171) = 2.92, $p < .05$, $R^2_{change} = .03$). The two-way interaction term that accounted for the significant portion of variance was the interaction between feedback and implicit self-esteem, $b = .70$, t = 2.95, $p < .01$, $pr^2 = .03$ (a small effect). In order to examine this relationship, 50% performance Go/No-go scores were regressed on feedback, implicit self-esteem and their interaction. The interaction term accounted for a significant portion (3%) of variance in behavioral inhibition, F_{change} (1, 177) = 8.72, $p < .01$, $R^2_{change} = .03$ (a small effect). The dataset was split by feedback condition such that relationships between implicit self-esteem and 50% Go/No-go performance were examined separately for individuals who received positive feedback versus negative feedback. These analyses revealed inverse correlations between implicit self-esteem and feedback, depending on the type of feedback. Individuals who received negative feedback made fewer errors on the 50% Go/No-go task as implicit self-esteem increased, $b = -.72$, t (84) = -2.22, $p < .05$, $pr^2 = .04$ (a medium effect). The relationship between positive feedback and implicit self-esteem was nonsignificant, but those participants who received positive feedback, tended to make more errors on the Go/No-go task as implicit self-esteem increased, $b = .55$, t (92) = 1.82, $p = .07$, $pr^2 = .02$ (a small effect).

Finally, the three-way interaction term was entered into the regression and was nonsignificant, F_{change} (1, 170) = .71, $p = .40$, $R^2_{change} = .00$.

Hypothesis 5: Following negative feedback, aggression toward the experimenter will be predicted by increases in error rates on a behavioral inhibition task.

Behavioral inhibition and feedback predicting ratings of the experimenter. Similar to above, ratings of the experimenter were recoded into a dichotomous variable and were regressed

on feedback and 50% Go/No-go scores while controlling for 80% Go/No-go performance (Table 8). The full model containing all predictors was not statistically significant, χ^2 (8, N = 182) = 6.97, *p* = .08, indicating that the model was unable to distinguish between participants who penalized the experimenter from those who did not. The model as a whole explained between 4.4% (Cox and Snell R^2) and 6.3% (Nagelkerke R^2) of the variance in experimenter ratings and correctly classified 71.4% of the cases. As shown in Table 8, no individual variable accounted for a significant portion of variance in the ratings of the experimenter.

Hypothesis 6: Individuals with discrepant self-esteem will be more likely than individuals with secure self-esteem to aggress toward the experimenter following negative feedback.

Implicit and explicit self-esteem predicting aggression. The relationship between self-esteem is hypothesized to be a small effect size. In order to maximize power to detect this effect, data from experiments 1 and 2 were combined. In order to account for any potential variance caused by different experimental procedures, an experiment variable was created through contrast coding and entered as a covariate (it did not account for any significant portion of the variance in any of the below regressions).

To examine the relationship between the two types of self-esteem and feedback in predicting aggression toward the experimenter, a logistic regression was utilized (Table 9)[2]. Binary logistic regression was performed to assess the impact of explicit self-esteem, implicit self-esteem and feedback on the likelihood that participants would give the experimenter a less-than-perfect rating. The model contained the three variables, their two-way interactions, and the

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[2] An alternative model was examined using only implicit self-esteem (without explicit self-esteem). Results are discussed in Appendix 3.

three-way interaction. The full model containing all predictors was statistically significant, χ^2 (7, N = 299) = 15.69, $p < .05$, indicating that the model was able to distinguish between participants who penalized the experimenter from those who did not. The model as a whole explained between 5.2% (Cox and Snell R^2) and 7.4% (Nagelkerke R^2) of the variance in experimenter ratings and correctly classified 71.4% of the cases. As shown in Table 9, two variables made a unique significant contribution to the model: feedback condition and implicit self-esteem. The strongest predictor of aggression was feedback type, recording an odds ratio of 2.25, such that individuals in the negative feedback condition were 2.25 times more likely to penalize the experimenter. The implicit self-esteem variable was less than 1, indicating that if an individual's implicit self-esteem increased by 1, they were .8% less likely to penalize the experimenter. (Two notes are relevant here: First, the implicit self-esteem variable is a logarithm of a difference score, so an increase of 1 is unrealistic. Second, this did not interact with feedback – this effect is regardless of condition.)[3].

Hypothesis 7: Performance on the behavioral inhibition task will mediate the relationship between discrepant self-esteem and aggression.

The relationships between discrepant self-esteem and inhibition, as well as the relationship between behavioral inhibition and aggression were nonsignificant. Therefore, the data did not meet the assumptions for mediation and this hypothesis was not tested.

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[3] A consistent finding in the aggression literature is a difference between the sexes on measures of aggression. A separate hierarchical regression was conducted to examine if sex of the participant had any effect on the relationships and it did not (four way interaction: F_{change} (1, 277) = 2.44, $p = .12$, $R^2_{change} = .01$). However, this could be due to the small percentage (6%) of men in the sample.

Discussion – Experiment 2

Experiment 2 examined the relationships between self-esteem and behavioral inhibition when presented with success or failure feedback. It was hypothesized that implicit and explicit self-esteem would interact to predict a loss of inhibition when presented with failure feedback, but this hypothesis was not supported. However, there was an interaction between implicit self-esteem and feedback, such that higher implicit self-esteem was associated with fewer behavioral inhibition errors following negative feedback. This finding is consistent with the idea of self-esteem as a buffer to criticism.

Unfortunately, there was no relationship between measures of behavioral inhibition and aggression in the present study. This finding is most likely not due to failure in the manipulation, as individuals who received negative feedback did show a trend toward rating the experimenter lower on the feedback form. The lack of relationship is more likely due to the type of measure used to quantify aggression. A questionnaire rating the experimenter (which is supposedly going to the supervisor) is a rather indirect and instrumental form of aggression, and instrumental aggression is not necessarily correlated with inhibition (unlike hostile aggression; Ramirez & Andreu, 2006). In future studies, laboratory tasks employing more direct forms of aggression (such as the Taylor Aggression Paradigm) may be able to overcome this limitation, or be better able to capture the relationship between these concepts.

There also was no relationship between implicit self-esteem, explicit self-esteem and aggression following failure feedback. Previous studies have shown that individuals with insecure self-esteem are more likely to use hostile interpersonal strategies as a method of self-regulation, to protect against ego-threat (Jordan, et al., 2003; Zeigler-Hill, 2006) and children with discrepant self-esteem are more aggressive than their secure self-esteem peers (Sandstrom

& Jordan, 2008) when aggression is measured by both physical and relational standards. Therefore, the absence of a relationship between the measures in the present study is challenging. One issue that arose in the collection of data was a restriction of range in the scores on the measure of aggression. The majority of participants (70%) did not rate the experimenter lower than the maximum points allowed (i.e., 70% of participants rated the participants as extremely competent, friendly, and suggested they be hired). In an attempt to work past this constraint, values were dichotomized and a logistic regression strategy was used to analyze the data. Future research should utilize measures of aggression that have a greater amount of variance before we can accept a true null relationship between these variables.

Experiment 3

Instructions that emphasize threat or challenge have been shown to affect physiological responses, but their effects on mental processes remain unclear. The third experiment manipulated threat and challenge using instructions similar to previous experiments (Blascovich & Tomaka, 1996) and then measured performance on working memory and inhibition tasks. It was predicted that individuals who receive instructions that emphasize threat would show lower working memory ability than individuals who receive instructions that emphasize challenge. It was also hypothesized that threat-related instructions would also be associated with a decreased ability to inhibit behavior, and this relationship would be mediated by the decrease in working memory ability (Figure 5).

Participants

A review of previous literature determined that the smallest effect size in the model was the relationship between working memory and behavioral inhibition (Mitchell, Macrae, &

Gilchrist, 2002; Cohen's d = .52, a medium effect size). A power analysis determined that 144 participants would be required to detect this effect (Soper, 2009). A total of 186 participants (58 men, 67 White, 64 African-American, 55 other ethnicity) were recruited online from the introductory Psychology research pool (ages 18-42, mean age 20.4 years old). Two participants were dropped for failing to pay attention to any of the tasks, three participants were dropped from the baseline operation span data for failing to follow instructions, and six participants did not have behavioral inhibition data collected due to equipment failure. This resulted in a final sample size of 175 participants with complete data.

Procedure

Upon arriving to the lab, participants were asked to complete self-report measures identical to Experiment 1. Participants were then given instructions on how to perform the operation span task (see Experiment 1). In addition to the instructions, a threat/challenge manipulation was added to the end of the instructions: one set of instructions presented the task as a challenge ("Think of the task as a challenge...think of yourself as someone who can meet this challenge") and another emphasized threat ("It is important to be as quick and as accurate as possible...your score will depend on it"). To reinforce this manipulation, a 3x5 note card was placed to the left of the computer screen with a challenge ("I can meet this challenge") or threat ("Do well. Your score depends on it.") message. Following the operation span task, participants completed the Go/No-go task (identical to experiment 2), followed by the automated operation span task (identical to experiment 1).

