ATTENTIONAL BIAS IN PATIENTS WITH IMPLANTABLE CARDIOVERTER DEFIBRILLATORS: EXAMINING MECHANISMS OF HYPERVIGILENCE AND ANXIETY

By

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A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

2008

To my amazing grandparents whose value for learning, education and zestful spirit of adventure forged the way for higher education in the generations to come. And to my own parents and husband: Your never ending support and love through this journey will always be with me. I am eternally grateful for each of you.

ACKNOWLEDGMENTS

I would like to thank my mentors, Bill Perlstein, Ph.D. and Samuel Sears, Ph.D., for their support, supervision, and examination of what was really important throughout my graduate school experience. You are both individuals who have made a permanent imprint on my mind, heart and values. In addition, I would like to thank the members of the Clinical Cognitive Neuroscience Lab and Cardiac Psychology Lab for their willingness to give assistance whenever needed. I would like to especially thank Leann King RN, and Marcela Miranda, ARNP for their efforts in aiding recruitment on this project. This research was supported by a pre-doctoral fellowship from the Florida/Puerto Rico Affiliate of the American Heart Association to Neha K. Dixit.

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August 2008

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Major: Psychology

Symptoms of anxiety and hypervigilance are prevalent in patients with arrhythmias, particularly in patients with life threatening arrhythmias such as ventricular fibrillation (VF). The treatment of choice for patients with VF is implantation of an implantable cardioverter defibrillator (ICD) which shocks patients out of life threatening arrhythmias and places them at risk for shock specific anxiety secondary to living with their device. Literature examining affective influences on attentional processing suggests that people with high levels of anxiety have biased attention towards threatening information, such that they have difficulty disengaging attention from negative or threatening stimuli. Using a modified emotional dot-probe task, we examined attentional bias in patients with ICDs comparing them to patients with atrial fibrillation (AF). Contrary to predictions, ICD patients did exhibit attentional bias towards clinically relevant information compared to AF controls, and levels of state and trait anxiety did not influence the magnitude of attentional bias in either group. ICD patients demonstrated higher levels of trait anxiety compared to AF patients as well as worse physical functioning. Additionally, results demonstrate efficacy of affective stimuli, with ICD patients rating clinical words as more unpleasant than AF controls. Overall, results suggest that this paradigm must be

examined and potentially modified in greater detail to elucidate the influence of affective cue words on attentional bias in the arrhythmia population.

CHAPTER 1
INTRODUCTION

Overview and Study Aims

Each year, approximately 350,000 Americans experience sudden cardiac death (SCD) related to the occurrence of cardiac arrhythmias, including ventricular fibrillation (VF) and ventricular tachycardia (VT; American Heart Association, 2004). The Implantable cardioverter defibrillator (ICD) is the treatment of choice for ventricular cardiac arrhythmias (Anti-arrhythmic versus Implantable Device [AVID] Investigators, 1997; Moss et al., for the Multicenter Automatic Defibrillator Implantation Trial [MADIT] Investigators, 1996), and nearly 60,000 Americans receive an ICD each year. Although the ICD has demonstrated impressive mortality benefits, the device nonetheless presents as a potential instigator of psychological maladjustment in recipients. This is primarily due to the shock mechanism necessary for the device to convert potentially lethal arrhythmias. Significant rates of panic symptoms (Godemann, Butter, Lampe, Linden, Werner, & Behrens, 2004) and avoidance behaviors (Lemon, Edelman, & Kirkness, 2004) have been documented among this population, as have difficulties with depression, anxiety, interpersonal functioning, and stress management (Sears & Conti, 2003).

Researchers have also implicated anxiety about the device and health related anxiety as significant predictors of psychosocial distress (Pauli et. al, 1999; Sears, 1999). Given the high levels of susceptibility for both device related and generalized disease specific anxiety in ICD recipients, it is critical to identify areas of cognitive functioning which may be affected by such distress and may also serve to maintain or exacerbate such distress. Considerable research has shown that selective attention, the ability to attend to and ignore information in the environment, may be a critical cognitive process that is affected by both normal and clinical (i.e., social and

specific phobic) anxiety (Compton, 2003). Emotional processing is tightly linked to levels of arousal (Damasio, 1996), such that high levels of arousal (e.g. fear, threat) may enhance attention during a threatening situation and low levels of arousal may allow an individual to ignore relevant information. Patients with cardiac disease, specifically arrhythmias, constantly evaluate their own levels of related threat (Pauli, 1999). The nature of their disease state warrants critical vigilance to symptomatology, adherence to medication regimens, knowledge of health care options and advances, and a host of medical information which may vary throughout the course of living with chronic cardiac disease. Attention or vigilance to medical knowledge and personal health status is important as it keeps arrhythmic patients focused on returning to full functioning. Too much or too little attention to such information can result in diminished physical and mental functioning. Thus, examining the levels of attention to cardiac specific information in ICD recipients (for whom anxiety is directly related to physical symptomatology and device specific characteristics) may give rise to further characterizing and understanding patients' beliefs and specific fears about their devices and disease state for future interpretation.

Specific Aims

The current study aimed to examine cardiac-specific *attentional biases* in patients living with ICDs. Patients with ICDs provide a unique perspective on the relationship among emotion, attention, and anxiety given the nature of the acquisition of their symptoms. ICD recipients who are psychologically healthy prior to implantation may experience clinical levels of anxiety following ICD implantation and the experience of ICD shock. Examining ICD patients' ability to disengage attention from shock-related information is critical to their quality of life and psychosocial health. It is important for patients to redirect from negative material (e.g. counting their pulse, catastrophic thoughts) in order for them to retain information provided by physicians and live actively with the benefits of the device and minimize drawback. Previous research has

suggested that a variety of anxiety-disordered patients demonstrate attentional biases towards clinically-relevant information (Derryberry & Reed, 1994) and that attention to threatening information is directly related to coping style and functional strategy. Research has demonstrated that patients with adaptive coping strategies are able to disengage better from negative disease specific information than those with maladaptive strategies. Thus, examination of attentional bias for cardiac-related information in ICD recipients could prove useful in tailoring future treatments to these patients.

- **Specific Aim 1:** To determine if the implantation of an ICD in cardiac patients, the frequency of ICD shock, and generalized state or trait anxiety are associated with specific affect-mediated selective attentional biases as measured using a variation of the Dot Probe task. Based on the literature suggesting attentional bias towards threatening information in individuals with high levels of anxiety (i.e. state) and specific phobias, it is hypothesized that both levels of distress and the presence of at least one ICD shock will contribute to biased performance, reflected by disproportionately slower reaction times under clinically-relevant cued conditions compared to both arrhythmia control patients and non-ICD-related cues.

- **Specific Aim 2:** To examine if varying levels of state and trait anxiety differentially affect attentional bias in both ICD patients and arrhythmia controls. Evidence suggests that living with an arrhythmia (whether life threatening or not) may increase the extent of ones' bodily or cardiac-specific vigilance. Additionally, studies of attentional bias in participants with sub-clinical levels of anxiety also show a bias towards threat-relevant information. It is hypothesized that the magnitude of attentional bias to threat will be positively correlated with levels of state, but not trait, anxiety in both groups as demonstrated in previous studies examining attentional biases in otherwise healthy individuals (Fox, Dutton, & Bowles, 2001). State anxiety has been implicated in attentional bias in anxiety-disordered individuals, whereas trait anxiety has not generally been correlated with indices of bias in similar dot probe paradigms (Mogg & Bradley, 2002).

In sum, the proposed research will examine potential selective-attention biases to cardiac-related information in patients who have received ICDs. The significance of this research is two-fold: 1) it may enhance our understanding of attentional biases in patients who are potentially developing heightening anxiety and concern with bodily symptoms, thereby providing a prospective means by which to study natural anxiety-disorder development, and 2) it may provide insight into treatment of cardiac specific anxiety-related symptoms in patients with ICDs

which can potentially improve their quality of life, lead to better adherence to treatment regimens, and improved understanding of their disease process.

Background and Significance

The following sections will first describe the prevalence and presentation of psychosocial distress in patients with ICDs and arrhythmias. Then, the use of the dot-probe paradigm to examine attentional bias in a variety of anxiety-disordered individuals will be discussed. Finally, the relationship between ICD placement, shock, anxiety, and attentional bias will be explained, including possible mechanisms for the observed relationship.

