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Temperament and Character Correlates of the Startle Reflex

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Temperament and Character Correlates of the Startle Reflex

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Each person whose signature appears below certifies that this thesis in his/her opinion is adequate, in scope and quality, as a thesis for the degree of Master of Arts in Psychology.

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ABSTRACT OF THE THESIS

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Some literature suggests that individual temperament traits can modulate the startle reflex. There is evidence supporting Cloninger's concept of Harm Avoidance as being predictive of individual differences in reactivity to aversive stimuli. (Corr, 1997). Since this finding, a new version Cloninger's measure includes character subscales that like temperament, have been proposed to modify the meaning of experiences, changing emotional reactions. High scorers on the character variables are less susceptible to excessive anxiety and tend to have neurochemical profiles that are not consistent with anxiety disorders (Gillespie, 2003; Tse & Bond, 2001; Peirson et al., 1999). It was thus hypothesized that individuals scoring low on character scales would have higher startle magnitude to negative pictures. *Method:* 73 undergraduate students underwent a standard emotion modulated startle reflex paradigm (Lang, 1994) and completed the TCI. *Results:* A significant linear trend was found for the within subjects factor 'valence' $F(1,82)=4.2$, $p<.05$, $\eta 2 = .049$ indicating that blink magnitude increased from positive to negative picture condition. A manipulation check found that in the negative condition, pictures were rated similarly negative, more arousing (t=4.60; p <.05) and made subjects feel more dominant (t= 5.77; p<.05) than the norm sample. The finding in the literature that

suggests high levels of Harm Avoidance predicts an increase in the startle response to negative pictures was not supported. Implications for the TCI as being a better measure of personality in clinical populations is an issue for further research, as well as the effects of perceived control on self-reported Harm Avoidance.

Temperament and Character Correlates of the Startle Reflex

Emotions, according to William James, seemed to be about doing things important for an organism's survival (Lang, Bradley & Cuthbert, 1997). Researchers who have conducted subsequent studies throughout the 20th and now the 21st century, such as Lang, Bradley, and others, have modified and developed the basic parts of this theory and a resulting modern theory of motivated emotion has emerged, finding physiological data that offers support for the original vision of James. The present level of individual difference research utilizing groups containing individuals of different genders, clinical diagnoses, or age cohorts is now where questions are being generated. This is primarily because they offer more detailed answers, not only about how emotion is related to physiological processes, but also why they are related.

Temperament is an inborn, relatively stable trait found in both men and women. Research supports the view that it is biologically based (Kagan, 1998; Gray, 1991). Kagan (1998) proposes a neuropsychological model for temperament, hypothesizing three emotional systems (inhibited, approach orientated, and fight-flight). According to Gray, (1991) temperament reflects relatively stable, individual differences in predispositions toward particular kinds of emotions. Temperament is able to be measured in a number of ways, but research investigating the psychophysiological relationships between emotion and temperament (Corr et al., 1996) has considered Cloninger's psychobiological model for temperament. The measure developed from this model is the Temperament and Character Inventory (TCI), (Cloninger, 1994) and only the temperament component of the scale has been used in psychophysiological research.

Lang's concept of defensive activation (Lang, 1994, 1997; Lang, Bradley, & Cuthbert, 1997; Lang, Davis, & Öhman, 2000) within the body is related to inhibited temperament. For example, those with highly inhibited temperaments may be susceptible to an increase in defensive reflex, while those with temperaments high in novelty seeking may not (Kagan, 1998). Kagan has also reported differences in fear potentiated startle in uninhibited and inhibited adolescents. If one is predisposed by his or her temperament to express emotion in a particular way, an inhibited person may be more susceptible to experiencing negative affect within anxiety-provoking situations (such as viewing a disturbing image) and could then react very strongly to a startle probe, whereas a very uninhibited person may welcome novel stimuli, no matter how aversive, and thus be less reactive.

Lang's concept of motivated emotion states that organisms have emotions which produce "dispositions" that cause them to avoid or approach certain stimuli in the environment. The question of how temperament and motivated emotion are related is of interest to the current research. If the relationship is sound, the role of Cloninger's concept of character, a construct that in theory is proposed to vary according to temperament might also be meaningfully related.

The first goal this study is to replicate the research conducted by Lang and colleagues which suggests that the startle reflex can be modulated by the emotional quality of the stimulus. Briefly, it is a robust finding in the literature that negative stimuli increase or potentiate the startle response (Lang, 1994, 1997; Lang et al. 1997, 2000). The second goal of this study is to investigate whether certain personality characteristics are predictive of emotional reactions (defined here as the startle response), as has been suggested by the research team led by Corr and colleagues (Corr, Kumari, Wilson, Checkley, & Gray, 1997). The older version of Cloninger's Temperament and Character Inventory (TCI), or the Tridimensional Personality Questionnaire (TPQ) is a measure whose temperament scales have been related to startle modulation in prior research (Corr et al., 1996). However, three new subscales have been added in addition to the four original temperament scales in the TPQ. The resulting TCI will be used in this research project to determine if the relationship between Cloninger's personality constructs and Lang's startle response findings is able to be repeated. Though previous work based on Cloninger's theory has shown interesting implications for temperament, it is unknown whether character might modulate the startle reflex as well. Therefore, it is of interest to determine if these findings may be repeated and extended in the newest edition of the TCI.

Review of the Literature

The effort to define a relationship between our emotions and our physiology represents only a single part of the existing literature concerned with emotion. This relationship has historically been framed through the philosophical study of ontology, a branch of which is defined as the mind-body problem (Viney & King, 2003). The mind-body problem (hereafter referred to as the mind-brain problem) is concerned with defining a relationship between the mind with its primarily psychological processes, and the brain, with its primarily physiological processes. With consideration to all of the different mind-brain philosophies, the focus here will come from a mainly materialistic viewpoint. This means, essentially, that most psychological processes (e.g., emotional experience) have physical origins.

Specific to emotion, historical theories date back to the scholars of the Renaissance: Olivia Sabuco wrote about the effects of negative emotional states on health (Viney & King, 2003). John B. Watson, in 1915, credited the Spanish humanist Juan Luis Vives as being one of the originators of the empirical inductive method of science. One of Vives's areas of interest was human emotion. During the 14^{th} century, he made the proposition that inherent temperamental differences influence emotions, and also that emotional processes influence bodily function and vice versa (Viney & King, 2003).

William James was a proponent of a theory which later was supported by Danish physiologist Carl Lange. This theory, as previously mentioned, came to be known as the James-Lange theory of emotion, which at its core, proposes that emotions are secondary phenomena, prompted by perceptions of physiological changes that have been elicited by external stimuli. (Lang, 1994). Current theories and studies of emotion within this physiological framework have their origins with this pioneering theory. However, the James-Lange theory was not without its critics. Wilhelm Wundt, with his tridimensional theory of feeling, disagreed with James. His theory is based on the following dichotomies: pleasure and pain, excitation and calm, and strain and relaxation. He posited that emotional states like fear represent certain combinations of these dimensions, and are also tied to particular cognitions. However, in contrast with what James and Lange stated, for Wundt, feelings are primary, unanalyzable, and similar to visual/auditory sensations (Viney & King, 2003).

Edward Titchener's (1910) work adds some depth and criticism to the James-Lange theory. While overall remaining supportive, he argued that emotions are complex and emotional experience may have multiple causes, not just environmental. For example, instinctive tendencies occur in environmental contexts, but they still may be associated with earlier memories. Titchener added the following idea: the physiological changes that James refers to may become manifest in different valence levels of the same emotion, such as tears of joy (positive valence) or tears of rage (negative valence). James accepted this, and later added to his original theory with the caveat that stimuli may produce responses that are approach oriented or avoidant oriented (Viney & King, 2003).

Many years later, other theorists have capitalized on James and Titchener's work.. Konorski (1967) proposed a biphasic model of emotional expression founded on a typology of unconditioned reflexes, either preservative or protective. Dickinson and Dearing (1979) renamed the two opponent motivational systems 'aversive' and 'attractive,' each activated by different unconditioned stimuli. In humans, ideas about emotions are hierarchically organized, and the primary division is between positivity (pleasant states such as love) and negativity (unpleasant states such as anger or sadness) (Ortony, Clore, & Collins, 1988). Lang's work concerning the physiology of emotion suggested that arousal and valence (Lang et al., 1997) are a way to classify emotional experience. Lang's work has become accepted as one of the major modern physiological theories of emotion, built on the theories and research findings previously described.

In its most basic form, Lang's theory states that human affective states (the emotion an individual experiences at the moment), will drive their response to stimuli in the environment. This can be termed their 'affective reaction.' Lang has hypothesized that the organism, when experiencing an emotion, is disposed to engage in a particular behavior. Individually and on a collective level, these emotions and the behaviors that have been influenced by them are driven by underlying neural circuits. The emotion circuits are part of the phylogenetically older primitive cortex, mid-brain, and subcortical structures, and are activated by unconditioned aversive and appetitive stimuli (Lang, Davis, & Ohman, 2000). Emotions experienced by the organism "dispose" the organism to act; for example, to flee an aversive stimulus, or to engage in an alternate action. One of first studies exploring the hypothesis has attempted to study the action of the organism using an acoustic probe: "…the magnitude of the acoustic startle reflex in human beings is modulated both by an immediately preceding stimulus…and by the emotional context in which the startle-evoking sound occurs" (Lang et al., 1997). In summary, emotions come first, and they dispose the organism to act.