Results

Data Screening. All variables were examined for normality. Automated operation span scores were negatively skewed (M = 54.70, SD = 12.96) which was corrected by reflecting and then $\log_{10}$ transformed. Four cases were identified as outliers (> 3 SD from the mean of the distribution) and were Winsorized to one unit greater than the largest value such that they retained their position in the distribution without exerting as substantial influence. As would be expected, Go/No-go data were positively skewed (50% condition M = 2.86, SD = 2.66; 80% condition M = 3.31, SD = 3.07). These data were log-transformed and seven values were Winsorized to a value of .29 (one unit less than the lowest value of .30). Baseline working memory scores were normally distributed (M = .73, SD = .10).

Manipulation Check. In order to assess the efficacy of the threat/challenge manipulation, self-reported emotion on the PANAS questionnaire was examined for before and after the manipulation using hierarchical regression. PANAS items reflecting threat were selected to index measures of threat (see Appendix B; α = .90), as were items to reflect challenge (α = .86). A mixed between-within subjects ANOVA was conducted to assess the impact of threat/challenge instructions on participants' self-reported emotion comparing between baseline (pre-manipulation) and at the end of the experiment (Figure 6). There was not a significant difference in threat appraisals across conditions, Wilks Lambda = .99, F (1, 179) = 2.01, p = .16, $p\eta^2$ = .01 (a small effect), nor was there a significant difference in challenge appraisals across conditions, Wilks Lambda = .99, F (1, 177) = 1.45, p = .23, $p\eta^2$ = .01 (a small effect). However, individuals overall felt more threatened at the end of the task relative to the beginning, regardless of condition, Wilks Lambda = .98, F (1, 178) = 4.65, p = .03, $p\eta^2$ = .03 (a small effect). There

was no main effect for challenge across time, Wilks Lambda = 1.00, F (1, 178) = .83, p = .36, $p\eta^2$ = .01 (a small effect).

Although the intended task manipulation did not have the desired effect, there was a significant main effect on feelings of threat regardless of task condition, Wilks Lambda = .98, F (1, 178) = 4.65, p = .03, $p\eta^2$ = .03 (a small effect). For this reason, an additional analysis examining the relationship between feelings of threat and dependent variables of interest was conducted, although causality cannot be inferred as threat was not experimentally manipulated.

Hypothesis 8: Threat appraisals will be associated with a decrease in working memory capacity, whereas challenge appraisals will be associated with an increase in working memory capacity.

Relationship of threat/challenge instructions to working memory. Threat/Challenge conditions were coded into a contrast variable such that the variable could be analyzed using regression methods. Hierarchical regression was used to examine the effect of threat/challenge on working memory (Table 10a). In the first step, baseline working memory was entered into the regression to act as a covariate, F_{change} (1, 174) = 16.51, $p < .001$, R^2_{change} = .08 (a medium effect). In the second step, threat/challenge condition was entered as a predictor of the automated working memory total score F_{change} (1, 173) = .37, p = .54, R^2_{change} = .002 (a small effect).

Relationship between feelings of threat and working memory. Because the manipulation of threat/challenge instructions were not sufficient to differentiate feelings of threat between the groups, a hierarchical regression was conducted to explore for potential relationships between feelings of threat engendered by the experiment and changes in working memory capacity. In the first step, baseline operation span score, experiment manipulation condition and baseline self-

reported threat emotion were entered to serve as covariates. After controlling for these variables, the post-manipulation working memory score was regressed on the post-manipulation feelings of threat. There was a relationship between threat and working memory with increased feelings of threat being associated with a higher working memory scores, $b = .14$, $t = 2.73$, $p < .01$, $r^2 = .04$ (a medium effect).

Relationship between feelings of challenge and working memory. Because the manipulation of threat/challenge instructions were not sufficient to differentiate feelings of threat between the groups, a hierarchical regression was conducted to explore for potential relationships between feelings of challenge engendered by the experiment and changes in working memory capacity. In the first step, baseline operation span score, experiment manipulation condition and baseline self-reported challenge emotion were entered to serve as covariates. After controlling for these variables, the post-manipulation working memory score was regressed on the post-manipulation feelings of challenge. There was a relationship between challenge and working memory with increased feelings of challenge being associated with lower working memory scores, $b = -.10$, $t = -2.79$, $p < .01$, $r^2 = .04$ (a medium effect).

Hypothesis 9: Threat appraisals will be associated with greater error rates on the behavioral inhibition task, whereas challenge appraisals will be associated with lower error rates.

Relationship of threat/challenge instructions to behavioral inhibition. Again, hierarchical regression was used to examine how threat/challenge instructions affect behavioral inhibition as measured by the Go/No-go task (Table 10b). Condition failed to predict behavioral inhibition errors, F_{change} (1, 175) = .24, $p = .62$, $R^2_{change} = .00$.

Relationship between feelings of threat and behavioral inhibition. In order to examine the relationship between feelings of threat and behavioral inhibition, Go/No-go scores were

regressed on feelings of threat. In the first step, baseline experiment manipulation condition, baseline self-reported threat emotion, and performance during 80% training were entered to serve as covariates. After controlling for these variables, the post-manipulation Go/No-go score was regressed on the post-manipulation feelings of threat. There was no relationship between feelings of threat and behavioral inhibition, b = -.01, t = -.69, p = .49, r^2 = .00.

Relationship between feelings of challenge and behavioral inhibition. In order to examine the relationship between feelings of challenge and behavioral inhibition, Go/No-go scores were regressed on feelings of challenge. In the first step, baseline experiment manipulation condition, baseline self-reported challenge emotion, and performance during 80% training were entered to serve as covariates. After controlling for these variables, the post-manipulation Go/No-go score was regressed on the post-manipulation feelings of challenge. There was no relationship between feelings of threat and behavioral inhibition, b = -.01, t = -1.23, p = .22, r^2 = .01.

Hypothesis 10: Working memory will mediate the relationship between threat/challenge appraisals and behavioral inhibition.

Relationship between working memory and behavioral inhibition. In order to examine the relationship between working memory and behavioral inhibition, hierarchical regression was used (Table 11). Threat/challenge condition assignment and performance in the 80% condition were entered in the first step, F_{change} (2, 170) = 39.76, p < .01, R^2_{change} = .32 (a large effect). Post-manipulation working memory score was then entered in a subsequent step and it did not account for a significant portion of variance in behavioral inhibition scores, F_{change} (1, 169) = .08, p = .77, R^2_{change} = .00. Because working memory did not account for a significant portion of variance in behavioral inhibition, the conditions were not met to test for mediation and therefore it was not tested.

Discussion – Experiment 3

Experiment 3 examined the consequences of threat/challenge appraisals on behavioral inhibition abilities and working memory. The experimental manipulation was insufficient to statistically differentiate threat and challenge in each experimental group; however, there was a significant increase in feelings of threat throughout the experiment. Therefore, in addition to the proposed analyses examining differences between groups, an additional analysis examined correlations between feelings of threat and dependent variables of interest.

With regard to working memory, the experimental manipulation had no effect on participants' working memory abilities. However, when working memory scores were regressed on feelings of threat (controlling for experimental manipulation), higher feelings of threat were associated with increased working memory scores. Although this is counter to the direction which was hypothesized, the most parsimonious explanation is likely that participants who felt more threatened were exerting greater effort than participants who were not experiencing a feeling of threat. Challenge, however, was associated with a decreased working memory capacity. This is opposite of what was hypothesized: that threat (via activation of the HPA axis and release of cortisol) would impair working memory performance. Challenge appraisals, as noted above, are thought to be marked by activation of the SAM axis, and its release of norepinephrine (NE). Although NE facilitates working memory at low doses, higher doses of NE impair the function of the prefrontal cortex and working memory performance (Arnsten & Robbins, 2002). Pharmacological administration of NE agonists, such as Clonidine, impair working memory, but other studies using more specific NE agonists have had mixed results (for review, see Chamberlain, Muller, Blackwell, Robbins & Sahakian, 2006). The results in the present study, suggesting that increased appraisals of challenge, and possibly greater SAM axis

activation, are associated with decrements in working memory performance may fit with this literature. Future studies utilizing psychophysiological measurements, such as MAP and salivary cortisol, may be able to better understand the relationships between SAM vs. HPA activation and working memory performance.