Sudden cardiac death is an increasingly frequent occurrence among patients with cardiovascular disease, particularly those with conditions compromising the electrophysiology of the heart. Recent advances in device technology have increased delivery of preferred treatment of life-threatening arrhythmias. A patient is considered at risk for sudden death if they have had a previous cardiac arrest from which they have been resuscitated, if they have an ejection fraction <35%, if they have a history of congestive heart failure, or have congenital cardiac issues such as long QT syndrome exist, where sudden death is a common outcome. ICDs are devices that prevent the heart from either going into a life threatening rhythm or shock the heart back from a chaotic rhythm. Sears and colleagues (1999, 2000, 2001, 2002, 2003, 2004), as well as other researchers, have discussed aspects of psychosocial distress related to living with an ICD. The two domains which have been commonly examined are affective and mood disturbances in patients and quality of life changes in patients. Sears (2003) has reported that the prevalence of anxiety symptoms in ICD patients is between 13-87% with rates of clinically-significant anxiety ranging between 15-38%. Rates of depression in this population are around 12-24%. Given these numbers, and the findings of researchers such as Hegal et al, (1997) who report that 30% of all recipients of ICDs have clinically-relevant depression and anxiety, psychosocial distress is an

important factor to examine in the life course of these patients. While anxiety and depression do exist in this population, it is important to note that rates of depression appear to be similar to those in the general cardiac population (Sears and Conti, 2003). It is the rates of anxiety and the unique development of this anxiety which distinguishes ICD patients from other medical populations (Godeman, 2004).

One of the interesting issues surrounding psychosocial distress in ICD patients is in the way one can attribute the distress. The CABG-PATCH trial, examined the quality of life and psychosocial distress in recipients of ICDs versus those who did not receive ICD post bypass surgery. Researchers in this study noted significant distress among the ICD group compared to the non-ICD group. Examining these data more thoroughly revealed that it was patients who received shocks who perceived their quality of life as diminished and contributed to the distress ratings in the group. Several other researchers have also implicated shock as an important contributor to psychosocial distress. Schron et al. (2004) showed that patients who got shocked in the first 6 months of receiving their device had a greater incidence of depression and anxiety than their non-shocked counterparts. Several other factors have been implicated in poor psychosocial functioning in recipients of ICDs including age, gender, premorbid psychological functioning, and general life coping skills (Sears et al, 1999). Pauli and colleagues (1999) have shown that individuals who adopt a coping style involving catastrophizing have more psychosocial distress and are less able to cope with both their device but also the aspects of having a life threatening condition. Such types of distress may manifest themselves in the inability to adequately manage treatment regimens, and intake of vital medical information. The accuracy of disease perception is critical to quality of life and survival of ICD patients.

Psychosocial Effects of ICD Implantation

Patients with life threatening arrhythmias face numerous medical and psychosocial challenges in today's environment. As stated previously, the advent of technology allows patients to live longer and more resilient medical lives, but in many patients the ICD comes at a price to their quality of life and mental health. Specifically, psychosocial and quality of life issues that coincide with implantation are being more carefully dissected.

Anxiety and the ICD Patient

Anxiety has been identified as a significant contributor to the pathogenesis of cardiac disease (Kubzansky, Kawachi, Weiss, & Sparrow, 1998). Through activation of the sympathetic nervous system and subsequent release of catecholamines, anxiety is implicated in platelet aggregation, injury of arterial lining, and release of fatty acids into the blood – all of which promote the atherosclerotic process. Anxiety also may cause injury by decreasing heart rate variability and increasing the incidence of ventricular premature beats, thereby contributing to electrical instability. Finally, anxiety may trigger a myocardial infarction (heart attack) due to the association between hyperventilation and coronary vasospasms. Behavioral mechanisms have also been established associating anxiety with health-compromising activities, such as smoking, decreased physical activity, or poor diet (Haywood, 1995; Januzzi, Stern, Pasternak, & DeSanctis, 2000).

Anxiety is the most common complaint among ICD patients who have been shocked. A number of studies have shown that recipients of ICDs experience psychological distress as a result of receiving one or multiple shocks. The role of classical conditioning in the presence of a predominantly neutral stimulus (non-shock ICD placement) plays an important role in the development of anxiety and psychological symptoms (Sears et al, 1999; Godemann, 2004). When an arrhythmia occurs, the patient receives a high-voltage shock to the chest. This is

intuitively an anxiety-provoking and fearful experience for patients (Herrman, von zur Muhen, Schaumann, Buss, Kemper, Wantzen, & Gonska, 1997; Luderitz, Jung, Deister, & Manz, 1996; Schuster, Phillips, Dillon, & Tomich, 1998; Sears, Todaro, Saia-Lewis, Sotile, & Conti, 1999). Research indicates that excessive cardiac worry, ICD-specific fears, as well as physiological arousal are among the anxiety symptoms experienced by patients with ICDs (Sears et al., 2000). Research has shown that up to 15.9% of patients who receive an ICD develop one or more anxiety disorders (e.g., panic disorder, generalized anxiety disorder) after implantation (Godemann et al, 2004). Accordingly, as many as 40% of ICD patients may exhibit clinically significant symptoms of anxiety (Sears & Conti, 2002).

Arrhythmias and Hypervigilance

Living with arrhythmias of any kind can be as stressful as living with other chronic illness. What makes arrhythmias even more difficult to live with is the specific nature of the symptoms they produce. A patient with atrial arrhythmia, for example, may feel fluttering of the heart, tightness in the chest, and dizziness, among other symptoms. They may also feel nothing. However, the consequence of their particular arrhythmia may be life threatening. Most patients with atrial fibrillation (a common arrhythmia in the elderly population) are on anti-coagulant therapy due to the high rates of thrombolic strokes which occur in these patients secondary to their arrhythmia. In the same regard, a patient with diagnosed susceptibility to supra ventricular tachycardia (SVT), ventricular tachycardia (VT), or ventricular fibrillation (VF) may feel dizzy, faint, have difficulty breathing and feel like their heart is racing. If these patients have ICDs, in most cases the response to their arrhythmia will be shock. Not surprisingly, it is not only the seriousness of the condition itself in patients with arrhythmias that contributes to anxiety and psychosocial distress, but the nature of the symptoms which are often themselves anxiety provoking (Burke, 2004). For example, Godemann (2004) found that ICD patients who had been

shocked were three times more likely to have diagnosable panic disorder and generalized anxiety disorder than their non-shocked counterparts. Evidence from the ICD literature (Pauli, 1999, Sears and Conti, 2003) shows that patients are constantly evaluating their level of health. Negative cognitions such as "will I die from this shock?" or "will by heart stop beating?" are acceptable and real questions for patients to ask themselves. The nature of their illness requires them to question their bodies. Problems arise when patients go from healthy questioning of symptoms to an unhealthy hypervigilence of their bodies. These individuals focus so much on factors determining their health status (e.g. checking their pulse, counting respirations, trying to predict shock), that they forgo living and general quality of life. Mallioux and Brenner (2002) described this phenomenon as "somatosensory amplification" in which patients overemphasize the responses of their parasympathetic nervous systems to normal stimuli and then worry about their health after making an inaccurate attribution. The illusion of control which is maintained by patients who are exceptionally anxious or hypervigilent is dangerous because it is not real. It is not based on actual physical merit and can actually cause increased numbers of arrhythmias, thus perpetuating the cycle of vigilance and distress.

Anxiety as Precipitant to Shock

Recent research in the ICD literature points to growing evidence that stress and anxiety are themselves contributers to shock. A study by Shedd and colleagues (2004) examined the incidence of shocks 30 days before the attacks on world trade center and 30 days post. Findings demonstrated a 2.8 fold increase in shock after the WTC attacks among people living in Florida, while researchers examining individuals in New York City and other parts of New York found similar results at a 2.4 fold increase. Both studies controlled for other mitigating factors which may have contributed to shocks. These numbers indicate that traumatic life events even far from their occurrence increase stress and cause arrhythmias to occur. Dunbar (1999) also showed a

relationship between aggression, hostility and shocks leading to the suggestion that there are patient relevant personality/trait factors which contribute to shock. Neurochemical support of these findings has been demonstrated by Lampert and colleagues (2004) who showed that higher levels of stress hormones (epinephrine and norephinephrine) were correlated with arrhythmic changes in the heart suggesting a biochemical pathway which may be excited when a patient gets anxious or stressed. Collectively, greater insights into anxiety processes may allow for some impact on the occurrence of shock itself.

Selective Attention

Selective attention is an important component of a human's cognitive experience. The brain's ability to make decisions about what information to attend to and what information to filter out is vital to maneuvering through the vast array of environmental and internal stimuli we perceive and take in. Several researchers have examined different models of attention. Posner's model of attention is well known to decompose the components of selective attention and aid in the understanding of mechanisms that comprise this system. This model of attention views attention as a system comprised of several voluntary and involuntary processes (Posner & Peterson, 1990; Posner & Raichle, 1994), which act in concert to orient a person to their environment. Selective attention is driven by the posterior attentional system that is defined as the "reactive" component of attention that orients a persons' focus from one location to another. According to Posner, orienting is accomplished through three operations: disengagement from the object, movement to another location, and engagement of that new location. This model theorizes that visual spatial attention involves both facilitation and inhibition of various competing visual information. In his seminal exogenous cueing task, Posner (1988) found that presentation of a visual cue increases a subject's vigilance and orients them to that spatial location, thus allowing for faster target detection in that location. While a subject orients to the

new location, he/she inhibits all other spatial information. Classical paradigms used to examine selective attention and orienting, have utilized Posner's exogenous cueing paradigm and his theoretical principles in the experimental setting.