Lang proposes that human emotions are evolutionary in nature. He states, "Emotions are a product of a Darwinian development, and can be characterized as motivationally tuned states of readiness. In human beings, the presumed indices of these affects include responses in three reactive systems: (a) expressive and evaluative language; (b) physiologic changes mediated by the somatic and autonomic systems; and (c) behavioral sequelae, such as patterns of avoidance or performance deficits" (Lang, 1997). The idea that the emotional influence on cognitive decisions is evolutionary leads to the idea that the emotional state of the organism should be a good indicator of how that organism should react within its environment. Animals may not experience as complex a repertoire of emotions as humans, but they do experience drive states. The very simplest of organisms demonstrate this idea: when a reptile experiences the drive state of hunger, its first instinct is to eat (positively orient itself), when it is threatened, it will flee (or, negatively orient itself). Part of Lang's theory is based on the idea that the autonomic nervous system and structures such as the amygdala are involved in a human orienting/defense system.

Animal studies involving the amygdala have studied the lateral, basolateral, and central nuclei. Hitchcock and Davis (1986) found that lesions to the central nucleus of the amygdala block fear potentiated startle using a visual conditioned stimulus. Excitotoxic lesions of the lateral and basolateral nuclei (Campeau & Davis, 1995) block fear potentiated startle using an auditory conditioned stimulus. However, there are inconsistencies between animal research and human research. Lang and his colleagues, for instance, explain that the previous inconsistencies might be due to species specific measures (eyeblink vs. whole body startle). They propose that cognitive networks representing emotional experiences are connected to the same (or analogous) motivational circuits in the brain (Vrana, Spence, & Lang, 1988; Lang, 1997). Research on the nucleus reticularis pontis caudalis (Krase, Koch, & Schnitzler, 1994) in animals as well as humans also suggests that there are inconsistencies.

Considering the abovementioned inconsistencies in the methods used to study the startle reflex, as well as the continued speculation on the precise involvement of the amygdala, researchers have turned to more advanced techniques to look at the how the brain integrates emotions and motivation. One of the questions asked by researchers in this field is how can the impact of these affective states be best measured. Current brain mapping studies have used advanced imaging strategies to explore these questions. Most have found that there is an important integration of human emotional state, motivational state, and human cognitive activity. There are basic structures and functions in the brain that are involved in these integrational patterns, such as the amygdala, the angular cingulate cortex, and the lateral prefrontal cortex. The connections and networks formed by these structures continue to be studied. Although Lang and his colleagues have done extensive work studying the startle reflex, there has been relatively little research studying the effects of individual differences on the blink reflex.

Smith, Haynes, Lazarus, & Pope (1993) has found evidence supporting the adaptational significance of emotion. It starts with the concept of natural selective attention: though in the laboratory attention is viewed as a cognitive activity, in the world of species survival, attention is more determined by motivational factors. This conception of attention is currently supported by biopsychological and neurophysiological research. The theory originates partly from a Pavlovian concept of orienting and defense (1927), later supported by such researchers as Sokolov and Graham in the 1960's and 1970's. The bulk of Lang's research on orienting and defense response is centered on human picture viewing, based in part on animal studies documenting their tendencies to "watch" things (Sapolsky, 1995).

The pictures used in the laboratory have been scientifically validated and are part of the International Affective Picture System (IAPS; Lang, Ohman, & Vaitl, 1988). Lang's approach is based on two major methodological points: that many picture contents do evoke strong affective responses (Lang, Greenwald, Bradley, & Hamm, 1993) and that these responses can be measured along dimensions of emotional valence (positive and negative), arousal (usually measured through skin conductance or heart rate), and dominance. This three dimensional view of measuring emotional feeling is based on Osgood's Semantic Differential Survey (OSD), which was originally published in 1957 (Osgood, Suci, & Tannenbaum, 1957). The OSD remains useful in current research when individuals are required to rate stimuli (Fann, Hunt, & Schaad, 2003). The advantage of the OSD approach to the evaluation of an attitude or feeling over the more common single Likert scale is that the OSD and ratings systems like it, such as the SAM used in this research design, are better able to capture the essences of feelings that are beyond the one-dimensional nature of a single Likert scale, which generally focuses on the evaluation, or good versus bad component of an individual's feeling. Like Osgood's additional measures of "potency" and "activity" add to the good versus bad element of attitudes, Lang's "arousal" and "dominance" measures add to the happy versus sad element of feelings. Essentially, there are three Likert scale ratings for each picture, resulting in a more rounded view of the emotion.

Out of this research has come an overarching theory of motivated emotion, postulating that there are two drive systems, aversive and appetitive that control perception and attention (Lang, Bradley, & Cuthbert, 1997). One of Lang's contributions to this view is an expansion and application of the motivational priming hypothesis, tested through studies using the startle reflex. Konorski (1967) originally proposed a version of motivational priming focusing on two factors: the type of reflex (whether appetitive or defensive) and the affective state of the individual. According to this Konorski/Lang theory of motivational priming, a defensive reflex is augmented when the individual is already reacting to aversive stimuli and is reduced when the individual is reacting to appetitive stimuli. In contrast, an appetitive reflex is augmented in an appetitive and inhibited in an aversive context. Furthermore, both of the 'priming effects' are enhanced as a function of the levels of affective drive (Lang, Bradley, & Cuthbert, 1997).

The concepts of orienting and defense, which are a component of Lang's research are described here in terms of autonomic nervous system activity. They are important to understand because they relate to several psychobiological theories regarding the make-up of human temperament, such as the models of Gray (1991) and Cloninger (1994). The combination of ideas among researchers itself forms a working theory which could possibly explain how the psychobiological characteristics of temperament might influence the startle reflex experiments Briefly, Gray (1991) proposes the BAS (behavioral approach system) is a positive feedback system associated with reward and guides the organism toward its goal for survival, thus the animal orients itself toward a stimulus. In contrast the BIS (behavioral inhibition system) is activated by aversive stimuli that eventually cause the ongoing behavior to stop, and attention and arousal levels increase. The details of Gray and Cloninger's theories on the psychobiology of temperament have similarities and differences, however, and both will be described later in greater detail.

Sokolov and Cacioppo (1997) define both the orienting and defense responses as general systems which "respond nonselectively to stimuli in any modality" (422). The orienting response (OR) and the defense response (DR) are contrastable phenomena. They are similar in that they both evoke sympathetic-parasympathetic nervous system activity. The OR is elicited by stimuli of a low or moderate intensity, while the DR is elicited by stimuli of high intensity. While the OR habituates rapidly to repetition, the DR intensifies or diminishes much more slowly. The OR, which is elicited by stimuli in the environment, focuses the attention of the organism, which allows the organism to update its information filter that also maintains the"neuronal model" In contrast, the DR's purpose is thought to be as a warning signal, denoting threatening stimuli, eliciting behavioral responses with the ultimate goals of protecting the organism and blunting the sensation. Sokolov's theory of the OR/DR dichotomy was published in 1963 in *Perception and the Conditioned Reflex*. Since then, hundreds of studies have appeared elaborating on this basic idea: many of these have focused on the cardiac response. Berntson, Cacioppo, Quigley and Fabro (1994) have studied cardiac orienting and defensive response. Other researchers have further studied the autonomic nervous system response patterns using blockading drugs (Cacioppo & Berntson, 1994). These studies have been able to demonstrate that the cardiac deceleration of the orienting reflex is primarily of parasympathetic origin in the autonomic nervous system.

There has been considerable research in the area of affective picture processing, a key element in the Lang's research. The pictures are the actual priming stimuli. There are several reasons why picture viewing is the procedure of choice for studying affective response. First, in picture viewing, the individual is passive and most motor interference can be minimized.

A specific picture is the focus of all current activity. Second, all subjects have a common processing task, in effect making it more likely that the physiological responses observed are those supporting perception and those that measure motivational choice are dictated by the stimulus. Third, and most importantly, the viewing process (timing, physical intensity, and valence) can be precisely controlled for, allowing for accurate replication and easy variation between laboratories.