Unlike working memory, there was no relationship between threat and behavioral inhibition performance: neither when comparing groups across the experimental manipulation, nor when regressing performance on self-reported changes in feelings of threat. There are several potential explanations for the failure to find this relationship. First, the method of assessing behavioral inhibition ability may not have been sensitive enough to detect impairments in inhibitory ability. The task used in the current study was selected from psychophysiology experiments that manipulated the probability of the Go and No-go signals. However, many cognitive experiments now utilize more sensitive measures of behavioral inhibition, such as Stop Signal Reaction Time tasks (SSRT). In these tasks, participants are instructed to respond to a Go signal, except when it is immediately followed by a second stimulus that occurs at a variable time point after the Go signal. Therefore, the behavioral measure is the ability to stop the prepotent response that has already been initiated by the Go signal (Band & Boxtel, 1999).

A second reason the behavioral inhibition measure may have been unrelated to the threat/challenge manipulation is because the manipulation was not sufficient to differentiate between appraisals of threat and challenge in self-reported feelings. During debriefing, in talking to participants, many reported feeling anxiety regarding the instructions of the automated working memory task, especially with the instructions that they had to keep their performance above 85% accuracy. If future studies wish to examine the relationship between threat/challenge and behavioral inhibition ability, the simplest way to overcome this problem

would be to manipulate threat and challenge and not include an intervening task that may alter appraisals of the situation.

In summary, the third experiment adds to the literature by investigating how threat/challenge appraisals can influence working memory. Counter to the hypothesis that threat would be associated with impairment of working memory, increases in challenge appraisals were associated with decreases in working memory capacity. However, these results are merely correlational and the manipulation of threat/challenge was insufficient to differentiate between groups. Future studies should consider utilizing different tasks of working memory (such as Trails B) that do not involve a math component as many participants reported anxiety as a result of this component. Furthermore, future studies that investigate the relationship between threat/challenge and behavioral inhibition should utilize a more sensitive task (such as the SSRT) and only include the threat/challenge manipulation directly before measuring inhibitory ability.

Table 1

Descriptive Statistics for Variables of Each Experiment

	n	Mean	Median	Standard Deviation
Experiment 1				
Explicit Self-Esteem	115	32.57	33.00	5.11
Implicit Self-Esteem	114	.07	.07	.06
Baseline Mean Arterial Pressure	115	83.24	83.00	9.17
Baseline Cortisol	108	7.88	7.04	3.75
Baseline Working Memory	113	.74	.74	.09
Automated Working Memory	113	49.00	52.00	15.53
Experiment 2				
Explicit Self-Esteem	179	32.67	33.00	4.88
Implicit Self-Esteem	182	.08	.07	.06
50% Go/No-go	182	3.24	3.00	3.30
80% Go/No-go	182	3.99	4.00	3.14
Evaluation Questionnaire	298	34.91	36.00	2.84
Experiment 3				
Baseline Working Memory	181	.73	.74	.10
Automated Working Memory	179	54.70	57.00	12.96
50% Go/No-go	178	2.86	2.00	2.66
80% Go/No-go	178	3.31	2.00	3.07

Table 2

Summary of Hierarchical Linear Regression Analysis Testing the Relationship Between Self-Esteem and Cortisol Reactivity

Variable	*b*	SE	*ß*	*t*
Step 1				
Feedback Type	-.70	.31	-.17	-2.27*
Explicit Self-Esteem	.64	.36	.14	1.80
Implicit Self-Esteem	.93	5.07	.01	.18
Step 2				
Feedback Type	-.73	1.03	-.18	-.71
Explicit Self-Esteem	.63	.37	.14	1.74
Implicit Self-Esteem	.52	18.71	.01	.03
Feedback x Explicit SE	-.01	.37	-.01	-.03
Feedback x Implicit SE	-.55	5.32	-.01	-.10
Explicit x Implicit SE	-.20	6.63	-.01	-.03
Step 3				
Feedback Type	-.75	1.04	-.18	-.71
Explicit Self-Esteem	.63	.37	.13	1.68
Implicit Self-Esteem	.00	19.09	.00	.00
Feedback x Explicit SE	-.01	.37	-.01	-.04
Feedback x Implicit SE	2.41	19.16	.04	.13
Explicit x Implicit SE	-.39	6.78	-.02	-.05

Feedback x Implicit x Explicit SE	1.09	6.79	.05	.16

Note. SE = Self-Esteem; Baseline cortisol values were entered as covariates in every step; $^{*}p < .05$.

Table 3

Summary of Hierarchical Linear Regression Analysis Testing the Relationship Between Self-Esteem and Mean Arterial Pressure Reactivity

Variable	*b*	SE	*ß*	*t*
Step 1				
Feedback Type	-.90	.50	-.09	-1.79
Explicit Self-Esteem	.73	.58	.07	1.27
Implicit Self-Esteem	-8.40	8.45	-.05	-.99
Step 2				
Feedback Type	-.91	1.69	-.09	-.54
Explicit Self-Esteem	.83	.59	.07	1.40
Implicit Self-Esteem	-38.07	31.41	-.23	1.21
Feedback x Explicit SE	.01	.59	.00	.01
Feedback x Implicit SE	2.71	8.63	.02	.31
Explicit x Implicit SE	-10.64	11.00	-.19	-.97
Step 3				
Feedback Type	-.93	1.71	-.09	-.54
Explicit Self-Esteem	.82	.60	.07	1.37
Implicit Self-Esteem	-38.30	31.86	-.234	1.20
Feedback x Explicit SE	.00	.60	.00	.00
Feedback x Implicit SE	4.34	32.00	.03	.14
Explicit x Implicit SE	-10.72	11.16	-.19	-.96

Feedback x Implicit x Explicit SE	.59	11.18	.01	.05

Note. SE = Self-Esteem; Baseline mean arterial pressure (MAP) values were entered as covariates in every step; * $p < .05$.

Table 4

Summary of Hierarchical Linear Regression Analysis Testing the Relationship Between Physiological Reactivity and Working Memory

Variable	*b*	SE	*ß*	*t*
Step 1				
Feedback Type	.14	.13	.10	1.11
MAP	.03	.02	.20	1.21
Cortisol	-.02	.04	-.05	-.35
Step 2				
Feedback Type	.14	.13	.10	1.09
MAP	.03	.02	.20	1.13
Cortisol	-.01	.05	-.04	-.27
Feedback x MAP	.00	.01	.00	.03
Feedback x Cortisol	.01	.03	.03	.26
MAP x Cortisol	.00	.00	.00	-.03
Step 3				
Feedback Type	.16	.13	.12	1.23
MAP	.02	.03	.16	.88
Cortisol	-.02	.05	-.05	-.37
Feedback x MAP	.00	.01	.03	.29
Feedback x Cortisol	.02	.04	.06	.57
MAP x Cortisol	.00	.00	-.02	-.17

Feedback x MAP x Cortisol	.00	.00	-.11	-.88

Note. Baseline cortisol and mean arterial pressure (MAP) values were entered as covariates in each step; ** $p < .01$; * $p < .05$.

Table 5

Logistic Regression – Physiology and Feedback Predicting Aggression

Note: MAP = Mean arterial pressure.

Variable	*B*	SE	*Wald*	*df*	*p*	Odds Ratio	95.0% C.I. Lower	95.0% C.I. Upper
Baseline Cortisol	.15	.09	2.52	1	.11	1.16	.97	1.38
Baseline MAP	-.01	.05	.02	1	.89	.99	.89	1.10
Post Cortisol	-.12	.11	1.03	1	.31	.89	.71	1.11
Post MAP	.06	.06	1.21	1	.27	1.06	.95	1.19
Feedback	1.22	.56	4.79	1	.03	3.40	1.14	10.16
Feedback x Cortisol	-.10	.09	1.22	1	.27	.90	.75	1.08
Feedback x MAP	-.09	.04	5.64	1	.02	.92	.85	.99
MAP x Cortisol	-.03	.01	4.05	1	.04	.98	.95	.99
Three Way	.03	.01	3.80	1	.05	1.03	1.00	1.05
Constant	-1.77	.43	17.25	1	.61	.09		

Table 6

Logistic Regression (Negative Feedback Only) – Physiology predicting aggression

Variable	*B*	SE	*Wald*	*df*	*p*	Odds Ratio	95.0% C.I. Lower	95.0% C.I. Upper
Baseline Cortisol	.31	.15	4.40	1	.04	1.37	1.02	1.83
Baseline MAP	.07	.10	.421	1	.52	1.07	.88	1.30
Post Cortisol	-.22	.18	1.48	1	.22	.80	.56	1.14
Post MAP	.08	.09	.66	1	.42	1.07	.90	1.30
MAP x Cortisol	-.06	.03	5.27	1	.02	.94	.89	.99
Constant	-.64	.39	2.72	1	.10	.53		

Note: MAP = Mean arterial pressure.