Attentional Bias and Emotion

Affective influences on information processing is critical for human function. The adaptive function of emotion depends upon the particular emotion being studied but basic emotions such as anger, fear, happiness, sadness, and disgust evolved distinctly to benefit the human experience (LeDoux, 1996; Lang, Davis, & Ohman, 2000). For example, it is likely that the basic emotion of fear evolved to enable an organism to rapidly detect and respond to danger in its environment (LeDoux, 1996). Contemporary theories of emotion argue that the initial appraisal of a situation or object (as neutral, positive, or negative) is one of the major determinants of the emotional response to that situation (Lazarus, 1966; Oatley & Johnson-Laird, 1987). Since emotional appraisal of an external stimulus may also determine its importance or priority, attentional input to that stimulus may be guided by such an appraisal (Lang, Bradley, & Cuthbert 1997; Damasio, 1998; Compton, 2003). Thus, given the vast amount of information in our external environment it is adaptive for emotional processing of stimuli and attentional selection to be integrally related.

Of particular interest to researchers who examine the interplay between emotion and attention is the speed with which appraisals and attentional shifts are made. For example, several researchers have demonstrated that emotional processing is encoded early in the processing stream and is fairly "automatic" (Ohman, 1997, Zajonc, 2000). Automatic processing has been defined by a time frame between 100-300 milliseconds after the appearance of an emotional stimulus (Compton, 2003). Neuroimaging techniques have allowed researchers to examine brain activity during these early stages of processing. One such technique is event-related potentials

(ERPs) which record fast electrical changes in the scalp during stimulus presentation. Studies using ERPs have demonstrated that discrimination of emotional content (e.g. face recognition-happy, sad, angry; provocative pictures) occurs during as early as 80-160 milliseconds with the onset of the stimulus (Broomfield & Turpin (2005). Masking studies, where the emotional stimulus is imperceptible to conscious processing (Lang, Davis, & Ohman, 2000), have also demonstrated early detection of both the content of emotional stimuli (pleasant, neutral, or unpleasant) and intensity of the emotional connotation (arousal).

Functional neuroimaging has provided additional insight into the relationship between selective attention and emotion. Neural structures involved in the early processing of emotional stimuli include the amygdala, anterior cingulate, and frontal cortex (Dolan, 2000). There is a large degree of overlap between these structures and those involved in processing selective attention. Two main neural mechanisms exist by which emotion may guide information processing. Regions of the brain that rely on sensory information such as the visual cortex and the extrastriate cortex regulate bottom-up influences on attention. During presentation of an emotional stimulus these regions show increased activity or amplification resulting in favored attentional selection to that stimulus (Mangun, Jha, Hopfinger, & Handy, 2000). Amplification is thought to occur via bottom up input from the amygdala that reacts to emotional representation put forth. For example, Lane and colleagues (1997, 1998) found that exposing subjects to emotionally- arousing pictures increased activation in the visual cortex compared to neutral pictures. Others such as Pessosa and Ungerleider (2004) have found increased activation of areas such as the fusiform gyrus (also involved in visual processing) when showing subjects fearful verses neutral faces.

While the amygdala sends amplifying signals to sensory cortices, other regions of the brain are implicated in top-down processing of emotional information to help modulate its selection. The two major brain regions involved in selection and suppression of information from the amygdala are the dorsolateral and ventromedial corticies (Mangun et al, 2000). The dorsolateral region is involved in selecting and maintaining stimulus attributes in working memory (Cohen et al, 1999, 2000), while the ventromedical region is involved in registering the emotional significance of stimuli and is also involved in motivational and goal directed processing (Bush, Luu, Posner, 2000). The anterior cingulate which is a part of the ventromedial frontal cortex, is a structure involved in conflict detection and may play a role in what emotional information to let into decision making processing and which to leave out (Hariri et al, 2004; Whalen & Bush, 1998). Bishop and colleagues (2004) showed using an fMRI study that, individuals who were highly anxious had higher anterior cingulate cortex (ACC) activation compared to less anxious comparison subject when viewing threatening stimuli. According to the somatic marker hypothesis of Damasio (1994) feedback from autonomatic (emotional) responses provides critical input via the amygdala to decision-making processes mediated by the frontal lobes. Given the neural mechanisms involved in emotional processing, theories of normal emotion have their parallel in theories of disordered emotions such as anxiety and depression where thinking, cognitive processing, and decision making has been shown to be distorted (Beck, 1976).

Experimental Paradigms Examining Attentional Bias

Two common experimental methodologies used to examine selective attention in adults are the emotional stroop task and the emotional dot probe paradigm. In both tasks, the basic premise is to orient a subject's attention to particular stimuli while utilizing interfering emotional stimuli to distract the subject. Together, these two tasks have been manipulated such that

researchers have been able to determine the nature of both cognitive and neuroanatomical aspects of anxiety disordered individuals and their ability/inability to attend meaningfully to specific stimuli.

Since its inception the Stroop has commonly been used as the gold standard for selective attention tasks. In this particular task, a subject is asked to read a set of emotional and neutral words and then asked to name the color of the word disregarding the word's content. It has been demonstrated by numerous researchers that subjects' response latencies to emotional words are longer for subjects for whom the words have relevance (e.g. socially relevant words for social phobias) compared to control subjects. The results indicate that the automaticity of word naming is overridden by the emotional content of the word. In fact word naming appears to take longer when examining emotional words for people with affective disorders. It has been posited that the Stroop is a task of conflict detection and monitoring. Although attentional networks have been implicated in this detection process, the results of the emotional version of this task are often misguided and interpreted inaccurately (Algom, Chajut & Lev, 2004). In the Stroop it is often the level of emotional content within the word that drives the attentional bias and is not considered a hallmark stroop color naming effect. The emotional content of the word itself is the interfering stimulus and can vary on its level of biasing attention. The dot probe task, a derivative of Posner's original exogenous cuing paradigm, is more commonly used to examine attentional bias in healthy and mood disordered individuals (Posner, 2000).

The dot probe paradigm orients a person's attention to a particular spatial location by the presentation of a cue prior to a target probe. In this task individuals are asked to attend to letters or dots presented in different spatial locations on a computer screen (cue). They are then shown a target probe in the same or different location of the previously presented cue and asked to

respond to the probe. The basic premise of the dot probe paradigm is that a person's visual selective attention can be oriented differentially to spatial locations. A subject's reaction time measured by response latencies between cue and target (i.e., probe) detection is the main measure of their attentional capture. Further analysis of the dot probe task involves examination of response latencies subjects have to valid trials and invalid trials, sometimes called the validity effect. Longer response latencies are observed for trials where probes occur in a different location from the cue (i.e., invalid or incongruent) suggesting that individuals are primed by the cue to orient their attention in one direction and have difficulty disengaging from that location in response to the probe. The dot probe paradigm has utilized the principles of Posner's "shift" and "disengage" components of attention (1980) to describe instances of disturbed selective attention during the task. The task has been manipulated in numerous ways to examine selective attention in anxious individuals mainly with the addition of emotional cue related stimuli; usually an emotional word, face, or picture and by priming locations in a valid/invalid manner to create an attentional response bias.

Evidence of Attentional Bias in Anxiety Disorders

Individuals with anxiety disorders are of particular interest when examining attentional biases because of the nature of the disease state. Mood congruent attentional biases are well established in the anxiety literature (Williams, Watts, MacLeod, &Mathews, 1997; Armony &LeDoux, 2000). It has been posited that human anxiety reflects a heightened response of the fear system (Lang & Ohman, 2000; Armony & LeDoux, 2000; Fox, Russo, Bowles, & Dutton 2001). Thus, it is adaptive for people who perceive a threat to get anxious and thereby engage neural systems to aid in the resolution of the threat. If resolution cannot be reached, higher order brain systems (frontal cortex, etc.) must come online and create alternative response options.

As such, both individuals with anxiety disorders and those with subclinical levels of anxiety may differentially strategize execution of action during the presence of threat (Derryberry & Reed, 2004).

Major findings in the dot probe literature demonstrate that anxious individuals show a bias towards threatening faces, words, and negative pictures. A study by MacLeod, Mathews and Tata (1986) demonstrated, using an emotional dot probe task, that anxious patients were faster to respond to the probe (dot) when it appeared in the location where a threat-related word has just appeared (valid cue) compared a non-threat related word. This effect was disproportionately seen in anxious individuals compared to non-anxious control participants and was specific to threat-relevant information. This result has been replicated throughout the literature (see Mogg & Bradley, 2000 for review) and suggests that threatening information captures visual attention particularly in those individuals who are especially sensitive to fear-relevant stimuli in the environment (e.g. anxious individuals). Hypervigligence to external stimuli and processes of relevance such may divert attentional resources away from non-threat related information and bias attention towards threat related information. Similar findings have also been shown in non-clinical populations (Fox et al, 2001). Individuals with subclinical levels of anxiety (high trait anxiety) have also demonstrated an attentional bias towards threatening information (Fox et. al, 2001, Wilson & McLeod, 2003) when compared to low trait- anxious individuals.