Carretie, Iglesias, and Garcia (1997) have studied the effects of emotionally charged visual stimuli on cerebral activity. The aim of the study was to find out where in the brain significant electrical activity takes place when a subject is exposed to emotionally charged visual stimuli. Further, the researchers wanted to improve the internal validity of the experiment by making sure that subjects would not overly react to an "emotional" slide because they suspected emotion to be a relevant variable. This was of interest to them primarily because past evidence (Johnston, Burleson & Miller, 1987; Johnston, Miller, and Burleson, 1986; Palomba, Angrilli, & Bravi, 1993) had indicated that the P300 is the ERP component of most significance when subjects are exposed to emotionally positive and negative stimuli. The solution to this problem was Carretie et al.'s (1997) development of "nonexplicit and nonevident stimuli," controlling for the "relevant for task effect," and thus making all conditions homogeneous for this effect. Their subsequent hypothesis followed that if this was controlled for, P300 would not be expected to show significant differences in response to the different valence and arousal charges. A second objective for the study was to find evidence for both affective dimensions of valence and arousal. Results indicated that P300 did not show any significant sensitivity, possibly supporting the idea that P300 actually reacts to the more cognitive aspects of thinking about which slide is the most relevant to the experiment than to actually experiencing the emotion. The second conclusion reached by Carretie and his colleagues was that the N300 amplitudes were higher to stimuli rated as more activating in the arousal dimension of the stimulus-selection questionnaire. N300 amplitudes have shown the greatest response to activating stimuli: negative and repulsive images were located in the frontal areas of the brain while positive and attractive images were located in the parietal areas. This research offers support that emotion is a multidimensional construct, and that three dimensional ratings instruments such as the SAM, which include arousal as part of the emotions-felt analysis can be useful in describing emotion.

A study by Cuthbert, Schupp, Bradley, Birbaumer & Lang (1999) also has investigated affective picture processing utilizing ERPs. This study was primarily concerned with defining the construct of the emotional response. According to Cuthbert et al., emotion has multiple output measures, such as self-report of feeling, somatic and autonomic physiological reactivity, and behavioral measures. Understanding the concept of ERP late positivity is necessary to understand the following goals. In general, positive ERP waves such as P300 have been associated with recognition processes such as target identification (Kok, 1997). P300 is generally thought of as the index of attention, recognition, and stimulus probability (Donchin & Coles, 1988). Slow waves have been supported in the literature as being those waves sensitive to perceptual tasks and memory storage (Ruchkin, Johnson, Mahaffey, & Sutton, 1988). Cuthbert and colleagues synthesize these views by suggesting that slow waves should be thus expected during picture viewing and should be specifically enhanced for emotionally enhanced stimuli, "reflecting a greater allocation of perceptual processing resources to motivationally relevant input." (Cuthbert et al.,1999).

Some of the major goals for Cuthbert et al. (1999) included the following: to determine if the different pictures evoked differences in affective ratings, facial muscle change, heart rate, and skin conductance; to determine if late positive potentials in the ERP and the slow wave were greater for emotional than neutral pictures, and also if this slow wave was more sustained; and finally, to determine, when looking exclusively at positive and negative pictures, whether ERP late positivity was greater for pictures rated higher in arousal.

The hypothesis proposed by Cuthbert et al. (1999) links emotional picture processing (slow waves and the P3) to motivational systems in the brain that prompt autonomic arousal, facial expression, and self-reports of affective experience. The findings of the study indicate that the brain does respond selectively to emotional stimuli. In fact, the emotional pictures did produce a "pronounced" late positive potential that was reduced for the nonaffective stimuli. This suggests, according to Lang, Bradley, and Cuthbert (1997) that because of this evidence for motivational significance, emotional stimuli can be thought of as being selected by the brain and paid attention to longer.

A study headed by Keil et al. (2002) supports Cuthbert et al.'s (1999) findings about positive slow wave ERP measurements. In addition, they had several other objectives for their study: first, to investigate how differences in the effects of timing in picture perception as also to estimate cortical sources of changes in ERPs. Support was found for the idea that cortical networks are activated according to the motivational relevance of the visual stimuli.

A preliminary MRI study conducted by Lane, Reiman, Ahern, Schwartz, and Davidson (1997) investigated the locations of three different emotional states in the brain. They were interested in these particular emotions (happiness, sadness, and disgust) because they differ in their valence (positive or negative) and are each associated with 'action tendencies' such as approach and avoidance/withdrawal. For example, a typical reaction to a positive stimulus is an approach response (no threat detected), while a typical reaction to a negative stimulus is the avoidance response (detection of threat). The following areas showed significant cerebral blood flow (CBF): Brodmann's area 9, parts of the thalamus and the medial prefrontal cortex, anterior and posterior temporal structures, the anterior insula (recalled sadness), and the ventral mesial frontal cortex (happiness). One model of emotion, proposed by Sackeim et al., (1982) supports the idea that the brain organizes emotions differently as a function of their valence. In this instance, positive emotions are mediated by the left hemisphere and negative emotions are mediated by the right hemisphere.

Gray, Braver, and Raichle (2002) hypothesized that emotional states can selectively influence cognitively related neural activity in the area of the brain known as the lateral prefrontal cortex. Their findings support the idea that emotion is a versatile entity that is both separable and inseparable from cognitive functioning, as well as the localization of function hypothesis. In addition, the findings imply that emotions have the ability to reduce and/or impose 'psychological loads,' yet do so differently within each hemisphere. These loads are characterized as being 'withdrawal motivated' and 'approach motivated.' The load hypothesis parallels Lang's hypothesis concerning the approach/avoidance orientating response to emotionally positive and negative stimuli, respectively.

Gray, Braver, and Raichle (2002) also studied the impact of emotional state on working memory tasks. They found that the withdrawal motivated responses led to decreased ability on the verbal working memory tasks, yet increased ability on spatial working memory tasks. The opposite was true for the approach motivated responses. There was an increased ability on verbal working memory and a decreased ability on spatial working memory. Traditionally, verbal tasks have been shown to be mediated by the left hemisphere, while spatially oriented tasks are generally mediated by the right hemisphere (Baynes & Gazzaniga, 2000). Given this, Sackeim's earlier findings of approach/avoidance hemispheric specialization support Gray's findings: in the right hemisphere during avoidance, verbal tasks will be impaired while spatial tasks are enhanced, and the opposite will be true for the left hemisphere.

A study conducted by Lane et al., (1998) investigated the role of the anterior cingulate cortex in the interaction between attention and emotion. In this study, positron emission tomography (PET) was used to measure the cerebral blood flow (CBF) of healthy women during film and recall induced emotion. Then, CBF changes associated with emotion were correlated with performance on the Levels of Emotional Awareness Scale (LEAS), which is a measure of individual differences in one's capacity to experience emotion. The choice of subjects was partly guided by Shield's research in 1991, which found that using only females maximized the likelihood of more intense emotional experience. Lane et al., (1998) however, were not concerned with gender differences, only in the particular role of the angular cingulate cortex and its relationship to emotional awareness.

A third group of researchers from Spain have also investigated brain potentials associated with positive and negative valence. Carretie, Martin-Loeches, Hinojosa, & Mercado (2001) and Carretie, Mercado, Tapia & Hinojosa, (2001) have conducted several studies in this area. The first study used event related potentials (ERPs) to chart both expectancy-related and input processing related attention. It was found that input-processing related attention associated with emotional visual stimulation involves an initial, rapid, and brief 'early' attentional response oriented to rapid motor action, being the most prominent towards negative stimulation. The positive, or appetitive type of stimulation, by contrast, has a slower, later, and longer response oriented to deeper processing.

So far, it has been discussed that emotional influence on cognition is evolutionary and that humans and animals adapt orienting and defense systems which are linked to their autonomic nervous systems. These adapted systems are useful when the animal or human has to function in an environment. Specifically, Lang and colleagues have proposed a theory of motivated emotion, with the idea that there are two distinct drive systems, appetitive and aversive, that operate depending upon the nature of the stimulus (positive or negative). Additionally, the International Affective Picture System (Lang, Bradley & Cuthbert, 1997) has been used to evoke these affective responses in experimental settings, allowing researchers to measure responses along dimensions of emotional valence and arousal level. One of the offshoots within the theory of motivated emotion is the priming hypothesis, which essentially proposes that defensive reflexes are augmented when the individual is reacting to an aversive stimulus and these same reflexes are reduced with appetitive stimuli. The question remains, then to try and understand other factors that might influence this priming effect.

In addition to the theory of motivated emotion, research utilizing event related potentials (ERPs) has looked at the processing of emotionally laden stimuli and found evidence that there is a link to motivational systems in the brain that are in charge of autonomic arousal and self report of affective experience. Can an individual's biologically rooted temperamental style augment these self-reports? This is a fundamental question for the current investigation.

Finally, there have been actual "approach and avoidance" areas in the brain that have been mapped, notably Area 9 (Lane et al., 1997), the lateral prefrontal cortex (LPFC) (Gray et al., 2002), and the anterior cingulate cortex. In the LPFC, it was found that emotional states alter cognitive related neural activity in accord with the "psychological load" hypothesis, that states there are withdrawal or approach motivated loads carried in this region. If temperament is a biologically based construct, there may be links in actual brain structures/pathways important to the "approach -avoidance" regions and those implicated in temperament research. Following is a review of the major biotemperamental theories.

The studies supporting the theory of motivated emotion form the basis for much of Lang's research into affective reactions to stimuli. Many of these studies involve structures of the brain which are collectively part of the limbic system. It is, however, necessary to explain in greater depth the physiological aspects of temperament in order to bring both of the constructs of emotion and temperament equally into the realm of physiological processes so that they may be validly compared. Concerning temperament, Gray's model (1991) is a model which runs parallel to the Lang's motivated emotion hypothesis. Involved in the model are various brain structures including the amygdala and the anterior cingulate. These structures located in the limbic system interact to affect emotions and subsequently, any behavior that is influenced by an emotional state, particularly the adverse emotional states which prime the startle reflex.