Table 7

Summary of Hierarchical Linear Regression Analysis Testing the Relationship Between Self-Esteem and Behavioral Inhibition

Variable	*b*	SE	*ß*	*t*
Step 1				
80% Go/No-go Condition	.69	.07	.62	10.32***
Explicit Self-Esteem	.01	.01	.04	.74
Implicit Self-Esteem	-.05	.23	-.01	-.22
Feedback Type	.00	.01	-.01	-.23
Step 2				
80% Go/No-go Condition	.66	.07	.60	10.01**
Explicit Self-Esteem	.00	.01	.02	.31
Implicit Self-Esteem	-.04	.23	-.01	-.15
Feedback Type	.00	.01	.02	.32
Explicit x Implicit SE	-.16	.21	-.05	-.76
Feedback x Implicit	.70	.24	.18	2.94**
Feedback x Explicit	.00	.01	-.01	-.09

Step 3				
80% Go/No-go Condition	.66	.07	.59	9.92***
Explicit Self-Esteem	.01	.01	.02	.37
Implicit Self-Esteem	-.08	.24	-.02	-.33
Feedback Type	.00	.01	.00	-.03
Explicit x Implicit SE	-.14	.21	-.04	-.65
Feedback x Implicit	.69	.24	.18	2.92**
Feedback x Explicit	.00	.01	.00	-.04
Feedback x Implicit x Explicit SE	.18	.21	.05	.84

Note. SE = Self-esteem; $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Table 8

Logistic Regression- Relationship Between Behavioral Inhibition and Aggression

Variable	*B*	SE	*Wald*	*df*	*p*	Odds Ratio	95.0% C.I. Lower	Upper
Feedback	-1.12	1.03	1.19	1	.27	.33	.04	2.45
80% Go/No go	-.63	1.01	.39	1	.53	.53	.07	3.83
50% Go/No go	.20	.94	.05	1	.83	1.22	.19	7.64
Feedback x 50% Go/No-go	-1.38	.76	3.25	1	.07	.25		
Constant	-.06	.80	.01	1	.94	.94		

Table 9

Summary of Logistic Regression Analysis Testing the Relationships Between Implicit & Explicit Self-Esteem, Feedback and Aggression

Variable	*B*	SE	*Wald*	*df*	*p*	Odds Ratio	95.0% C.I. Lower	Upper
Feedback	.82	.28	8.68	1	.00	2.25	1.31	3.86
Explicit SE	-.20	.16	1.69	1	.19	.82	.60	1.10
Implicit SE	-4.77	2.36	4.08	1	.04	.01	.00	.87
Feedback x Implicit SE	-.80	2.36	.12	1	.74	.45	.00	46.00
Feedback x Explicit SE	.02	.16	.01	1	.91	1.02	.75	1.38
Implicit SE x Explicit SE	-1.83	2.60	.50	1	.48	.16	.00	26.28
Three-Way	-2.86	2.60	1.21	1	.27	.06	.00	9.41
Constant	-1.37	.21	42.12	1	.00	.25		

Note. SE = Self-Esteem.

Table 10

Summary of Hierarchical Linear Regression Analyses Testing the Relationships Between Threat/Challenge Manipulation and (a) Working Memory; (b) Behavioral Inhibition

Variable	*b*	SE	*ß*	*t*
a) Criterion: Working Memory				
Step 1				
Baseline Working Memory	-4.56	1.12	-.294	-4.06**
Step 2				
Baseline Working Memory	-4.53	1.13	-.29	-4.02**
Threat/Challenge Condition	.06	.11	.04	.60
b) Criterion: Go/No Go				
80% Condition Performance	.53	.06	.56	8.93***
Threat/Challenge Condition	-.01	.02	-.05	-.681

Note. ** $p < .01$., *** $p < .001$

Table 11

Summary of Hierarchical Linear Regression Analyses Testing the Relationship Between Working Memory and Behavioral Inhibition

Variable	*b*	SE	*ß*	*t*
Step 1				
Condition	-.01	.02	-.03	-.44
80% performance	.53	.06	.56	8.91***
Step 2				
Condition	-.01	.02	-.04	-.47
80% performance	.53	.06	.56	8.88***
Post-Manipulation Working Memory	.01	.04	.02	.29

***p < .001.

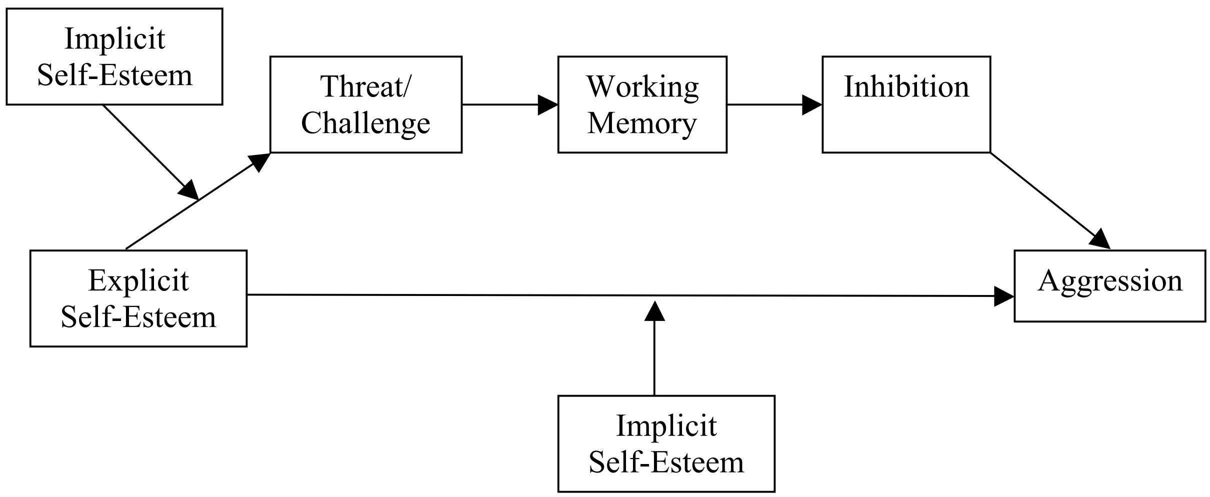

Figure 1 - Conceptual Model for Project.

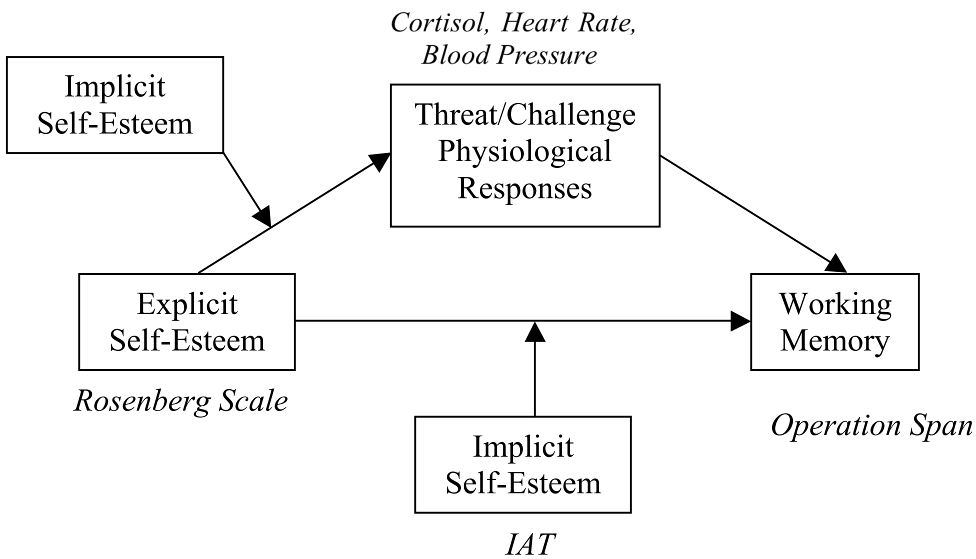

Figure 2 - Conceptual Model for Experiment 1.