An important issue raised in the dot probe literature is one of individual differences in anxiety-disordered patients. While some patients may exhibit heightened attentional capture to threatening information, it has been demonstrated that some have difficulty disengaging from threatening stimuli. A series of studies have shown individuals with high levels of state anxiety

to have difficulty disengaging from negative or threatening information (Amir, Elias, Klumpp, & Przeworski, 2003; Fox et al, 2001; Yiend & Mathews 2001) that is particularly relevant to them. Personal or individual threat therefore is an important consideration when interpreting dot probe findings.

Other models discussing biased attentional direction (e.g. Williams, MacLeod) posit that high trait-anxious individuals orient their attention towards threatening information while low trait anxious individuals will orient away from the threatening information. The shifted attentional model account proposed by Mogg and Bradley (2000), posits that regardless of level of anxiety, all individuals will direct attention away from mild threat intensity stimuli and orient towards stimuli with a high threat intensity. The observable difference between the two groups is the intermediate levels of threat intensity. McLeod and Wilson (2003) designed a unique study in which they varied the intensity level of a variety of angry faces on a continuum of threat. Findings showed that all subjects showed greater vigilance (longer response times) to the most extreme and intense faces. They did not show any effects at very low levels of intensity. The critical difference in this study was to intermediate levels of angry faces. High trait anxious individuals displayed a greater vigilance to threat compared to low anxious individuals. These findings appear to suggest another mechanistic view of anxious individuals. They appear to predict that high trait anxious participants reach a threshold of subjective threat at lower levels of perceived threat than low anxious individuals.

The ability to disengage from personally relevant threat has been demonstrated in medical populations. Researchers have demonstrated that patients with chronic pain show attentional bias towards pain related information (e.g. words) when compared to medical counterparts who did not have chronic pain (Dehgani, Sharpe, & Nicholas, 2003; Beck et al,

2001). In fact, pain patients show differential bias towards words that are related to their particular type of pain. For example, Van Damme, Lorenz, Eccleston, Koster, DeClercq, & Crombez, 2004 showed that patients with increased negative cognitions about their pain were more likely to have increased response latencies to affective pain words compared to sensory pain words. Patients rating their subjective pain experience as more intense (e.g., burning, stinging) showed increased response latencies to sensory words compared to affective words. Similar findings, demonstrating disproportionately increased response latencies to clinically-relevant words compared to other words and compared to controls exist in literature examining social phobia, specific phobia, and generalized anxiety disorder (Compton, 2003).

In sum, the dot probe literature highlights what has been interpreted as the highly anxious individual's inability to disengage from relevant threat information as evidenced by longer response latencies during negative verses pleasant conditions. This generally results in disproportionate slowing during clinically relevant or threatening conditions during invalid verses valid trials.

Significance

The present study furthered an understanding of the relationship between anxiety and cardiac arrhythmias, specifically the role of information processing in ICD recipients. The number and proportion of individuals being implanted with ICDs is growing in this country. With new advances in technology, ICDs will increase in their favorability as treatment of choice in both arrhythmias and congestive heart failure. Research suggests the presence of anxiety, specifically shock-related anxiety results in an increase in hypervigilence to bodily symptoms and health-related stress (Pauli et. al, 1999; Sears et al, 2001; Godemann, 2004). In addition, shock-related anxiety is associated with depression and decreased quality of life (Sears et al., 1999, 2001, 2003). ICD recipients are, by nature of the mechanism of their device and disease

state biased towards potentially threatening sensations from their bodies. Much like studies of attentional bias in pain patients, ICD recipients offer a unique perspective to examine the relationship between emotion and attentional bias. In addition, the present study has clinical significance in that findings may identify mechanisms by which ICD recipients may process information, particularly cardiac related information, and to what degree they may over engage this information is critical to treating them. This line of research may aid in the development of individually tailored psychosocial interventions and the types of patient information that is offered in a clinical setting.

CHAPTER 2
EXPERIMENTAL DESIGN AND METHODS

Participants

Thirty seven VF (ICD) patients (ages 34-80) and 41 AF patients (ages 37-80) participated in the study. Participants were recruited through the Electrophysiology Clinics at Shands Hospital at the University of Florida Health Science Center. Per interview, all participants were right-handed native-English speakers. Our sample consisted of 93% Caucasian, 4% African-American, and 3% Hispanic. Potential participants were excluded from the study for the following reasons: 1) Major Axis I psychopathology; 2) dementia or other neurological disease; 3) acute medical illness; 4) current use of antiepileptics or other medication known to significantly affect cognitive functioning; 5) motor deficits that would interfere with the use of the dominant hand for performance of button press associated with the dot-probe task; and 6) a score of less than 30 on the Telephone Interview for Cognitive Status (TICS; Brandt, Spencer, & Folstein, 1988). All participants provided written informed consent according to procedures established by the University of Florida Health Science Center Institutional Review Board. Participants were compensated $10 for their time.

Demographic characteristics of study participants are provided in Table 2-1. ICD and AF patients were well matched for education, $t(78) = -.57$, $p > .68$, and were screened for reading using the North American Adult Reading Test (NAART; Blair & Spreen, 1989; Nelson, 1982). ICD patients and AF patients reported similar levels of depressive symptoms on the Beck Depression Inventory, 2nd Edition (BDI-II; Beck, 1996), $t(78) = -.03$, $p > .90$. ICD patients and AF patients also reported similar levels of state anxiety state, but greater trait anxiety, compared to AF patients $t(78) = 1.29$, $p < .04$.

Medical data on cardiac diagnoses, current medication, and ICD-related information was also obtained for purposes of characterizing the two groups. Mean ejection fraction was 35.87 (*S.D.* = 14.36). Respondents' medical history was significant for ventricular tachycardia (21%), ventricular fibrillation (11%), coronary artery disease (45%), and myocardial infarction (23%). Seventy two percent of the sample had been diagnosed with congestive heart failure. Medication use was as follows: 58% endorsed taking aspirin, 51% Coumadin, 84% beta-blockers, 15% calcium channel blockers, 30% ACE inhibitors, 20% angiotensin receptor blockers, 48% diuretics, 10% amiodarone, and 5% sotalol.

Procedure

Participants attended one 1- ½ hour testing session. Prior to the first session, participants were administered the TICS (Brandt et al., 1988) as an initial screen for cognitive impairment. Potential participants with TICS scores of less than 30 were excluded from the study. Using this cutoff score, the TICS has a reported sensitivity of 94% and a specificity of 100% for distinguishing demented individuals from cognitively intact individuals (Brandt et al., 1988). Thus, the TICS provided a means to exclude demented individuals from the study. No participants were excluded using this criterion during recruitment for this study.

During the experimental session, all participants received a screening[1] of relevant psychiatric and medical history. Participants were also screened for neurological insult that might be an exclusionary criterion. They were asked whether they have difficulty reading the newspaper to determine visual acuity problems that might interfere with performing the computer task. The presence and severity of depressive symptoms were assessed via the BDI-II.

[1] Participants were screened for psychiatric conditions via clinical interview and review of the medical record.

Participants were also given several psychosocial measures to examine general psychological and emotional functioning. The measures given were: (1) The Florida Shock Anxiety Scale (FSAS) was developed to assess the fear and anxiety that patients commonly have regarding the ICD and its shocks. This 16-item measure examines the cognitive, behavioral, emotional, and social impact of shock anxiety; (2) Spielberger State-Trait Anxiety Inventory (STAI), a clinical measure of anxiety; (3) SF-12, a generalized measure of health related quality of life; (4) The Left Ventricular Dysfunction Questionnaire (LVD-36) a cardiac specific quality of life measure; (5) The Beck Depression Inventory, 2nd Edition (BDI-II) and (6) Telephone Interview for Cognitive Status (TICS). These measures are described in detail below.

Shock Anxiety

The Florida Shock Anxiety Scale (FSAS): This scale was developed in the Cardiac Psychology Lab at the University of Florida for a previous study to assess the fear and anxiety that patients may have regarding the ICD and its shocks. This 16-item measure examines the cognitive, behavioral, emotional and social impact of shock anxiety. Full psychometric validation available (Kuhl, Dixit, Wallace, Sears, & Conti, 2005).

General Anxiety

State-Trait Anxiety Inventory (STAI): The STAI is a 40-item self-report questionnaire designed to measure both state and trait anxiety (Speilberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). Trait anxiety is defined as a relatively enduring personality characteristic, or more specifically, as anxiety proneness. State Anxiety is defined by a short-lived anxiety, usually induced by an event or circumstance. Both of these indices of anxiety will be examined to differentiate the extent and level of anxiety.

General Health-Related Quality of Life

Short Form-12 (SF-12): This measure was developed to gauge mental and physical functioning and can be separated into two components: physical component summary (PCS-12) and mental component summary (MCS-12). All scores of the SF-12 are comparable and highly correlated with scores from the SF-36, from which it was derived, (ranging from .63-.97; Ware et al., 1995; Ware, Kosinski, & Keller, 1996). The SF-12 reproduced 90% of the variance in the SF-36 PCS and MCS measures in the United States and on cross-validation in the MOS (Ware et al., 1996).