Steinmetz (1994) reviews the origins of temperament in the brain by offering a summary of the workings of the limbic system. It is known that the brain regions making up the limbic system are highly interconnected. Among the first to recognize the relationship between limbic system activity and temperament was Papez in 1937 (as cited in Steinmetz, 1994) who outlined the septohippocampal system (SHC system). This system is a basic framework of structures including the hippocampus, the mammillary bodies, the anterior thalamic nuclei, and the cingulate gyrus. A loop system, or circuit, is the primary way that information in the SHC system is conveyed. The SHC loop is responsible for regulating the processing necessary for generating emotional response.

A second important structure within the limbic system is the amygdala, or more specifically the amygdaloid complex. The complex is divided into four major areas, and support for its role in the integration and control of emotional and autonomic behavior, reproduction, and memory has been documented. Kluver and Bucy (as cited in Steinmetz, 1994) were probably one of the first to document changes in emotion-related primate behavior due to amygdaloid lesions. Interestingly, the amygdala is also an important structure to consider because of its documented role in the human blink reflex.

Animal studies have been conducted using both visual and auditory stimuli to evoke a response. When the central nucleus of the amygdala is blocked, either by lesion (Davis, Hitchcock & Rosen, 1987) or by drug effect (Kim et al., 1993), the fear induced blink reflex is not expressed.

The hypothalamus has many different functions within the limbic system (Steinmetz, 1994). For example, it is responsible for the production of regulating hormones that control thyroid function and growth and for regulating the sympathetic and parasympathetic regions of the brain stem.

What role does the limbic system play in temperament? Steinmetz (1994) argues that since there are so many patterns of connectivity between each part of the system, and many connect to the neocortex, the brain stem, and the hypothalamus, that all of the connections are in place for a bidirectional transfer of cognitive aspects of emotion (the neocortical connection) with physiological aspects of emotion (hypothalamic connection). Gray (1991) has proposed a model that takes these structures and integrates them within an emotional systems framework. Human temperament, according to Gray (1991) is generated by three emotional systems, the behavioral inhibition system (BIS), the fight-flight system (FFS), and the behavioral approach system (BAS). The model is useful in that it gives a clear indication of how these brain systems might interact and directly influence an individual's temperament and thus also their predisposition to experiencing a given emotion.

The BAS is a positive feedback system that is activated by stimuli associated with reward or termination of punishment and is arranged to guide an organism toward its goals for survival. Of more relevance to the current study, however are the other two systems, both of which are more involved with behavioral reactions to negative stimuli. The BIS is a system activated by conditioned aversive stimuli, or by novel stimuli (of which could include a picture, for example). The stimuli which most affect the BIS cause a termination of the ongoing behavior, an increase in arousal, and an increase in attention. How this happens, according to Gray, is through a comparator system within the septohippocampal area, which is thought of as continually predicting the next likely event and comparing the prediction to the actual event. If a mismatch is detected, the BIS terminates behavior. Nelson (1994) states that because the BIS is a system concerned with avoiding certain situations, negative affect should correspond with behavioral inhibition (56-57). Other studies show support for Nelson. Notably, a PET study by Reiman, Raichle, Butler, Herscovitch & Roins (1984) found patients with diagnosed panic disorder differ from normals in that their entorhinal cortex and subiculum areas are hyperactivated. Reiman, Fusselman, Fox & Raichle (1989) also found that under conditions of anticipatory anxiety, a non-clinical sample showed bilateral activation of the temporal poles. Another study has found that induced dysphoric states in normals cause activation in the left OFC of men and bilaterally in the OFC regions of women (Pardo, Pardo, & Raichle, 1993). Drevets et al. (1992) observed that those with depression show left OFC activation, left amygdaloid activation, and bilateral caudate activation in comparison to normal controls. A follow up study with the same depressed individuals, this time in remission, showed normal activity in the frontal regions, yet continued hyperactivation in the left amygdaloid area. These findings might suggest that amygdaloid activation is a trait marker, whereas frontal activation is at state marker (Drevets et al., 1992).

The FFS in contrast, is activated by unconditioned aversive stimuli and once activated, results in defensive or escape behavior. Some structures implicated in the FFS are the amygdala, which inhibits the medial hypothalamus, which in turn inhibits a final output pathway in the central gray. Concerning startle potentiation, support for Gray's FFS system can be found in original work by Graham (1979), who found that the eyeblink reflex is actually primitive that serves a protective function (avoiding organ injury) and also as a behavioral interrupt clearing processes to deal with potential threat.

So how must the FFS, BIS, and BAS form the basis for something as complex as temperament? In Gray's hypothesized model, temperament is actually a reflection of individual differences in predispositions to experiencing frequent and common typologies of emotions. The 'parameter value' hypothesis states that the operating characteristics of the BIS, FFS, and BAS determine patterns of emotion and emotion influenced behavior in each individual. Gray (1991) adds another basic assumption about the major dimensions in personality. This is a possible explanation for how temperament is physiologically based: personalities vary in the individual as a result of each individual's unique emotional system activity. Gray's model proposes a place to begin in describing biotemperamental research; for example, predictions can now be made for individual difference research concerned with predicting primed behavioral outcomes like eyeblink magnitude.

In an empirical investigation of Gray's Three-Systems Model, Corr, Tynan, & Kumari (2002) performed two experiments analyzing various personality correlates of prepulse inhibition (PPI) of the startle reflex. The underlying concept of PPI is based on previous findings that acoustic startle reflexes (ASR) are reduced (or inhibited) if the main stimulus is preceded by a weaker stimulus. Here, Corr et al. (2002) were interested in two experimental questions. First, can personality (trait emotionality) differences influence the PPI? The researchers were interested at determining this at three different prepulse-to-pulse intervals, (30, 60, and 120ms). Second, the researchers wanted to determine whether these associations were independent of gender. The personality measures used within this experiment were the Eysenck scales (extraversion, neuroticism, and psychoticism) as well as purpose built measures of Gray's model measuring BIS activity and three subcomponents of BAS activity (drive, fun, and reward reactivity). The BIS and BAS scales were modeled after Gray's theories (previously discussed) of behavioral inhibition and behavioral approach.

What was found by Corr et al. (2002) is rather interesting. First, they do mention that there is a need for further studies in the arena of personality and its effects upon physiological phenomena related to the blink reflex, and general emotional expression. In particular, Corr and his team saw a gap in the research between personality measurement (a psychological construct) and PPI. The results from both experiments indicated that there was a significant negative correlation between the trait neuroticism with PPI at all three intervals. In addition, though not statistically significant, the effect attributed to the BAS-drive (behavioral approach system) approached statistical significance from 30ms to 120ms. The gender interaction with PPI was not consistent across the two experiments, with PPI being significantly lower in females only in the first experiment. Corr et al. (2002) suggests that a possible reason for this may be related to variations across the phases of the menstrual cycle. Being as these studies are correlational, the inferences cannot be causal.

Corr et al. (2002) offer several direct and indirect explanations for their results. Indirectly, the authors suggest, personality dimensions and PPI may be associated by their both being correlated by a third variable, the subjective intensity of the stimuli. Directly, the authors suggest that because PPI can be modulated by attentional factors, individuals that are high in emotionality may be sensitive to ambient reinforcing cues, and may subsequently spend more time on internal thought processes or other environmental stimuli. Thus, the amount of time allocated by these "attentionally impaired" subjects may limit the amount of processing ability for the non-task relevant stimulus, in this case, the prepulse. Corr indicates that this explanation is in agreement by Gray & McNaughton's (2000) proposed neurobiological model for personality.

Grigsby and Stevens (2000), who propose a theory of temperament within their book, *The Neurodynamics of Personality,* maintain the position that temperament has a strong biological component, which reflects both early developmental influences and heritability. They propose the idea that temperament is a property of many different systems that may influence mood, motivational status, short-term emotional status, sleep-wake cycles, arousal, and activity level. Interestingly, Grigsby and Stevens do not discount environmental influences on our temperament, instead proposing that both temperament and environment have impacts upon personality. If this is true, it would be in the best interest of a researcher who is mainly interested in gauging temperamental effects on a given behavior to account for environmental factors that cannot otherwise be controlled. Because Grigsby and Stevens (2000) define temperament as being an emergent property of a self-organizing system, they explain that temperament can therefore also be discussed as a neuropsychological variable. Zuckerman (1995) had proposed that what is actually inherited when we speak of 'inherited personality traits' are the chemical templates that give rise to a certain structure of the nervous system. Elaborating upon Zuckerman, there are also likely to be structural templates that are inherited as well. So what one is actually born with is not a harm avoidant personality per se, but actually a certain template for specific interactions of brain structures and chemical regulators. In this respect, Grigsby and Stevens (2000) conclude that temperament is an abstract representation of the dispositional activity of underlying neural networks. Lang's approach relates to this theory in that Lang refers to emotions as behavioral or response dispositions. So, temperament could be said to be an abstract representation of emotion, emotions being more acute and temperaments being more stable over time. It would be a great advantage to have an in-depth understanding of the physiology of these various networks, the neurotransmitters that work within them, hormones, and the like, in order to more effectively understand what one means when one describes temperament.