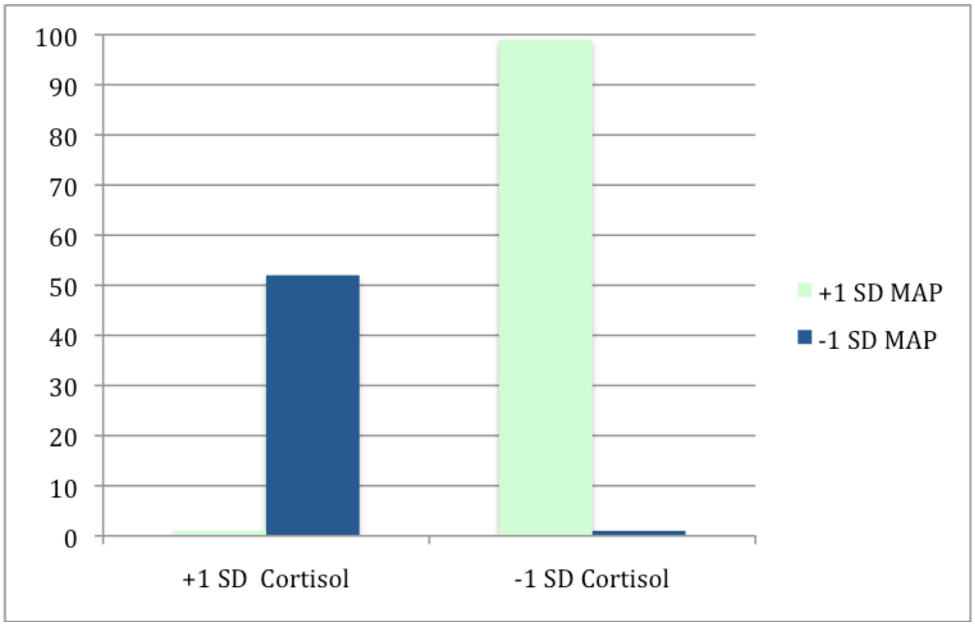

Figure 3 - Probabilities of Aggression Based on Physiological Responses. Individuals with discrepant physiological responses are more likely to aggress toward the experimenter – participants with low cortisol responses but high mean arterial pressure responses are nearly 100% likely to aggress.

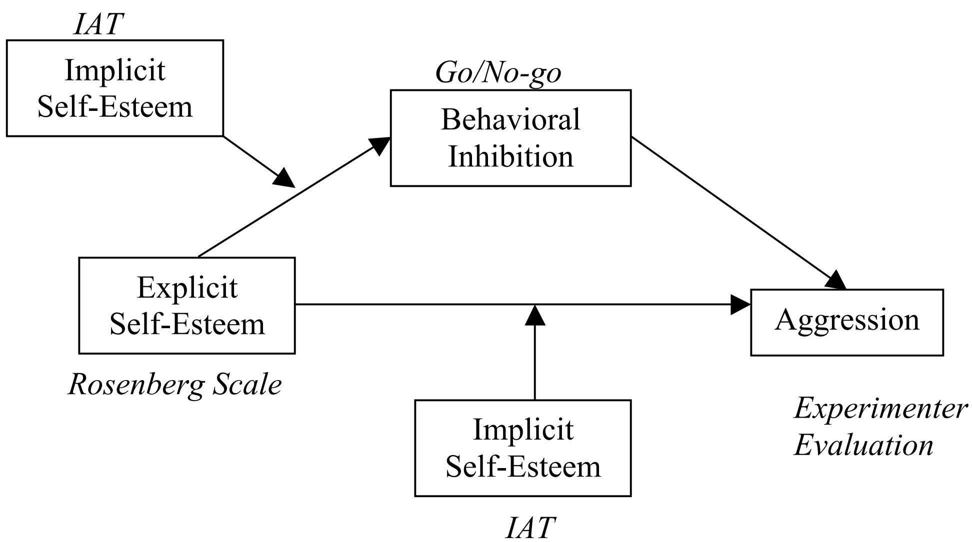

Figure 4 - Conceptual Model for Experiment 2.

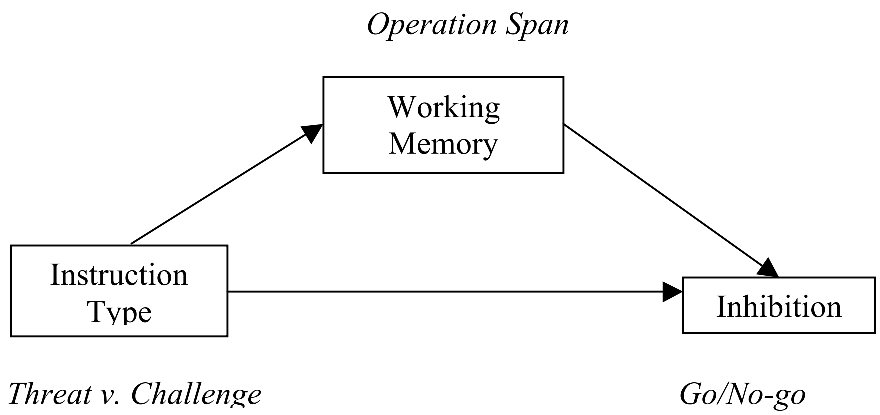

Figure 5 - Conceptual Model for Experiment 3.

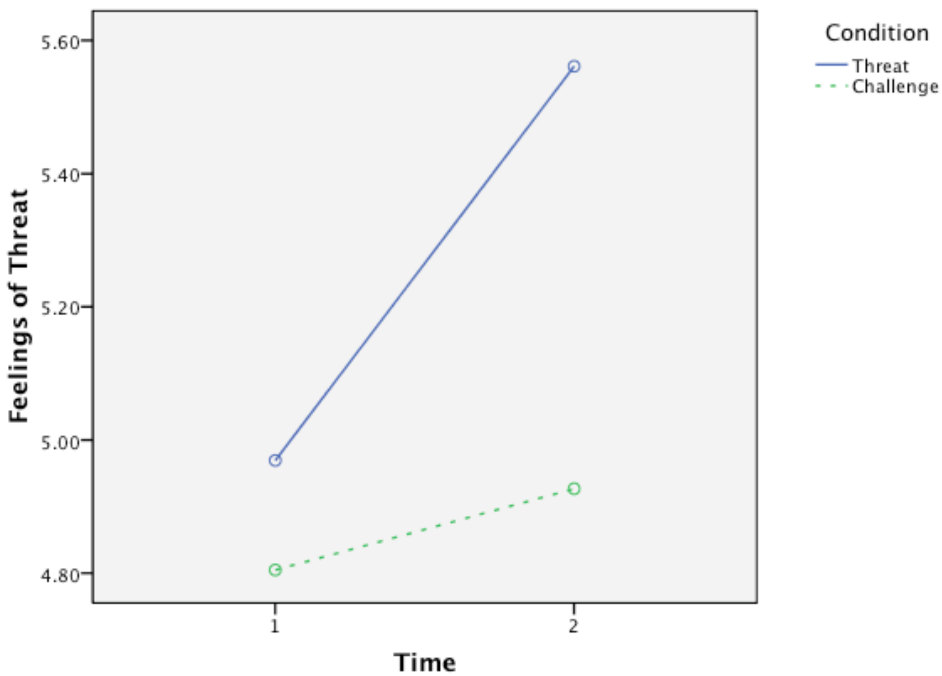

Figure 6 - Feelings of Threat at Baseline and End of Study.

CHAPTER THREE: GENERAL DISCUSSION

The goal of the present study is to help understand the relationships between self-esteem (explicit vs. implicit) and aggression by examining the physiological and cognitive consequences of receiving failure feedback. The overarching model was that individuals with insecure self-esteem react to failure feedback with a physiological threat response, which depletes working memory capacity, reduces behavioral inhibition abilities and thereby increases aggressive tendencies (Figure 1). This model was tested in a series of three experiments. In experiment one, blood pressure and cortisol levels were recorded before and after participants received failure (or praise) feedback. Relationships between changes in physiology, working memory and aggression were examined. Experiment two repeated the failure/praise feedback manipulation and examined consequences for behavioral inhibition and aggression. Finally, experiment three attempted to manipulate threat/challenge appraisals to directly examine implication for cognition – specifically behavioral inhibition and working memory.

Unfortunately, this model was not supported by the data, and therefore may need to be revised (Figure 7). The revised model suggests that threat/challenge responding (as marked by physiological markers in response to negative feedback) may directly influence working memory and aggression, but working memory and aggression may not be necessarily interrelated. Furthermore, implicit self-esteem may buffer against negative feedback in preventing errors in behavioral inhibition, but this is not necessarily related to an increase in aggressive tendencies. However, as discussed above, more sensitive measures of behavioral inhibition, such as a stop-signal task, may be better suited to detect this relationship. Future studies should seek to test individual components of this revised model to better understand how the separate constructs may be interrelated.

The present study is one of the first studies to utilize implicit self-esteem to examine consequences for aggression. A large number of studies have examined the relationship between explicit self-esteem and aggression but as self-esteem researchers have identified the existence of implicit self-attitudes, their inclusion in studies of aggression has been absent. A second contribution of the present study is that it is the first study to integrate threat/challenge physiology in the prediction of aggression. By utilizing a multiple level approach, the ability to predict behavior was increased by recording psychophysiology.