The Left Ventricular Dysfunction Questionnaire (LVD-36): This cardiac-specific measure was designed to assess the impact of left ventricular dysfunction on daily life and well-being. Responses are dichotomous (true or false). True responses are summed, which are then calculated as a percentage; higher scores indicate worse functioning (i.e., 0 = best possible score). The measure demonstrated high internal consistency in a sample with chronic left ventricular dysfunction (Kuder-Richardson coefficient = .95) (O'Leary & Jones, 2000).

Depression

Beck Depression Inventory-2nd Edition (BDI-II): The BDI-II is a 21-item self-report instrument assessing the presence and severity of depression symptomatology over the preceding two weeks (Beck et al., 1996). Its internal consistency ranges from .91 to .93, its one-week test-retest reliability is .93 and moderate to high correlations with other measures of depressive symptomatology supports its convergent validity. BDI-II has been widely used in cardiac populations (Carney, Freedland, Sheline, & Weiss, 1997) and is the gold standard for assessing depressive symptoms in health-related populations (JAMA, 2000).

Cognitive Screener

Telephone Interview for Cognitive Status TICS: The TICS is a brief test of cognitive functioning developed. The TICS is similar to the Mini-Mental Status Exam (Folstein, Folstein, & McHugh, 1975), but has a more comprehensive memory assessment, designed for identifying dementia. Potential participants with TICS scores of less than 30 were excluded from the study. Research has demonstrated that it is as reliable and valid as face-to-face administration. It has a sensitivity of 94% and specificity of 100% for distinguishing normal controls and demented individuals (Brandt et al., 1988) and sensitivity of 82% and specificity of 87% for distinguishing normal controls and amnestic mild cognitively impaired older adults (Cook, Marsiske, & McCoy, 2006).

Reading

The NAART (Blair & Spreen, 1989; Nelson, 1982) was used to estimate overall reading abilities.

Experimental Task

The computerized task was run on a DELL PC laptop computer using E-Prime software for stimulus presentation and behavioral data collection. To ensure that participants understood task instructions and to increase familiarity with the button-press procedure, participants were pre-practiced on the computerized cognitive task. The task paradigm utilized was a modified version of a classical dot-probe paradigm developed by Williams, Watts and McLeod (1988). Figure 2-1 illustrates a sample trial of the dot-probe task used in this experiment.

The task comprised a briefly-presented word cue, shortly followed by a target to which participants made a speeded button-press response. Specifically, participants were instructed to focus on the center of the screen where they saw a fixation point. Each trial of the task began with a centrally-located 200-ms duration fixation point followed by a cue word presented to the

top or bottom of the fixation cross. After 800 ms, the cue word was immediately replaced by a dot "*" target, which appeared randomly in the same (congruent) or opposing (incongruent) location as the word. Participants were instructed to respond to the presentation of the target by pressing the "h" or "j" keys indicating the location of the dot as quickly and accurately as possible. The dot serving as a target disappeared after the key press or after 4000ms. The inter-trial interval from the target offset to the next fixation cross was 1200ms. The participants' response time (with ms accuracy; RTs) and accuracy to the target were recorded as dependent variables.

Participants performed a total 240 experimental trials, equally and randomly distributed across four word types and two word positions. Each word was repeated four times during the entire task. Fifty percent of trials were congruent, drawing the attention of the participant to the area where the word and asterisk appeared, while the remaining fifty percent of trials were incongruent, drawing participants' attention to the area opposite the one where the asterisk appeared. Trials were randomized for each word category, with each category presented an equal number of times across the task.

Four different word types were employed as cues, including cardiac-specific threat words (e.g. shock, defibrillator, flutter), non-cardiac-specific threatening words (e.g., fearful, scared, danger), pleasant words (e.g. delighted, confident, happy), and neutral words (e.g. tile, doorknob, bland). Positive, threat and neutral words were chosen from norms of emotional words taken from the Affective Norms for English Words (ANEW; Bradley & Lang, 1999) and matched for frequency of usage in English, average word length, and grammatical structure. Cardiac specific words were chosen from a group amassed and rated by clinicians at the Shands EP clinics and graduate students in the Cardiac Psychology Lab. The cardiac-specific words were selected

based on rating for “high” valence and arousal. Valence and arousal ratings were measured separately using a computerized administration of the Self-Assessment Manikin (SAM; Lang, 1980). Both dimensions of valence and arousal were rated on a 9-point Likert scale with 1=least pleasant/arousing and 9=most pleasant/arousing. Forty words comprised the final set of stimuli (Appendix A). As a manipulation check, participants performed valence and arousal ratings for each word seen in the experiment, using the Self-Assessment Manikin (SAM; Lang, 1980) after completion of the dot probe task.

Table 2-1. Mean (±standard deviation) demographic and psychological test data for VF and AF patients.

	Min/Max	VF Patients (n=37)	AF Patients (n=41)	t-value
Age (years)	34/80	62.36 (13.72)	63.12 (9.99)	-.280
Education (years)	12/20	14.44 (2.41)	14.76 (2.35)	-.572
TICS (raw score)	34/50	42.60 (4.45)	40.13 (3.23)	.451
BDI (raw score)	0/11	6.85 (4.50)	5.34 (2.31)	-.03
STAI-S (raw score)	20/62	32.48 (9.82)	34.25 (12.35)	-.678
STAI-T (raw score)	24/56	37.77 (6.04)	34.05 (9.87)	1.29*
LVD-36 (total score)	5.56/100	62.27 (25.99)	71.47 (27.65)	-1.336
SF-12 {Physical}	17.06/57.66	34.94 (9.20)	40.58 (11.65)	-2.321*
SF-12 {Mental Health}	24.50/65.14	50.49 (10.41)	49.15 (10.58)	.555

Note: TICS = Telephone Interview for Cognitive Status; BDI-II = Beck Depression Inventory; STAI-S = State Trait Anxiety Inventory state score; STAI-T = State Trait Anxiety Inventory trait score ; LVD-36 = Left Ventricular Dysfunction Questionnaire *Groups significantly different at $p < .05$.

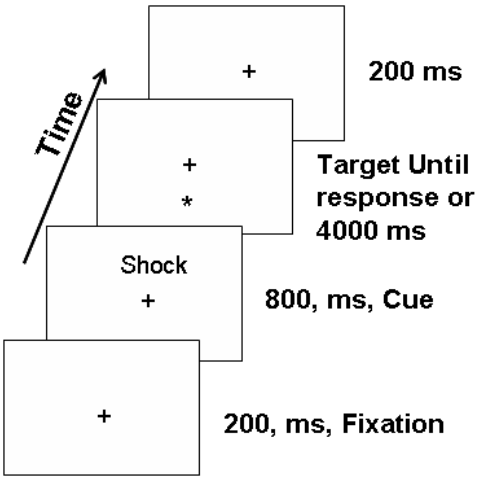

Figure 2-1. Example of a typical incongruent, clinically relevant trial.

CHAPTER 3
DATA ANALYSIS AND RESULTS

Data Analysis

Dot Probe Task

Dependant measures for the dot probe will include reaction times and error rates for each of the experimental conditions. For analyses involving RT, we employed median RTs (Ratcliff, 1993) for correct responses. For analyses involving error rates, data were arcsine transformed (Neter, Wasserman, & Kutner, 1985) prior to all analyses. This transformation was used to normalize the distribution of the error data, which is often skewed because the error rates are so low proportionately. Median correct-trial reaction times (RTs) and arcsine errors were calculated for each participant and experimental condition, and subjected to separate Group x 2-Cue Validity (Congruent, Incongruent) x 4-Cue Valence (Pleasant, Neutral, General Threat, Cardiac Threat) Analyses of Variance (ANOVAs). Group served as the between-subjects factor, and cue congruency and cue valence served as within-subject factors. To correct for possible violations of sphericity, a Hyundt-felt epsilon adjustment was calculated where appropriate and adjusted *p*-values and unadjusted degrees of freedom are reported. Effect sizes for ANOVAS were measured using Eta squared. The following hypotheses were addressed in the analyses:

> **Hypothesis 1:** A main effect of congruency will be seen across groups (slower RTs and greater error rates to incongruent than congruent trials).
>
> **Hypothesis 2**: ICD patients, compared to arrhythmia controls, will exhibit a specific and disproportionate RT slowing to incongruent- relative to congruent-cue trials specifically involving clinically relevant words.
>
> **Hypothesis 3**: There will be a significant 3-way interaction, reflecting disproportionate slowing of ICD patients to clinically specific incongruent vs. congruent cues compared to other word types and to AF controls.

Reaction Time Data

Overall, there was a significant effect of congruency in the opposite direction than predicted, $F(1, 78) = 16.377$, $p < .001$, $\eta^2 = .98$, with longer RTs to the congruent than incongruent condition. There was no significant effect of valence, $F(3,228) = .713$, $p>.55$, $\eta^2 = .15$, nor was there a Group x Valence interaction $F(3,228) = .478$, $p>.67$, $\eta^2 = .11$. Finally, no Group x Congruency x Valence interaction, was found as hypothesized for RTs $F(3,228) = 1.857$, $p>0.14$, $\eta^2 = .27$ (Figure 3-1).