There are several other points made by Grigsby and Stevens (2000) concerning the neurodynamics of temperament. First, temperament is not a static property, but is rather influenced by the many different neural networks involved in the activities of the brain; it is referred to in this context as being part of a modular distributed architecture. According to the authors, this is a plausible explanation for the reasons people with a certain temperament may show variability in their expression of a certain characteristic over time. For example, those with highly harm avoidant personalities may not always react strongly to the various negative stimuli they may encounter in their environments. This indicates one of the difficulties and challenges with creating an appropriate experimental design as there is not likely to be a completely perfect consistency in those with high harm avoidance scores and a set eyeblink magnitude. Yet over time, temperament is still relatively stable, as Grigsby and Stevens maintain, and this is likely to be due to the fact that barring any psychotropic influence or other such invasion or trauma to the nervous system, the functioning of this system in normals should still be relatively stable. In addition, the authors suggest that temperament will reflect the probabilistic functioning of the nervous system.

An important question to ask is how a person's temperament affects their reactions to stimuli in the environment and how these different reactions can be classified into types. Before Cloninger's work, theorists during the 1970's and 1980's suggested different models for temperament. Thomas and Chess (1977, 1980), for example, proposed that there are nine stable dimensions of temperament, including persistence, attention span, distractibility, quality of mood, intensity of reaction, stimulation, and interestingly, approach or withdrawal to novelty, among others. In 1975, Plomin had already suggested that people can be classified along just four dimensions, including activity level, impulsivity, sociability, and emotionality. During the same year that Thomas and Chess were proposing nine temperamental dimensions, Plomin revised previous conclusions expanding the original four dimensions to six, dropping impulsivity to include three new dimensions: soothability, persistence, and attention span. Grigsby and Stevens (2000), who have cited these earlier studies, believe that all the dimensions listed may not be entirely independent of one another. This brings in the possibility for the dimensions on the Temperament and Character Inventory (Cloninger, 1992) to have some overlap with these older temperamental models.

Grigsby and Stevens (2000), while acknowledging that these dimensions overlap, also propose that not every individual should be categorized in one specific group or another. Ideally, they maintain, in holding with the hypothesis that there is inherent variability among individuals, the basic components of temperament regulate the individuals' present state and any given time. So one might say that the basic components of temperament and possibly character could regulate the individual's present emotional state, or physiological expression of that emotional state. Some current work in the field of psychophysiology suggests that it does (Corr et al., 1997), with the finding of a relationship between certain types of temperament and psychophysiological reflexes modulated by emotional stimuli. However, methodologically, this hypothesis needs to be repeated. Additionally, repeating the Corr experiment under a more holistic personality model, such as Cloninger's revised 7-factor model, might offer a broader picture of the workings between personality effects and the individual's emotional expression. Studying temperament, with its high levels of intrinsic variability, will be a challenge, however, and part of the purpose of the current research is to help understand whether or not temperament and character variables faithfully modulate physiological reactions, or whether their tendency to vary within individuals (Grigsby & Stevens, 2000) makes it improbable that a single score on a temperament or character scale is able to describe the neural underpinnings of these phenomena.

Recent directions in personality theory suggest a view that personality can be broken down into distinct psychobiological dimensions, suggesting that there are more meaningful distinctions between personality dimensions and mood traits than was previously believed (Svrakic, Przybeck, Whitehead & Cloninger, 1999).

The evolution of personality, according to Cloninger et al., (1993)) involves the ascent of consciousness in two major stages. There are two dimensions to this ascension. First, there are automatic impulses (temperament) that occur in response to basic associative stimuli that ordinarily give rise to basic emotions such as fear, anger, or joy. Temperament is the emotional core of personality and is proposed by Cloninger, Przybeck, & Svrakic (1993) to be related to a perceptual memory system involving corticostriatal projections underlying the processing of affective valence, visuospatial information, and habit formation.

Empirical evidence (Svrakic et al., 1999) is available to show support for the relationship between Cloninger's higher order temperament traits (novelty seeking, harm avoidance, and reward dependence) and the emotions of anger and impulsivity, fear and anxiety, and love and attachment, respectively. Of specific interest to the hypotheses of this study will be the relationship between harm avoidance (HA) and the emotions of fear and anxiety. Svrakic et al. (1999) sought to find support for Cloninger's theoretical relationships between the temperamental traits and emotions by analyzing the relationship between the traits assessed by the TCI (Cloninger, 1991) and mood traits assessed by the Multiple Affective Adjective Checklist-Revised trait form (MAACL R; Zuckerman and Lubin, 1985). In addition, the construct validity of the TCI was assessed. The conclusions drawn from this study correspond to Cloninger's theoretical predictions about harm avoidance, while also supporting the construct validity of the TCI temperament and character dimensions (Svrakic et al., 1999). The Cronbach's alpha for the Harm Avoidance subscale was reported to be 0.88. The MAACL R predicted the following HA subscales: HA1 (anticipatory worry) was predicted by high anxiety (r^2 =

.38) and low positive affect ($r^2 = 0.06$); HA2 (fear of uncertainty) by low sensation seeking ($r^2 = 0.22$), high anxiety ($r^2 = 0.07$), and hostility ($r^2 = 0.04$); HA3 (shyness with strangers) by low sensation seeking ($r^2 = 0.12$), high anxiety ($r^2 = 0.08$), and depression ($r^2 = 0.04$); HA4 (fatigability) by low sensation seeking ($r^2 = 0.20$) (Svrakic et al., 1999). To summarize, Cloninger (1987), Cloninger and Svrakic (1992), and Cloninger et al. 1993 have proposed that basic temperament traits represent heritable emotional dispositions than can manifest themselves as behavioral patterns.

The second part of Cloninger's personality theory involves concrete operations, abstract deductions, and the intuition of basic cognitive schemas (character). Character, in particular, is the "awareness of ones' self as distinguished from other objects," and can be further distinguished along three minor dimensions: self-directedness, self-transcendence, and cooperativeness. As defined in the theory, basic development of character is stepwise, influenced by temperament, experience, intuitive schemas, and preconceptions. This description of personality is similar to Gray's three emotional systems. Cloninger, like Gray, ties in certain brain structures to support his theory of personality supposing that emotionality has an important part in the brain systems that regulate motivated behavior. In 1991, Cloninger developed the Temperament and Character Inventory (TCI) which is a test that evaluates four temperament and three higher-order character traits.

As a corollary to the theory are Cloninger's speculations on the impact of a poorly developed versus evolved personality, with poorly developed character producing individuals who are more susceptible to mental illness versus more healthy individuals that are likely to have optimal character development. Character is not the emotional core of personality per se, but when adequately developed, is likely to aid the organism in using its motivated emotional system to assist in goal directed behaviors. In addition, it is likely to be underactive in individuals with overly-activated fear response systems.

The three dimensions of character are conveniently rooted in a "person as predictor of own environment" orientation. Self-directedness is the extent to which the individual has the ability to act on other objects in the environment to accomplish personal goals, giving rise to hope in the face of challenge. The self-directed individual is very resourceful. Self-transcendence is the extent to which the individual has the ability to forget themselves, to realize that all objects are vital participants in the evolution of all that is whole, and to align the understanding of their environments into a whole, coherent, and meaningful scene. Cooperativeness is the extent to which the individual can identify with other individuals empathically, can give rise to compassion and love for others equally as with oneself.

In addition to Cloninger's basic definitions, character may assess the following variables: goal directed behaviors (Cloninger, 1993), adaptive social functioning (Bond, 2001), propositional learning tasks (Gillespie, 2003), and brain maturity (Cloninger, 1993). These additional variables may allow the construct of character to be measured in experimental designs that are not exclusively focused on personality. For example, character as an individual difference variable might be important for research focused on emotion and emotional processes. The development of character was described above to be stepwise, influenced along the way by temperament, experience, intuitive schemas and preconceptions. Yet once this development is roughly in place, the resulting adult character might be influenced by a number of other brain processes. Are there any online processes which might influence the highly Self-Directed individual, for example, differently than the individual low in Cooperativeness? And what of the individuals who are highly developed in all three character dimensions? It may be interesting to look at the certain variables that character is tapping into, such as goal-directed behaviors, and to see how emotion and emotional processes might impact them. If emotional processes important in goal-directed behaviors can be identified than maybe one could venture to say that differences in individual characters would be affected by the emotional process in question. It is also possible that different aspects of emotional experience (i.e., physiology, expression) are differentially influenced.