Specific Aims

Specific Aim 1: Examine how failure feedback alters physiological responding and how these responses alter working memory capacity. In Experiment 1, the impact of failure feedback on physiology and working memory was examined. Individuals with high explicit self-esteem showed larger increases in cortisol, regardless of feedback, and the interaction between implicit self-esteem and explicit self-esteem did not predict increases in mean arterial pressure nor cortisol responses to failure feedback. Implicit self-esteem alone did not account for a significant portion of variance in physiology, or working memory in response to failure feedback. Cortisol increases were not associated with a decrease in working memory, as was hypothesized, but increases in challenge appraisals were associated with decreases in working memory capacity.

The link between discrepant self-esteem and working memory is a more distant theoretical connection, but the lack of a relationship between rise in cortisol levels and decrease in working memory is surprising. Recent studies have found an association between stress and working memory in humans (Evans et al., 2009; Luethi, et al., 2009), but, as mentioned above, there are methodological differences in those studies that could account for the differences.

Luethi and colleagues (2009) examined differences in working memory across groups, one of which was exposed to the Trier Social Stressor Task, and the other was not. The social stress group performed lower on a test of working memory, but the authors did not correlate these data with the cortisol data collected in the study thereby failing to demonstrate a dose-response relationship between cortisol changes and working memory depletion. In order to determine causality, such a relationship will need to be demonstrated. A recent study by Lewis, Nikolova, Chang and Weekes (2008) found an increase in working memory (as measured by backward digit span) when participants were undergoing examination stress, but there was no relationship between working memory augmentation and cortisol levels.

There are a few potential explanations for the absence of this relationship in the present data. The first is the time course of the cortisol response. Cortisol typically takes 20+ minutes to reach peak levels in the bloodstream in humans. The time between the failure feedback and beginning the working memory task was approximately 7 minutes (with the task taking 20 minutes), such that the cortisol level may not have had time to reach peak levels in time to significantly impair task performance. A second potential explanation is that the failure feedback may not have been sufficient to generate a large enough cortisol response to impair working memory. Failure feedback tended to increase cortisol levels, but not significantly (p = .06). Using traditional tasks such as the Trier Social Stressor Task tends to have a much stronger effect on cortisol levels, which would help detect any relationship between cortisol and cognition. Therefore, future studies should consider including a longer delay between failure feedback and working memory, or use a more standardized method of experimentally manipulating cortisol (e.g. pharmacological administration).

Implicit self-esteem did not predict a significant portion of variance in the model, neither when it was an independent variable nor when taken in combination with explicit self-esteem.

Specific Aim 2: Examine the impact of failure feedback on physiology, and the consequences physiological changes have on aggression. A significant interaction was found between cortisol and mean arterial pressure (MAP) responding, when presented with negative feedback. This interaction predicted aggression toward the experimenter, as well as a reduction in positive affect. Individuals with congruent physiological responses – i.e., an increase in cortisol accompanied by an increase in MAP – were less likely to become aggressive toward the experimenter. Individuals who reacted to negative feedback with an increase in MAP, but without an accompanying increase in cortisol – a physiological challenge response – were more likely to become aggressive toward the experimenter. Individuals who exhibited a physiological threat response (i.e., an increase in cortisol without concurrent increase in blood pressure) had an equal probability of being aggressive toward the experimenter.

The initial hypothesis was that individuals who exhibited a threat response – marked by an increase in cortisol, with no increase in blood pressure – would be the individuals who became aggressive in response to failure feedback. Based on previous research suggesting that cortisol would impair working memory, it was hypothesized that a rise in cortisol would result in greater aggressive tendencies, mediated by a decrease in working memory capacity. However, the opposite was the case: individuals with a physiological challenge response – increased blood pressure without an accompanying increase in cortisol – were the most aggressive individuals. This finding fits well with the literature on cortisol and aggression (for review, see Terburg, Morgan and van Honk, in press). The triple-balance model of emotion processing suggests that cortisol increases communication between cortical and subcortical structures involved in

emotional decision making, and therefore individuals with low cortisol levels should have reduced levels of communication between these emotion regulation and action structures (van Honk & Schutter, 2006).[4] The present study did not find an effect for baseline levels of cortisol, but cortisol change, when combined with the change in blood pressure, was a significant predictor of aggressive behavior.

Challenge motivations are hypothesized to result from an individual's appraisal as having the resources to accomplish goals, and therefore is associated with approach-related affect. This conception of aggression as an approach-motivated behavior is an interesting addition to the literature suggesting that anger as an approach-related affect (Carver & Harmon-Jones, 2009). Anger and aggression are traditionally closely related (for review, see Wilkowski & Robinson, 2008), and the inclusion of psychophysiological measures in future research could assist in understanding this link.

Specific Aim 3: Examine the impact discrepant self-esteem has on physiology, working memory and aggression when presented with failure feedback. One goal of the present research was to use personality variables, specifically implicit and explicit self-esteem, to predict which participants are more likely to have a threat vs. challenge physiological response. As discussed above, the present study is one of the first studies to examine the relationship between self-esteem and aggression in the context of a dual-attitude model of self-esteem (implicit and explicit). Unfortunately, no relationships were present between discrepant (high explicit, low implicit) self-esteem and physiology or aggressive behavior. This fails to replicate an earlier

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[4] However, this model predicts that low cortisol levels should be associated with increased behavioral activation tendencies, and in the present study there was no relationship between baseline cortisol levels and behavioral activation as measured by the Behavioral Activation/Inhibition Scale (Carver & White, 1993).

finding by Seery et al. (2004) that found that individuals with unstable self-esteem responded to failure feedback with a threat response. In the present study, there was no relationship between discrepant self-esteem and any of the physiological variables. As discussed above, this failure to replicate could be due to several factors. Most notably, Seery and colleagues used a measure of self-esteem stability, in which participants complete an explicit self-esteem questionnaire at 12-hour intervals. The relationship between self-esteem stability and implicit self-esteem is not yet clear, but individuals with high implicit and explicit (i.e. secure) self-esteem show more stable self-esteem than individuals with discrepant self-esteem. No research to date has examined the stability of implicit self-esteem, or what consequences unstable implicit self-esteem may have for the self and behavior. Future research should compare and contrast self-esteem stability and implicit self-esteem, and examine any individual consequences they have for behavior.

Similarly, there was no relationship between discrepant self-esteem and changes in working memory capacity following failure feedback. The hypothesis that discrepant self-esteem would result in an increased ego threat, thereby depleting working memory, was constructed to be parallel to the literature which has found a decrease in working memory in individuals who experience stereotype threat (e.g., Schmader et al., 2003). Stereotype threat is a psychological state brought on by "situations that pose a significant threat to self-integrity, the sense of oneself as a coherent and valued entity that is adaptable to the environment" (p. 3; Schmader, Johns & Forbes, 2008). In their integrated process model of stereotype threat, Schmader and colleagues base the existence of threat on a cognitive imbalance, which closely parallels the imbalance between implicit and explicit self-esteem. As a result of this imbalance, the authors propose that when presented with stereotypes that "expect" poor performance (e.g.

the performance of women on math exams), the individual experiences a stress response, which depletes cognitive reserve capacity, specifically working memory.

The present study attempted to replicate this finding in individuals with insecure self-esteem, and to understand a potential physiological mechanism (i.e., cortisol increase) by which threat and stress could deplete working memory. There was no relationship between an imbalance in self-esteem, working memory performance following failure feedback, nor between physiological threat responses and working memory performance. Therefore, the depletion of working memory in stereotype threat may potentially be due to other factors (for review, see Schmader et al., 2008). These potential mechanisms are cognitive strategies that compete for limited cognitive resources, such as increased self-monitoring, and attempting to suppress thoughts associated with the stereotype threat. Investigating these potential mediators and developing strategies for reducing them should be a goal of future research on the relationship between threat, cognitive discrepancies and cognitive resources. With regard to aggression, a potential clinical use of this study would be to investigate how helping individuals reappraise a situation can alter their physiological responding and potentially mitigate aggressive behavior.

Working memory was not changed as a result of physiological reactivity, nor was the change in working memory able to predict aggressive behavior. However, baseline working memory was able to predict the likelihood that an individual would aggress following negative behavior. This finding replicates an earlier study by Kleider, Parrott and King (in press) that found police officers were more likely to make errors on a shooting task if they had low working memory span scores. This conceptual replication of that previous study has found that working memory also predicts aggression after negative feedback, and future studies should continue to examine the relationships between working memory and aggressive behavior.