Error Data

A main effect of group was observed for error rates, $F(1, 78) = 16.099$, $p < .001$, $\eta^2 = .98$, with ICD patients making greater errors overall, than AF patients. Next, we examined the effects of cue type (valence) on dot-probe task performance. There were no significant effects of valence on error rates, $F(3,228) = .684$, $p>0.55$, $\eta^2 = .02$, nor was there a Group x Valence interaction $F(3,228) = .865$, $p>0.45$, $\eta^2 = .01$. Finally, no significant Group x Congruency x Valence interaction was found for error rates, $F(3,78) = .781$, $p>0.50$, $\eta^2 =.01$ (Figure 3-2).

Cue Word Valence and Arousal Ratings

To determine if the words selected for the emotional manipulation in the dot probe task resulted in differential valence and arousal ratings within and between groups, post-task SAM assessment valence and arousal ratings were analyzed using separate ANOVAs; with group as a between-subjects factor and word category (Pleasant, Neutral, Unpleasant, Clinical) as a within-subject factor.

Results indicate that the words were, indeed, effective in producing the desired effects: (1) Both arousal and valence ratings for the Pleasant, Neutral, and Unpleasant words were consistent with expectations, (2) the two groups did not differ in ratings of these standard words, (3) but VF patients rated the clinically-relevant words as significantly more unpleasant than AF controls.

Cue Word Valence Ratings

Analyses of valence ratings demonstrated a main effect of valence, $F(3,110) = 734.58$, $p<0.001$, $p < .001$, $\eta 2 = .99$. This main effect was qualified by a significant Group x Valence interaction $F(3,110) = 11.32$, $p<0.001$, $\eta 2 = .92$. Follow-up independent samples t-test revealed that ICD patients rated the clinically-relevant words as significantly more unpleasant than AF patients, $t(76) = 3.771$, $p<0.001$; yet they did not differ in their rating of the other word categories (Figure 3-3).

Cue Word Arousal Ratings

Analyses of arousal ratings revealed a significant main effect of word category, $F(3, 110) = 274.29$, $p<0.001$, $\eta 2 = .87$. In general both groups rated pleasant, neutral and clinical words as more arousing than neutral words. No group by valence interaction was seen for arousal $F(3, 110) = 3.07$, $p>.08$, $\eta 2 = .12$ suggesting that ICD and AF patients found the words, equally arousing despite a priori predictions (Figure 3-4).

Effect of Shock on Dot Probe Task

Shock and Reaction Time

To examine the unique effects of shock on task performance, ICD recipients were grouped into "shock" and "no shock" categories. Fourteen ICD recipients received one or more shocks and 21 recipients had no history of shock. There were no significant effects of presence or absence of shock with respect to RTs, $F(1,36) = 2.15$, $p>.53$, $\eta 2 = .08$. Additionally, no significant effect of valence $F(3,102) =.774$, $p>.49$, $\eta 2 = .13$ or Shock x Valence interaction was found $F(3,102) = 2.15$, $p>.09$, $\eta 2 = .23$. Finally, no Shock x Congruency x Valence interaction was found as hypothesized for RTs, $F(3,102) = 1.288$, $p>0.33$, $\eta 2 = .07$ (Figure 3-5).

Shock and Error Rates

There were no significant effects of presence or absence of shock on error rates,

$F(1,36)= .57$, $p>.45$, $\eta 2 = .08$. Additionally, no significant effect of valence $F(3,102) =.1.037$, $p>.35$, $\eta 2 = .02$ or Shock x Valence interaction was found $F(3,102) = .90$, $p>.96$, $\eta 2 = .05$. Finally, no Shock x Congruency x Valence interaction was found for errors, $F(3,102) = 1.04$, $p>0.37$, $\eta 2 = .02$ (Figure 3-6).

To further examine the impact of ICD shock on psychosocial measures of state, trait, and shock related anxiety, additional ANOVAs were run using only ICD shock as the group variable. No significant differences between groups were found for state anxiety, $F(1,36)= .87$, $p>.35$, $\eta 2 =.12$, trait anxiety, $F(1,36)= .28$, $p>.59$, $\eta 2 = .15$, and shock anxiety (FSAS), $F(1,36)= .68$, $p>.41$, $\eta 2 = .20$.

General attentional bias scores were calculated to qualitatively examine trends in the data by subtracting incongruent RT trials from congruent RT trials (Figure 3-7). While no significant differences emerged between groups (as discussed above); there was a pattern of decreased bias to unpleasant and clinically-relevant stimuli compared to pleasant and neutral stimuli.

To examine the hypothesis that magnitude of bias was positively correlated with both ICD and AF patients' anxiety levels, Pearson correlations were calculated between bias scores and psychosocial measures of state, and trait anxiety. No significant relationships emerged amongst bias scores and anxiety all ps > .05

Psychosocial Data

Psychosocial measures described in the methods were used to characterize the sample. ICD patients and AF controls were similar in their levels of psychological distress, such that they endorsed low levels of depression; similar levels of state anxiety, cardiac specific quality of life and general mental health (Table 2-1). Notably, ICD patients demonstrated significantly more trait anxiety than AF controls $t(78) = 1.29$, $p < .04$, as well as worse physical health than AF

controls $t(78) = . -2.321$, $p < .03$. Additionally, when examining ICD patients alone, female recipients endorsed a greater level of shock related anxiety than male patients.

Pearson correlations were calculated amongst psychosocial measures of anxiety. As expected, state anxiety was positively correlated with trait anxiety $r(78) = .709$, $p < .01$, suggesting, that AF and ICD patients who experience greater levels of moment to moment anxiety are more likely to be generally anxious individuals. Additionally, because this study highlighted participants' experience of living with an ICD, state anxiety was positively correlated with shock related anxiety $r(37) = .412$, $p < .01$.

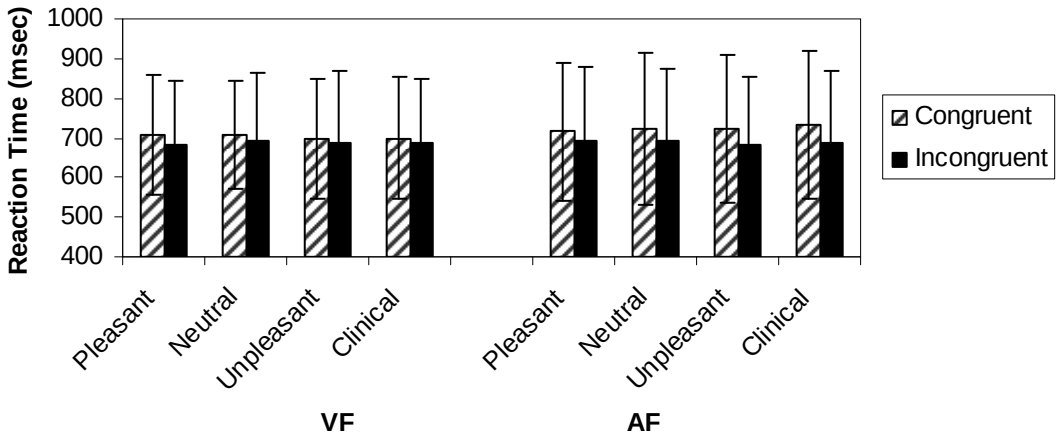

Figure 3-1. Dot-probe task reaction times for VF (ICD) and AF (control) patients.

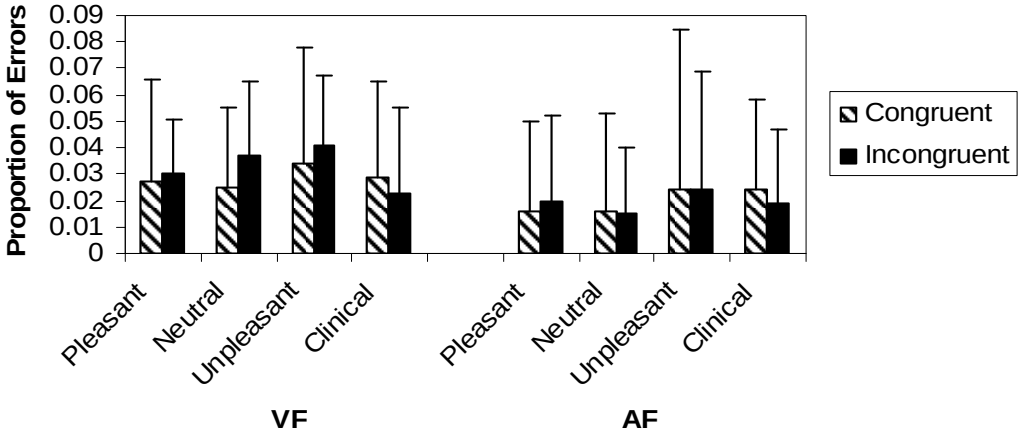

Figure 3-2. Dot-probe task error rates for VF (ICD) and AF (control) patients.