Interestingly, current psychopharmacological research might offer support for the suggestion that character is more than just a social-psychological construct removed from the basic physiological level of measurement. Even though the construct of character was originally theorized to have been important for personality psychology, some studies indicate that the character dimensions on the TCI have been significantly correlated with brain-related functions at the physiological level, especially related to neurotransmitter activity (Allugulander et al., 1998; Black & Sheline, 1997; Richter, Eisemann, & Richter, 2000; Tse & Bond, 2001; Chien & Dunner, 1996; Sato et al., 1999). In Cloninger's original model, the character scales were designed with personality description in mind, for use in determining vulnerabilities to psychopathology. Past research focus has been on the personality disorders, but often these psychopathological conditions are mood related. Of course, there are elements of mood regulation even within individual personality disorders, with emotional problems for example in borderline individuals.

The question remains, then, how can the construct of character be expanded to offer a good explanation for these new psychophysiological associations? Could understanding the full definition of character, as it pertains to both the study of personality and psychophysiology have importance? If so, what might be the links between the two, when speaking of character? One possibility is human emotional regulation. For example, from a physiological standpoint, one might feel it is possible that individual differences in emotional functioning, such as the way in which an individual regulates emotion or the degree to which one reacts to emotional stimuli in the environment, might have an effect upon higher-order processes like the expression of goal-directed behaviors, how one cooperates interpersonally, and how adjusted one is, or how one cooperates with the environment at large. Often, how these higher order psychological variables are expressed has a direct impact upon quality of life, and usually, character patterns that are in a good working partnership with the environment are most adaptive. But is there a model that might reflect the broader idea that emotional functioning affects higher order environmental adjustment? There is, in fact, but before the theoretical model is introduced, it is important to outline the research supporting the expanded definition of character, which includes interesting findings at the neural level.

Bond (2001) hypothesizes that social adaptation is related to the character dimensions measured by the TCI, which may be linked to serotonergic function. Whereas the temperament factors of the TCI have been said to be heritable (Cloninger, 1987), the character dimensions are not supposed to be, according to the original theory. Evidence from studies in molecular genetics shows that the character traits of Self-Directedness and Cooperativeness are associated with the serotonin transporter 5-

HTTLPR (Hamer, Greenberg, Sabol & Murphy, 1999). These associations are higher than those for the temperament trait Harm Avoidance (HA). However, due to the often contradicting findings in molecular genetic studies and personality (Plomin & Caspi in Pervin & John, 1999), it is likely that a complex interaction among several genes is involved in the expression of individual character traits.

A collection of studies interested in the relationship between the personality dimensions of the TCI and neurotransmitter functioning, have found, in addition to the traditional serotonin-Harm Avoidance link, that the character dimensions are also affected in psychiatric populations. For example, Allugulander, Cloninger, Przybeck & Brandt (1998) showed that in populations diagnosed with generalized anxiety disorder (GAD), treatment with the drug paroxetine, a selective serotonin reuptake inhibitor (SSRI), Harm Avoidance (as predicted) decreases and Novelty Seeking increases. Interestingly, however, there were also increases in the character dimensions of Self-Directedness (SD) and Cooperativeness (C). In another study looking at serotonergic antidepressant therapy on unipolar depression, Black and Sheline (1997) found an increase in SD and C, which paralleled an overall improvement in depressed mood.

In non-psychiatric populations, similar results have been found for the character scales. Tse and Bond (2001), in a placebo study, report that positive character changes can occur in healthy adults, without the confound of depressive illness. Twenty male volunteers were tested pre and post citalopram (an SSRI) or placebo. While Tse and Bond did not find any changes on the temperament dimensions, an increase in SD occurred after citalopram.

The specific relationship between serotonin and the TCI was also tested in a between subjects, cross-sectional study (Peirson et al., 1999) using healthy volunteers. These researchers focus on the correlation between EC_{50}, a 5-HT_2 receptor sensitivity index, and the TCI scores. Using this index is a way to assess serotonergic functioning by using blood platelets as a neuronal model. The key relationship is that lower EC_{50} levels are an indication of higher 5-HT_2 sensitivity. In addition, Harvey (1997) proposes that this particular receptor's sensitivity is related to central basal serotonin levels. In this study, an inverse correlation between HA scores and EC_{50} ($r = -0.64$) was found, which is in accord with the previous research supporting the relationship between serotonergic deficiencies and high HA scores. Remarkably, Self-Directedness (SD) was significantly positively correlated with EC_{50} If it is true that the serotonin sensitivity index is related to basal serotonin levels, then, high basal serotonin levels should theoretically correlate with high SD. Additional significant correlations were found for the SD subscales (SD1, responsibility) and (SD2, resourcefulness), suggesting that these two traits are related to low 5-HT_2 receptor sensitivity.

In summary, a few studies investigating the functioning relationship between certain neurotransmitters and the temperament scales of the TCI have also found significant evidence that the character scales are influenced by different neurotransmitter effects. Both neuropsychological studies, supplemented with certain psychophysiological measures such as EEG and ERP, and psychophysiological experiments in their own right have found interesting relationships between certain character profiles and psychopathology, attentional functioning, and the P300 wave.

Bergvall, Nilsson, & Hansen (2003) recently investigated the task of attentional set shifting in relationship with personality variables. The results show that poor development of certain personality traits, including those related to the character dimensions of Self-Directedness (SD) and Cooperativeness (C) are associated with deficits in neuropsychological functioning. The population of interest in this study was a group of incarcerated offenders convicted for serious violent crimes. Executive tasks, such as attentional set shifting require prefrontal cortex processing as do many personality dimensions. It has also been established in the literature that prefrontal damage changes aspects of personality (Damasio, Tranel & Damasio, 1990; Eslinger, 1998). Importantly, prefrontal damage is also associated with emotional reactivity, especially with asymmetries in resting anterior EEG activity (left activation associated with positive affect) (Wheeler, Davidson, & Tomarken, 1993). Briefly, attentional set shifting tasks require the individual to shift attention across perceptual domains. The process can be divided into two types: extra-dimensional (i.e., shift from shapes to lines) and intra-dimensional (from one shape to another). Each of these two tasks is controlled in different areas of the prefrontal cortex. Bergvall et al. (2003) found that the group with the lowest SD and C scores made more dimensional shift errors. This group was, in fact the group that tested in the clinical range for antisocial personality disorder (PD). The PD group was especially impaired in the extra-dimensional shift task.

The authors speculate that the personality profile of the population under study, highly Harm Avoidant, combined with low SD and C, is similar to the high negative emotionality/low constraint profiles in other studies with violent offenders (Caspi et al., 1994). This evidence might predict an interesting connection to emotion: even though the Global Personality Function (GPF) scale in both offspring of schizophrenics and controls was found. Individuals with higher GPF scores have maladaptive personality traits that impair social, emotional, and occupational functioning (Squires-Wheeler, Friedman, Skodol & Erlenmeyer-Kimling, 1993). These traits seem to be similar to those who are low in Self-Directedness, according to the Cloninger model. From this study, the authors speculate that information processing and attendant behavior may be conditioned and modified as a result of changes in the significance of stimuli, determined by developed concepts of identity, as reflected in Self-Directedness levels (Cloninger, 1993). So this evidence offers tentative support for the hypothesis that there is some sort of physiological undercurrent for character. This then leads to the link between character and emotion. Are the character dimensions of the TCI indirectly influenced by or associated with emotional phenomena, and if so, what is the nature of these phenomena?

The character dimensions of Self-Directedness, Cooperativeness, and Self-Transcendence are said to reflect goal directed behaviors (Cloninger, 1993). As such, those with poorly developed character may have difficulty achieving their goals, or might not achieve goals at all. It would therefore be logical to identify the factors which may optimize goal achievement, and to see if it is plausible that these factors are emotional in nature.

Parallel to the theory of Lang and colleagues, Carver and Scheier (1999) propose that goal directed behaviors are the end result of a complex interaction between actions and feelings. The basic theory can be pictured with two important loops, the action loop and the secondary affect loop. The purpose of the action loop is to achieve goals, thus, behaviors are initiated with the end goal as the result. The purpose of the secondary affect loop, however, is to monitor the progress of the action loop. The result of this assessment is a nonverbal sense of positive or negative feeling, depending upon whether or not the goal has been achieved.

Carver and Scheier (1999) are also in agreement with Lang and colleagues when they propose that the origins of positive and negative feelings are in two basic psychological systems, the approach system and the avoidance system. Approach systems, according to Carver and Scheier however are termed discrepancy reducers, that is, when they are working, the goal is attained leading to positive affective states. Similarly, when not working, the approach system is not able to reduce discrepancies between the behavior and goal, resulting in a general state of negative affect. The second system, or the avoidance system, is a discrepancy enlarger, working to enlarge the differences between the goal and the behavior. Again, when this system is working, positive affective states result and when discrepancies cannot be enlarged, negative affective states result.