Although no relationships were present between discrepant self-esteem and physiological reactivity, nor between discrepant self-esteem and aggression, the current study did find some interesting results that do lend support to the idea of self-esteem as a buffer against negative encounters. First, implicit self-esteem served a protective role against negative criticism when performing a behavioral inhibition task. Individuals with higher implicit self-esteem made fewer errors on the Go/No-go task after receiving negative feedback. Second, explicit self-esteem predicted cortisol reactivity, regardless of feedback condition. In the context of the findings that individuals without a cortisol response were more likely to become aggressive following negative feedback, this finding suggests that higher self-esteem may be associated with greater cortisol reactivity, which, in turn, may protect against aggressive behavior. However, this reactivity was occurring regardless of feedback condition which may be maladaptive.

Specific Aim 4: Examine the impact of threat/challenge manipulations on behavioral inhibition and working memory. A final goal of the present study was to examine how manipulating threat/challenge appraisals could affect cognitive abilities, specifically working memory and behavioral inhibition (as measured by the Go/No-go task). Unfortunately, the threat/challenge manipulation that was utilized was insufficient to alter participants' appraisals of the task – participants in the threat condition were not more threatened by the instructions than participants in the challenge condition. Although participants were not asked explicitly during debriefing if they felt threatened/challenged, the self-report Positive and Negative Affect Scale (PANAS) was used to detect changes in feelings of threat/challenge over the course of the experiment. In hindsight, part of the reason for the failure to successfully manipulate threat and challenge was likely the nature of the the Operation Span Task. Many participants reported that the task itself was stressful, especially the act of completing math problems in the presence of

another person and needing to keep task performance above 85% accuracy. This obstacle could easily be overcome in future studies by utilizing a working memory task that is perceived as less stressful by participants, such as backwards digit span.

In order to examine relationships between feelings of threat and performance on working memory task, data were pooled across experimental manipulation and working memory performance was regressed on changes in threat feelings over the course of the experiment. Individuals who felt threatened by the experiment (relative to baseline) tended to have an increase in working memory performance, but there was no relationship between threat and behavioral inhibition.

Similarly, challenge appraisals were pooled across experimental manipulation and working memory scores were regressed on changes in challenge appraisals during the experiment. Working memory was significantly predicted by changes in challenge appraisals, such that individuals who showed an increase in challenge showed a decrease in working memory capacity (relative to baseline). There was no relationship between challenge and behavioral inhibition.

This relationship between challenge appraisals and decreases in working memory is particularly interesting because of its irony. Supposedly, challenge is an appraisal of having the resources to deal with a task, and yet here is evidence that a challenge appraisal *depletes* a resource that is needed to perform well on tasks. The potential psychological and physiological mechanisms for this relationship should be explored in future studies.

Limitations and Future Directions

Although the present study was able to add to the literature by demonstrating how physiological reactions to failure feedback can be used to predict aggressive behavior, several of

the null results could potentially be due to a failure to detect effects that may be present but were not detected by the measurement of constructs. For example, there was a lack of variability in the aggression variable, with the majority of participants not penalizing the experimenter, thereby making it more difficult to examine relationships between psychological, physiological and behavioral variables. Future studies should implement variables with more variability – such as the Taylor Aggression Paradigm (Taylor, 1967) – to better understand relationships between personality and behavior. A second benefit of using more direct measures of aggression, such as the TAP is that it could possibly be a better measure of hostile aggression which may be more directly related to behavioral inhibition and cognitive constructs such as working memory and emotional experiences such as anger (Ramirez & Andreu, 2006). Another way to increase variance in aggression would be to use a stronger manipulation of insult. Rather than a single insult, as was provided in the present study, the experimenter could substantially increase their insulting behavior – for example, berating the participant after every task, and asking questions such as "Did you even try?" This stronger manipulation may increase variance in the aggression variable and could help to elucidate relationships between the independent variables and aggression.

Another limitation of the present study is a confound between feelings of threat and the working memory task. Several participants reported feeling threatened by the task itself, especially the instruction to make sure to keep the math score over 85%. In order to obtain a more pure examination of the relationships between appraisals, working memory and aggression, future studies should employ measures of working memory that are less threatening to participants.

A final weakness of the present study is that the physiological markers of threat and challenge did not predict self-reported feelings of threat and challenge. There are several potential reasons for this discrepancy. First, the manipulations may not have sufficiently activated threat and challenge appraisals of the situations, although the relationship between physiology and challenge self-report did show a nonsignificant trend in the hypothesized direction. Second, the self-report measure that was utilized to measure threat/challenge appraisals may have been inadequate. The measure that was utilized asked the participant to rate how they were feeling at that moment. An appraisal is technically how a person feels toward an object or situation. Therefore, a more appropriate question may have been "how are you feeling right at this moment toward the tasks in this experiment?" Or, retrospectively, "how were you feeling about your performance on the tasks as you completed them?" This may have increased the correlations between self-report and physiological variables. Finally, threat and challenge are, by definition, anticipatory appraisals and occur before a stressful situation (Tomaka, Blascovich, Kelsey, & Leitten, 1993). The self-report questionnaire was administered at the conclusion of the study and therefore was measuring emotional reactions that were the result of the appraisals that had occurred earlier. In order to measure the appraisals directly, the self-report questionnaires should have been administered prior to the behavioral task (e.g., before the automated working memory task) instead of at the conclusion of the study when there was no anticipation occurring.

Although the current research has found a relationship between challenge appraisals and aggression, the predictors of which individuals exhibit a challenge response when presented with failure feedback remain elusive. A previous study had found that insecure explicit self-esteem was able to predict threat/challenge responses to negative feedback (Seery et al., 2004), but the

previous study found no relationship between implicit and explicit self-esteem in predicting threat/challenge responses. Few studies have examined individual differences in predicting threat/challenge appraisals, but one study (Tomaka et al., 1999) found that assertiveness was able to predict threat/challenge responses to situations such that high levels of assertiveness were associated with challenge appraisals, whereas low levels of assertiveness were associated with threat. In a later study, it was found that neuroticism is able to predict threat appraisals and task performance in response to a stressor (Schneider, 2004). Future studies should integrate these promising personality variables, such as neuroticism and assertiveness, to better understand individual differences in threat/challenge appraisals and how they can be used to predict behavior.

One potential explanation for the lack of findings in the behavioral inhibition data may be that the methods that were utilized in the present study were not sufficiently sensitive to measure behavioral inhibition. The present method of measuring behavioral inhibition was adapted from studies that modified the Go/No-go task for use in functional imaging and event-related potential studies, which typically correlate Go/No-go performance with brain activity rather than behavior. Cognitive Psychology studies typically use more sensitive measures of behavioral inhibition, such as a stop-signal reaction time task (Logan & Cowan, 1984). In a stop-signal task, the participant is required to respond to a stimulus in almost every presentation, except when a stop-signal is presented (such as the sounding of a tone). The tone is presented shortly after the presentation of the go-signal, and by varying the delay of the tone, the probability of successful inhibition is varied (Aron & Poldrack, 2006). By utilizing a more specific manipulation of threat/challenge appraisals, and a more sensitive measure of behavioral inhibition, any potential relationships that may not have been detected in the present study may become clear.

In summary, if I were to repeat this investigation, I would choose measures that have increased variability (such as the Taylor Aggression Paradigm), sensitivity (such as a Stop Signal Reaction Time task) and are not as threatening to the participants (i.e., working memory tasks involving solving math problems in the presence of an experimenter). I would also add a more direct measure of appraisals (via self-report) that would be administered immediately after the manipulation, but before the behavioral task for which the manipulation was intended. I feel these changes to the procedure would significantly strengthen the investigation of the relationships between the present constructs.

One goal of the present study was to better understand the cognitive mechanisms that mediate the relationship between threat/challenge and aggressive behavior. Based on previous research, it was hypothesized that working memory and behavioral inhibition would be the primary mediators between appraisals and behavior. Unfortunately, the data did not support such a model. However, other studies have found support for a relationship between threat appraisals and working memory (Schmader et al., 2003), and inhibition and aggression (Strüber, Lück, & Roth, 2008). One difference between the present study and other studies of threat and working memory is that the present study utilized a baseline measure of working memory and observed how the appraisals of threat or challenge were associated with a change in working memory. The hypothesized link between threat and working memory in the present study relied on the influence of cortisol in directly inhibiting working memory abilities. As was discussed above, there was no relationship between cortisol and working memory changes, and the relationship between cortisol and working memory abilities has been inconsistent in other studies. This may hint at a separate mediating mechanism by which stress impairs working memory (e.g. redirecting selective attention toward opposing goals, away from working memory

capacity). Future studies should investigate these pathways by experimentally manipulating cortisol and examining the influence on attention, working memory and other executive functions.

Conclusion

The present study has examined how failure feedback leads to aggressive behavior in certain individuals. Those participants who exhibited a physiological challenge response to failure feedback were the most aggressive, and in a separate study, challenge appraisals were associated with a decrease in working memory. However, there was no relationship present between physiology, working memory, or working memory and aggression. The present study contributes to the literature on aggression by integrating a psychophysiological approach, utilizing a biopsychosocial model of information processing. By utilizing such an approach, it has helped understand the antecedents of aggressive behavior.