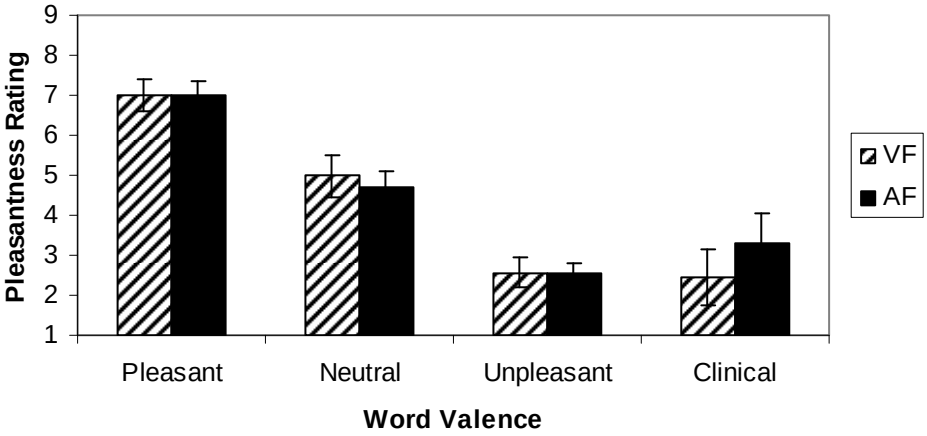

Figure 3-3. Subjective ratings for cue-word valence.

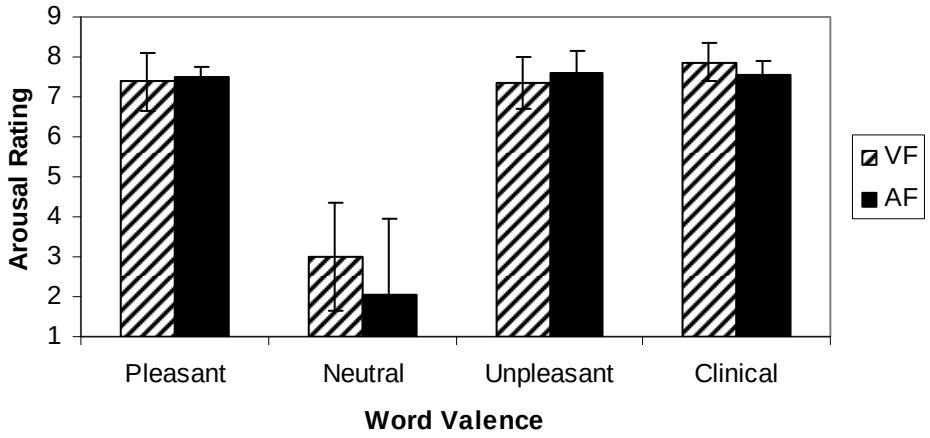

Figure 3-4. Subjective ratings for cue-word arousal.

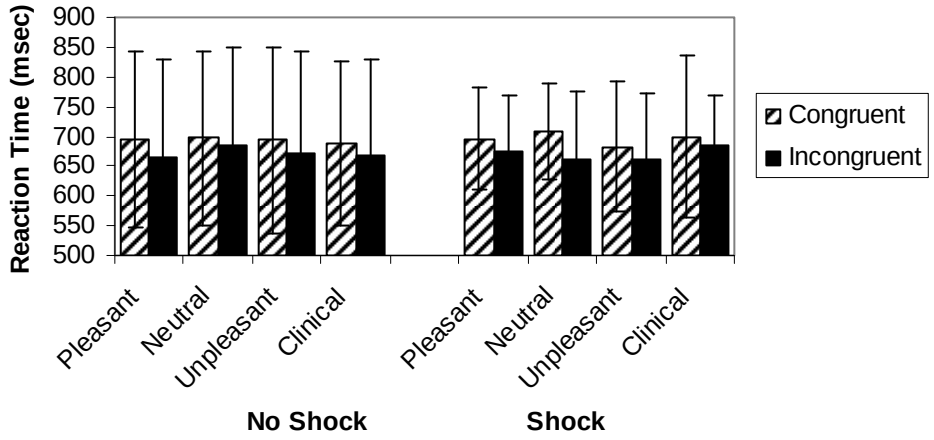

Figure 3-5. Dot-probe task reaction times for no shock (ICD) and shocked (ICD) patients.

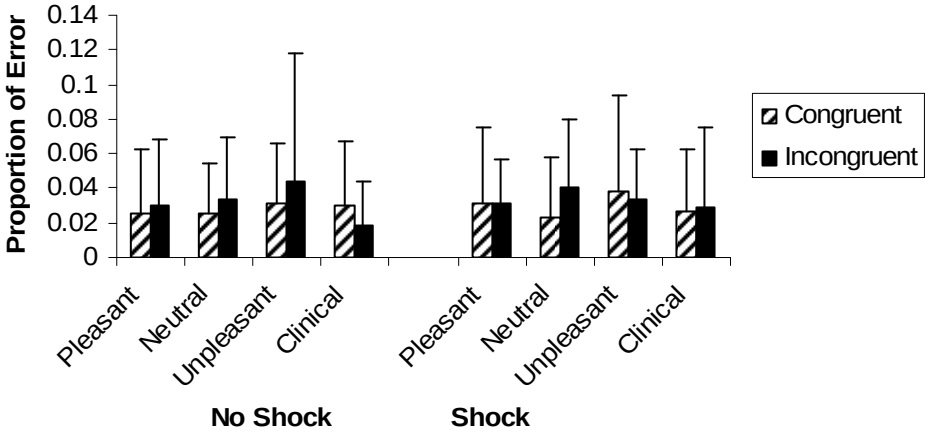

Figure 3-6. Dot-probe task error rates for no shock (ICD) and shocked (ICD) patients.

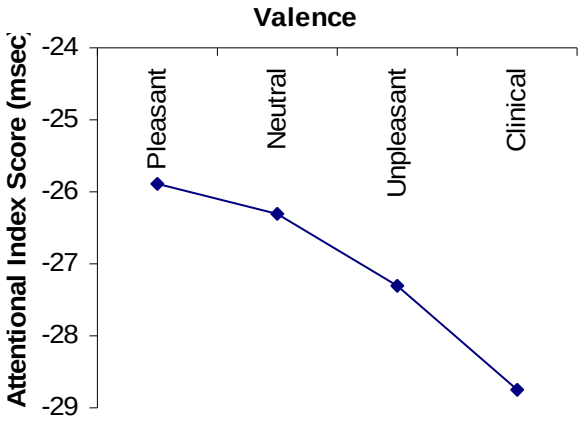

Figure 3-7. Average attentional bias scores (incongruent-congruent). Negative scores indicate decreased bias.

CHAPTER 4
DISCUSSION

Our study is the first to examine the relationships between disease-related anxiety and attentional processing in patients living with ICDs. While many studies have examined ICD and AF patient functioning from a biomedical perspective, evaluating symptoms, quality of life outcomes, and medical outcomes (Sears, 2004; Sears & Conti 2005; Godemann 2004.), this is the first examination of potential attentional bias in this patient population. Four main findings emerged from the research: First, both ICD and AF patients showed a significant attentional bias towards congruent information, irrespective of emotional valence of the task word cue. Second and unexpectedly, ICD patients committed more errors overall than AF patients. Third, ICD patients demonstrated worse general physical functioning and greater trait anxiety as a group compared to AF patients. Contrary to predictions, however, the presence or absence of ICD shock did not distinguish this difference. Finally, ICD patients found the clinically-relevant cue words more unpleasant than did AF patients.

Evidence of Attentional Bias

A primary aim of this study was to examine the ICD patients' ability to disengage attention from shock-related (cardiac specific) information using a modified dot-probe paradigm; that is, to determine if they exhibit evidence of a specific attentional bias towards clinically-relevant stimuli. The hypothesis was that ICD patients would be slower to respond to incongruent clinical trials compared to AF patients. Results demonstrated that regardless of group (ICD or AF control) or emotional valence of the words presented in the task, both groups were slower to respond to a probe presented at a congruent than incongruent location, suggesting a "reverse" congruency effect. This finding is novel and generally inconsistent with the literature on dot probe and Stroop tasks which consistently demonstrate that subjects have longer

reaction times under incongruent than congruent conditions. The literature also demonstrates that emotional valence of the cue (e.g., word, picture, face) differentially affects a person's ability to respond to corresponding probes such that incongruent trials with affectively arousing words, give rise to disproportionately slower responses.

Although the finding that participants were slower to respond to a probe presented directly after an emotional word is surprising, past research has previously suggested similar inconsistencies, particularly in older populations. Fox and colleagues (2005) demonstrated that older adults with high levels of state anxiety did not demonstrate a classical interference effect on an emotional Stroop task. In fact, their findings demonstrated that older adults have a tendency to disregard the threat content of task relevant information and perform similarly on both congruent and incongruent trials. The findings from this study and another by Mather and Carstensen (2003) also suggest that older adults with low levels of anxiety tend to avoid attending to negative emotional material. One explanation of the findings in this study is that age may have factored into the response style of participants. Our participants did not endorse clinically significant levels of state anxiety and were older than most cohorts in the classical dot-probe literature. As such, they may have disregarded the emotional content of the words during the task, focusing more on the directions asking them to respond to the probe.