As acknowledged in Perugini & Bagozzi (2001) above, there is support for the connection between the differentiation of positive and negative affect in anticipated emotions, and the effects these emotions have on goal-directed behaviors, with similar physiological differentiations in emotional reaction research. The research that is concerned with the physiology of emotional reactions is based on a two-system theory of approach and avoidance. For example, Lang has hypothesized that different organisms have different 'behavioral dispositions' which are most likely influenced by underlying neural circuits. These circuits are part of the phylogenically older primitive cortex, mid-brain, and subcortical structures, and are activated by unconditioned aversive and appetitive stimuli (Lang, Davis, & Ohman, 2000). Emotions experienced by the organism "dispose" the organism to act; for example, to flee an aversive stimulus, or to engage in an alternate action. One of first studies exploring the hypothesis has attempted to study the action of the organism using an acoustic probe: "…the magnitude of the acoustic startle reflex in human beings is modulated both by an immediately preceding stimulus…and by the emotional context in which the startle-evoking sound occurs" (Lang et al., 2000).

These differences in behavioral dispositions may also affect goal achievement capabilities. Though the exact relationship between these psychological and physiological approach/avoidance systems is not clear, theoretically, the ideas behind them and the behaviors they initiate are very similar. It could be worth investigating more thoroughly how the approach/avoidance systems within personality (Carver & Scheier, 1999) are related to the approach/avoidance systems in emotion that are influenced by underlying neural circuits (Lang et al., 2000). Part of the connection might be through the scientific study of the newly expanded construct of character.

To summarize, lower character scores might be associated with deficiencies in the approach/avoidance systems, as well as poor monitoring or even a malfunction of the affect loop. Emotion researchers interested in defining the approach avoidance system would do well to inform future studies with individual differences in personality, as has been done with the temperament scales of the TCI.

To venture a step further with this theoretical direction one can look at a second definition of character, the proposition that character variables reflect adaptive social functioning. One of the key words in this construct is *adaptive*, because each of the emotion systems thus far mentioned have been adaptive, lending a similar theoretical origin for character. If character might be seen as adaptive, is its optimal functioning contingent upon certain brain processes? The nature of these brain processes, of course, has not yet been studied because traditionally character was not thought of as having a direct (translation: measurable) physiological basis. To date, no research has looked at the nature of the adaptive qualities of character at the neurophysiological level.

So how would one propose the character dimensions to be linked to physiological measures in emotion? If the three character dimensions reflect adaptive social functioning, it may be assumed that deficiencies in character scores on the TCI may be correlated with less success in achieving one's goals, (or, rather, a malfunction in Carver & Scheier's (1999) loop system). A general state of negative affect is the result of these goal system malfunctions at the psychological level. If it were possible to operationally define goal achievers versus non achievers, the differences between how these two groups interact with their environments might be different. It could be speculated that baseline differences in any psychophysiological variables would be found. It may not be wise to even categorize these individuals, but maybe by placing them on a continuum, a trend might appear that those with less developed characters would show a certain pattern of characteristics.

The process of achieving goals falls on a continuum. Those at the higher end of the continuum are more likely to be successful at initiating goal-directed behaviors and achieving goals. These individuals would be more likely to display positive affect, as well as higher character scores, higher serotonin levels, be less prone to anxiety and depression, have better attentional set-shifting/executive functioning capabilities, and normal P300 levels. In contrast, on the low end or non-achieving side of the continuum, individuals might be more prone to negative affect, lower character scores, serotonin abnormalities, higher levels of subjective anxiety and depression, disruptions in executive functioning and attention, lowered P300 levels, and a generally overactive avoidance system. To the extent that these characteristics are valid, individuals across the continuum would be expected to differ in their responses when tested in the startle probe paradigm for reactions to emotional stimuli.

Cloninger's Temperament and Character Inventory (TCI) is a scale that has been created based on a psychobiological model of personality with the purpose of measuring temperament and character dimensions. Derived from the Tridimensional Personality Questionnaire (TPQ), developed in 1987, the TCI has since been modified to fit conceptual changes in the theory (e.g., Cloninger, 1993). The revisions improve self-report evaluations of personality and its disorders in general as well as clinical population samples (Svrakic et al., 1999). There are 240 items in the actual measure, with seven basic higher order scales broken down into 25 subscales (12 for temperament traits, 13 for character traits). Specifically there are 4 dimensions on the Harm Avoidance scale made up of 35 items. HA1 (11 items) measures worry and pessimism vs. uninhabited optimism, HA2 (7 items) measures fear of uncertainty, HA3 (8 items) measures shyness vs. gregariousness, and HA4 (9 items) measures fatigability vs. vigor. Svrakic et al. propose that the structure of temperament (as used in deriving the items on the TCI) can be inferred from other psychometric and genetic studies of personality in humans and also from neurobiological studies involving classical and operant responses to appetitive and aversive stimuli in humans and mammals (250). Behaviorally, temperament is defined as how the individual reacts to novelty, danger and reward. Of interest to the motivated emotion hypotheses discussed within Lang's research and studied through experiments measuring potentiated fear reflexes is the Harm Avoidance dimension, defined by Cloninger as a heritable bias in the inhibition or cessation of behaviors related to fear and anxiety.

The second variables of interest, the character scales, are also important to look at within this research paradigm because they have not yet been empirically studied within a startle response paradigm before. Also, theoretically, deficiencies in character scores might be associated with similar deficiencies in the approach/avoidance system and adaptive social functioning.

Research Questions

Because of the potential usefulness of knowing more about the role of temperament and character in the startle response, it is the aim of this research to test the following hypotheses. First, it is predicted that there will be an increase in the startle response for negative picture conditions as opposed to positive or neutral picture conditions. Specifically, from positive to neutral to negative picture conditions, increasing blink magnitudes are expected. This hypothesis is an attempt to replicate the results found by Lang and colleagues that suggests negative emotional states can potentiate the startle response (Lang, 1993, 1994; Lang et al., 1997) Confirming this hypothesis will provide a manipulation check for the startle modulation paradigm. Second, it is predicted that subjects will rate negative pictures more negatively than positive or neutral pictures as well as rate the positive pictures more positively than negative or neutral pictures. This will provide a second manipulation check, verifying whether or not each subject perceived the pictures accurately according to the IAPS normative sample. Third, it is predicted that viewing times on the IAPS task will be greater for the negative picture condition. Although the IAPS procedure is a rating task, an additional factor, differences in viewing time, will be able to demonstrate that subjects take longer to look at negative pictures versus the positive or neutral condition. Fourth, it is predicted that there will be a positive, linear correlation between the average maximum blink magnitude recorded during the negative condition and the TCI subscale of Harm Avoidance, which would support the results found by Corr et al., (1997). Fifth, if the relationship between character scores and physiological variables is viable, as described above, then it is predicted that there will be a negative linear relationship between the character subscale scores and average maximum blink magnitude during the negative condition. Thus, those with lower scores on the character subscales will have higher startle responses in the negative picture condition.

To answer these questions, an experiment was carried out in which participants first viewed a series of pictures representing different categories of emotion including positive, negative, and neutral. The pictures were designed to elucidate each type of emotion. While viewing the pictures, the subjects heard a loud stimulus sound through headphones which was designed to induce the startle reflex. The component of the reflex that was measured was the magnitude of the characteristic "eyeblink." This experiment was designed to answer the question of whether emotion modulates the startle reflex, specifically, whether negative emotions increase the magnitude of the eyeblink. To demonstrate that the subjects were perceiving the pictures as positive, negative, or neutral, a computerized self-ratings task was used during which each subject was asked to rate the pictures on 3 dimensional levels (i.e., positive to negative, high arousal to low arousal, and high dominance to low dominance). This ratings task also included data on viewing time for each subject, which was analyzed separately. To answer the questions of whether or not those individuals with certain personality characteristics (increased Harm Avoidance, lower Character scores) have increased blink magnitudes during the emotion-modulated startle reflex, each subject was asked to complete the computerized version of the TCI. Physiological data were then compared with personality data.

Method

Subjects

Based on power analysis for medium effect size, (Cohen et al., 1988) the goal was to recruit 85 subjects. After data screening and considering missing data, 83 subjects were entered into the measurement of emotion modulated startle (average maximum blink magnitude). These data were analyzed with PSYLAB (Contact Precision Instruments, London, UK) analysis software. 73 subjects were entered into the IAPS analysis, and 78 subjects were entered into the analysis correlating average maximum magnitude data and TCI data. Demographic data are presented in Table 1 for the sample that underwent all three analyses (N=73). Subjects were undergraduate students above age 18 recruited from The California State University, San Bernadino. Recruitment method followed a standardized protocol for human subject research at CSUSB. Participants signed up for 5 extra credit points for participation. Each participant was given a written informed consent document to sign, indicating they understood risks and benefits for participation.

Table 1

Sample Demographic Data

Analyses	***PSYLAB, IAPS, TCI***
N	**73**
Males	**15**
Females	**58**
Average Age	**26.06**

Stimuli

Picture stimuli were pictures selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1994) on the basis of the normed ratings for affective valence using the Self Assessment Manikin (SAM; Lang, 1980). Each picture was selected on the basis of its membership in the positive, negative, or neutral category (Appendix A). In order for each of the three emotional conditions to be represented validly, the pictures rated most negative, most positive, and most neutral were selected. Additionally, positive and negative pictures that were most arousing and neutral pictures that were not arousing were selected, to increase the potential for each emotion to be more accurately represented during the experiment. A list of each picture and its corresponding ratings data is provided in the Appendix. Based on prior research by Lang et al., (1993) 33 pictures, (11 from each valence category) were assigned. Each trial began with the onset of a picture that was presented for 6 seconds on a computer screen in front of the subject. Each picture was presented in a pseudo-random order, meaning that within valence categories even numbered pictures were assigned to a place in the presentation order, and after 20 subjects, they were replaced by odd numbered pictures.