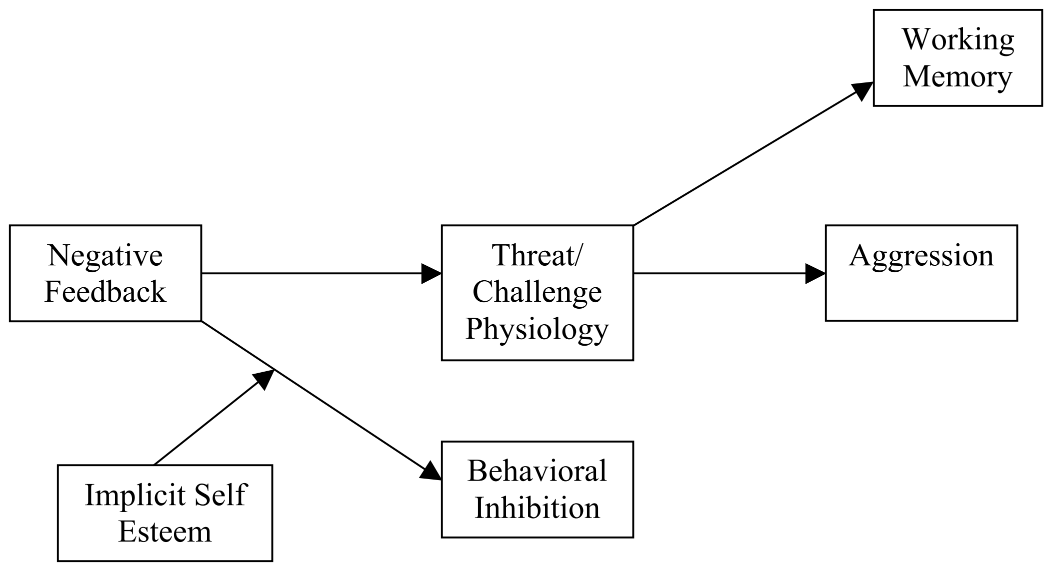

Figure 7 – Revised Conceptual Model.

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APPENDIX A – EXPERIMENTER EVALUATION FORM

Experimenter Evaluation Form

The Clinical Neuropsychology Lab takes great effort to ensure that each participant is treated in a friendly and professional manner. To that end, we ask each participant to rate their experience with the experimenter. These evaluations will be viewed by the laboratory director (Dr. Tricia King). Dr. King then uses this feedback to make decisions on whether or not to hire the experimenter next semester.

To ensure anonymity, please place this evaluation in an envelope and place it in the survey drop box. **Please do not write your name on this form.**

The experimenter seemed to be capable and competent.

1	2	3	4	5	6	7	8	9
Strongly Disagree				Neutral				Strongly Agree

The experimenter was friendly and likable.

1	2	3	4	5	6	7	8	9
Strongly Disagree				Neutral				Strongly Agree

The experimenter is doing a good job and represents the lab well.

1	2	3	4	5	6	7	8	9
Strongly Disagree				Neutral				Strongly Agree

Based on my experience today, I would recommend this researcher be hired to conduct this study next semester.

1	2	3	4	5	6	7	8	9
Strongly Disagree				Neutral				Strongly Agree

APPENDIX B – THREAT/CHALLENGE FACTORS

In order to measure threat and challenge, selected words from the PANAS questionnaire were selected. Participants rated how much they were feeling each emotion "right at this moment" (1 = slightly or not at all, 5 = extremely). It is worth noting that all items for the challenge list were selected from the positive section of the PANAS, whereas all of the threat items were selected from the negative section. The items that were selected were chosen because it was felt they reflected words that are associated with threatening (or challenging) motivational states. Threat appraisals have been shown to be associated more strongly with negative emotional reactions (Fischer, Shaver, & Carnochan, 1990; Tomaka et al., 1993), whereas challenge appraisals are more associated with positive incentives and result in positive mood states (Tomaka et al., 1993).

PANAS questionnaires were pooled across the three experiments, producing a total of 482 participants. The dataset was split randomly in half with the purpose of conducting exploratory and confirmatory factor analyses. Data were analyzed using maximum likelihood (ML) analysis. All sixteen variables were subjected to factor analysis with Promax (oblique) rotation. This rotation was chosen a priori because it was likely that the factors would be correlated due to the relatedness of the variables on the scale. Initially, three components were identified with eigenvalues greater than 1.0, but after examining the Scree plot only two factors were retained. Therefore, the factor analysis was re-run with the intent of extracting two factors. Rotated factor loadings are shown below. Variables with loadings greater than .4 were assigned to the corresponding factor. The first factor was associated with nine items and accounted for 29% of the variance in the model. The second factor was associated with six items and

accounted for 22% of the variance. In total, the two factors accounted for 52% of the variance and were correlated at r = .08.

In order to test this model, the other half of the data was utilized in a confirmatory factor analysis. Again, ML Analysis with Promax rotation was utilized and two factors were extracted. Again, nine items loaded on factor 1 which accounted for 31% of the variance, and six items loaded on factor 2, accounting for 25% of the variance. The two factors were correlated at r = -.07. Critically, the same items loaded on the same factors in both analyses.

Factor 1 (Threat): guilty, scared, afraid, ashamed, upset, nervous, distressed, irritable, hostile

Factor 2 (Challenge): excited, strong, enthusiastic, proud, active, inspired

APPENDIX C – IMPLICIT SELF-ESTEEM MODEL

After examining the data, it appeared that a more parsimonious model involving only implicit self-esteem (without explicit self-esteem) might result in a better fit of the data. In order to examine this possibility, analyses for Experiment 1 (self-esteem predicting working memory and physiology) and Experiment 2 (self-esteem predicting inhibition and aggression) were conducted with implicit self-esteem as the only self-esteem variable.

Implicit-Self Esteem and Physiology. To examine the relationship between implicit self-esteem, feedback and physiology, separate hierarchical regressions were performed with self-esteem and feedback as predictors of cortisol and MAP reactivity. In each regression, baseline physiology levels were entered in a preliminary step as a covariate. When post-task cortisol levels were regressed on feedback type, implicit self-esteem, and the interaction between the two variables, the first-order variables accounted for a nonsignificant portion of the variance, F_{change} (2, 98) = 2.43, p = .09, R^2_{change} = .03. The interaction term did not account for a significant portion of variance above the first order terms, F_{change} (1, 97) = .11, p = .74, R^2_{change} = .00.

For mean arterial pressure, first-order terms did not account for a significant portion of variance, F_{change} (2, 109) = 2.19, p = .12, R^2_{change} = .01, nor did the interaction term, F_{change} (1, 108) = .03, p = .85, R^2_{change} = .00.

Implicit self-esteem and behavioral inhibition. The relationship between feedback, implicit self-esteem and behavioral inhibition was investigated in the deconstructed interaction in Experiment 2. Following negative feedback, implicit self-esteem was inversely correlated with behavioral inhibition (i.e., higher implicit self-esteem was associated with fewer mistakes in behavioral inhibition), b = -.72, t (84) = -2.22, $p < .05$, pr^2 = .04.

Implicit self-esteem and aggression. In order to examine the relationship between implicit self-esteem and aggression, a logistic regression analysis was conducted with implicit self-esteem, feedback, and the interaction between self-esteem and feedback as the sole predictors of aggressive behavior. The full model containing all predictors exhibited a trend toward significance, χ^2 (8, N = 299) = 14.81, $p = .06$, indicating that the model was unable to distinguish between participants who penalized the experimenter from those who did not. The model as a whole explained between 4.3% (Cox and Snell R^2) and 6.2% (Nagelkerke R^2) of the variance in experimenter ratings and correctly classified 69.7% of the cases. Feedback type (B = .789, Wald = 8.70, Odds Ratio = 2.20, $p < .05$) and implicit self-esteem (B = -4.48, Wald = 4.04, Odds Ratio = .01, $p < .05$) were significant predictors of aggression. However, the interaction term was nonsignificant (B = .09, Wald = .00, $p = .96$).

Therefore, it appears that a model including only implicit self-esteem (without explicit self-esteem) does not adequately represent the data. Although this is the case in this dataset, I do not feel it suggests that implicit self-esteem is not a relevant construct to include in investigations of the relationship between self-esteem and aggression. As discussed above (General Discussion), the present study had several shortcomings, including a measure of aggression that lacked variability and may not have been directly related to impulsive aggression. Modern attitude research has continually found evidence for the existence, and importance, of dual-attitudes and therefore steps should be taken to measure both attitudes whenever possible in order to gain a more complete understanding of variance in constructs.