The "reverse" congruency effect in this task may be better understood through paradigms in the literature examining attentional engagement. Posner and colleagues (e.g. Posner, Cohen & Rafel, 1982) demonstrated the concept of attentional engagement vs. disengagement to spatial location using a cued target paradigm. In this task, participants were instructed to focus on a fixation point between two rectangles, wait for a cue (the brightening of one rectangle) and respond to congruent or incongruent probes presented in one of the two rectangles. Participants

in Posner's experiment were faster to respond to congruent than incongruent trials, suggesting an effect of cue dependency.

In the paradigm used in this study, it is possible that cue word reading prior to a congruent probe response resulted in facilitated attention to that spatial location such that participants attended to the word and responded to the probe in an "automatic" manner without paying conscious attention to the probe itself. Additionally, directing gaze towards a probe in the opposite location of the cue word (incongruent probe) may have required heightened disengagement of attentional resources (to make a correct probe response) such that participants could not dwell on the emotional content of the word presented. Finally, the magnitude of attentional bias in this study was in the opposite direction demonstrating decreased bias towards clinically-relevant and unpleasant words compared to neutral and pleasant words. This suggests that participants spent less time attending to the clinical words compared to the non-clinical words. While the result was not statistically significant, it may provide further evidence for the "reverse" congruency effect.

Cohort Effects on Task

Contrary to expectations there was no effect of valence on task performance. A potential explanation for this may be that participants were experiencing heightened arousal during the entire task and may have allocated all possible resources to performing that task correctly at the expense of attending to the valence of the words. Participants may have been over aroused throughout the task such that valence specific effects were washed out. Direct measurements of autonomic arousal (i.e., skin conductance) (Lang et al. 2000) may have been useful in gaining information about physiological arousal in participants.

Another notable finding in this study was that ICD patients exhibited greater levels of trait anxiety and worse self-reported physical functioning compared to AF controls. It is

plausible that this increased generalized anxiety led ICD patients to make more errors in the dot-probe task compared to AF controls. Further support for this hypothesis is provided by the fact that there was no speed-accuracy trade off in either group. ICD patients' greater trait anxiety may also help to explain why no main effects of valence were found. Mogg and Bradley (1998) proposed that anxiety is the locus of the individual differences in a person's threat appraisal mechanism. These researchers posit that high trait-anxious individuals appraise all levels of threat as subjectively greater than low trait-anxious individuals. As such, ICD patients in this sample may have reached a high level of "threat vigilance" by viewing personally-threatening (clinical) words and subsequently appraised other valences as more unpleasant across the trials, suggesting the presence of a "carryover effect."

Differences in Methodology

Another consideration given the general results of this study is the methodology employed to elicit evidence of emotional attentional bias. The traditional dot-probe task developed by McLeod and colleagues (1997) presented word pairs such that spatial attention during the "cue" phase of the task was captured across the screen with a different set of stimuli each time (e.g. a neutral word always accompanied an emotional arousing word). On the traditional task, trials can be examined to delineate preferences towards and away from threat related and neutral word pairs. The modified dot-probe task in this study was developed based on findings by Amir and colleagues (2004), who did not employ the use of word pairs when examining attentional bias in social phobics. Thus, it is possible that the task employed in this study may not have been robust enough to elicit an attentional bias at the magnitude of other dot-probe tasks. Another methodological difference that potentially influenced the results in this study is the lack of a probability manipulation (Amir et al., 2004, Fox et al., 2000). Other

researchers have used a disproportionately larger set of congruent trials verses incongruent trials, priming participants' response patterns and increasing the magnitude of bias observed.

Manipulation Check

Finally, participants' ratings of the valence and arousal of the cue words, demonstrate a positive manipulation check. The ratings showed a disproportionate affective response to clinically-relevant stimuli in ICD patients, who rated the clinically-relevant (cardiac) words as more unpleasant compared to AF controls. One explanation of this finding is that the personal relevance of the clinical words was greater for the ICD patients than the AF patients. An example of a clinical word used in the task is "shock." This word has clinical meaning for both groups. For ICD patients shock may refer to their device going off, and be a reminder to them that they have a life threatening arrhythmia. For AF patients shock may refer to an external defibrillation treatment that helps to control their symptoms, potentially alleviating them. While the word is relevant to both groups, it has the potential to connote greater negativity for ICD patients than AF patients.

The pattern of findings suggests that both groups were equally aroused by the word-cues irrespective of valence. Both the valence and arousal findings are novel and the first to be demonstrated in an arrhythmia population. Given that both ICD and AF patients found the cardiac words highly arousing, it is possible that the words developed for this sample did not discriminate ICD related threat from AF related threat. Alternatively, the findings may suggest that recipients of ICDs and patients living with symptoms of AF are more similar with respect to levels of clinical hypervigilence than they are different. This is further evidence that the sample in this study may have been too affectively homogenous to clearly elucidate the specific affective attentional bias hypotheses.

Limitations

The current study represented a first step in the application of principles and paradigms of cognitive neuroscience to the study of attentional processing in ICD recipients. Additionally it offered a unique perspective in merging mechanistic research with demonstrated psychosocial phenomena. Like many studies examining novel populations and paradigms, it ventured into uncharted territory and potential limitations must be addressed. A number of pragmatic and resource constraints may have affected the results.

The first limitation of the present study may have been with the study sample itself. The participants were highly selected and consisted mainly of Caucasian, highly educated arrhythmia patients, which may not be representative of the general cardiac/arrhythmia population in the United States. In addition, stringent criteria were used to control for medical and emotional health. As such, the patients in this sample were psychologically healthier than similar samples described in the ICD literature (Sears, 2003; Goodeman, 2004; Kuhl, 2006). Given that most of our hypotheses were based on the prediction of high anxiety, specifically shock-related anxiety, the lack of shock-specific anxiety in this cohort may have affected the results obtained. Alternatively, it is possible that the ICD patients as well as AF controls were not anxious enough (given the low state/trait anxiety scores for both groups) for robust group effects to emerge. Other similar studies have found individuals with higher STAI scores, specifically after experimental mood induction (Wilson & MacLeod, 2003; Fox et al, 2005) have biased attentional processing to emotionally-relevant information.

Another critical limitation that may have affected the ICD cohort in this study is the changing nature of the technology. More and more patients are being "paced" out of life threatening arrhythmias. That is, the ICD can detect an abnormally fast heart rhythm and as it prepares to fire, may terminate the rhythm before it becomes necessary to shock. The ICD group

in this study had a low incidence of shock (63% had no shocks), as a result, they may not have been as anxious regarding their devices nor were they even familiar with post-shock psychological sequelae. Additionally, those who had been shocked at least once may have been educated about device acceptance and ICD shock and were therefore less concerned about the device. The ICD cohort at Shands hospital has been involved in numerous studies over the past 15 years specifically focusing on ICD education and device acceptance. Given the small number of clinics from which recruitment occurred, it is possible that oversampling of this population affected their responses on familiar measures of psychosocial effects and device knowledge.

Finally, the present study may have benefited from a post-task questionnaire as well as post-task ratings of state, trait and shock-related anxiety. Qualitative feedback from participants regarding their subjective experience during the task may have aided in clarifying inherent cohort specific problems with the task (e.g. too easy, unclear etc). Post-task anxiety questionnaires would have offered a data point to examine whether the task itself induced anxiety in our patients.

Future Directions

Future studies may improve on the present methodology by employing a "classic" dot-probe paradigm which uses word pairs as cues (McLeod, Mathews, & Tata, 1986). Additionally, given the low levels of anxiety in this cohort, ICD related mood induction may prove useful in clarifying effects of device specific anxiety on attentional bias. Mood induction is widely used in studies examining affective processing and is a powerful tool to induce an affective state (Compton, 2003). Use of the startle paradigm (e.g. eye-blink reflex) may provide more direct measurement of heightened threat relevant arousal and vigilance in arrhythmia patients. Additionally, direct measures of physiological arousal such as skin conductance, heart rate, and blood pressure may also be useful in characterizing and differentiating VF and AF patients.

APPENDIX
WORD STIMULI USED IN TASK

Table A-1.Word stimuli used in task

Pleasant	Neutral	Threat (noncardiac)	Cardiac Threat
Fame	Align	Agitate	Shock
Grin	Mascot	Bully	Defibrillate
Sunrise	Logic	Ruin	Flutter
Delight	Depot	Curse	Fatal
Brave	Perform	Avenge	Palpitations
Bold	Panel	Damage	Dizzy
Affection	Prompt	Insult	Faint
Cheer	Review	Hurt	Racing
Cute	Knit	Horrify	Heartbeat
Kitten	Invent	Loathe	Pain

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BIOGRAPHICAL SKETCH

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