Auditory stimuli were heard binaurally through a headphone set with each headphone covering the entire ear. Auditory stimuli were 50ms bursts of white noise, each at 100 decibels. Startle responses were elicited on trials 1-4, 6-7, 10-12, 14-17, 19-20, 22, 24, 25-26, 28-29, and 31-33 by the white noise stimulus presented 4.5 seconds after picture onset. This design resulted in an 8 positive, 8 negative and 8 neutral pictures probed for a startle response, 24 in total. The time between trials, defined as the Inter-trial Interval (ITI) was 15 seconds. The white noise stimulus was also presented during six inter-trial intervals after trials 2, 8, 14, 20, 26, and 32. In all, twenty four startle responses per subject were recorded.

Procedure

Blink Magnitude

In order to measure eyeblink magnitude, each subject was asked to look upwards while two electrodes were attached under the right eye. The center of each electrode was placed approximately 12-13 mm apart. A third ground electrode was placed behind the left ear. The purpose behind this standard arrangement of electrodes in affective startle response research is that the measurement of interest is the muscle activity of *orbicularis oculi, pars orbitalis*. To measure the post-auricular reflex, two electrodes were placed behind the right ear, and the ground electrode was placed on the top of the dominant hand. All physiological data were collected using the Psylab system (Contact Precision Instruments, London, UK). Electromyogram (EMG) from orbicularis oculi and the post-auricular muscle were first bandpass filtered online between x and y Hz, then digitized (16 bit) and recorded at 1000 samples per second

Next, the subject was instructed that a series of slides would be presented, and that each slide should be viewed for the entire duration that it was presented on the screen. They were also advised to imagine while they were viewing each image that they were encountering what was in the picture. They were told that an occasional noise on headphones would be heard, but to ignore it.

Picture Ratings

Each subject, upon finishing the first viewing of the pictures while their blink reflexes were being recorded, was then instructed to remove all electrodes and the headphones. The examiner then instructed them on the second part of the experiment in which each picture was rated using a system based on the Self-Assessment Manikin (SAM) (Hodes, Cook, & Lang, 1985; Lang, 1980). The SAM is used to assess subject self report to each picture on three dimensions: valence, arousal, and dominance. These ratings were used as an index of the subjects' emotional reactions. The subjects were allowed to view each picture for as long as they desired-the time collected as viewing time. Next, each subject was asked to rate each individual slide on three likert-scale variables: pleasant to unpleasant (valence), calm to excited (arousal), and controlled to in-control (dominance). All data, including slide viewing times, and ratings from 1-9 on each variable were recorded using E-Prime software (Schneider, Eschman & Zuccolotto, 2002). After screening outliers, averages for each subject, and finally, the grand averages for reaction time, valence, arousal, and dominance were calculated in Excel. This data was transferred to SPSS version 10.0 for analysis.

Lang used this system to rate the IAPS because it has high internal consistency between mean ratings of valence and arousal. Split-half coefficients for valence and arousal dimensions ($p < .001$) for pencil and paper ($R = 0.94$) and for computer administration ($R = 0.94$) are very high (Lang, 1997). Using the interactive computer SAM instrument, it was found that the rating for a subset of pictures were similar to the same pictures presented in an earlier experiment for mean valence ratings ($R = .99$) and mean arousal ratings ($R = 0.97$). T-tests revealed no significant differences in picture valence or arousal means across studies (Lang, 1997).

TCI

The computerized version of Cloninger's Temperament and Character Inventory Version 9 (Cloninger et al., 1994) was used in this study. Each subject was asked to respond to a 240 item true-false computerized questionnaire. They were specifically instructed to answer each question, which could describe opinions, likes, dislikes, feelings, etc in a way that generally best describes them. The TCI provided data for all seven scales, which were automatically produced as T scores for each of the scales and subscales which were used in the data analyses.

Data Analysis

Screening

Psychophysiological data. Using analysis routines in Psylab, the EMG data for each trial were rectified and the maximum blink amplitude within a window from 20 to 100 ms after the stimulus onset was recorded. Per subject, there were 29 startle trials. Because the startle response undergoes significant habituation across the initial trials which varies considerably across individuals, the first three startle trials for each subject were omited from analyses leaving a total of 27 trials for analysis. For each subject, the maximum amplitudes for each trial were then converted to z scores. Because each score was based on n=27, outliers were determined to be those trials with z scores of 2.0 or greater. Each score was then converted to a T score, for easier comparison with the TCI data. There was no missing psychophysiological data. The final blink magnitude average T-score within each of four categories (positive, neutral, negative, ITI) for each subject was used for the primary analyses.

TCI data. The TCI data consisted of T scores for each of the seven personality variables as well as their respective subscales. All data was analyzed in SPSS version 10.0 for homogeneity of variance with Levene's test. Normality, skewness, and kurtosis were analyzed with histograms. There were no missing TCI data, however, for several subjects the TCI did not produce a report, and the data for these individuals was lost.

Picture-Rating data. The SAM data consisted of four variables, reaction time (in milliseconds), valence, arousal, and dominance ratings. The mean value for each of these measures was computed for pictures groups by the a priori valence categories. These means were used in the analyses.

Results

Research Question 1: Emotion Modulation of the Startle Reflex

To determine if viewing pictures from positive, neutral, and negative valence categories produced effects on the average maximum magnitude of the startle response, a one-way repeated measures ANOVA was conducted. The 3-level within subjects factor was defined as valence category. A significant linear trend was found across the valence categories $F(1,82) = 4.2$, $p < .05$, $\eta^2 = .049$ (Figure 1) indicating that the mean startle response was smallest in the positive picture condition and greatest in the negative.

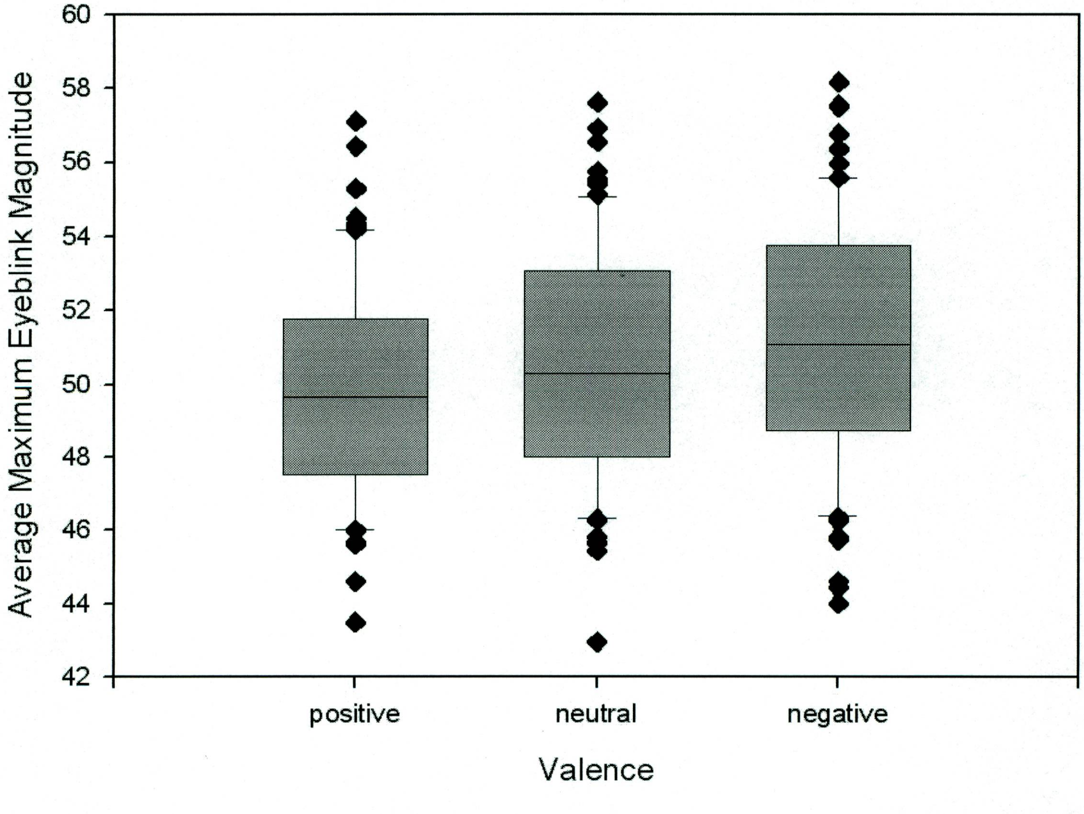

Figure 1. Emotional modulation of the startle reflex. A significant linear trend was found across the valence categories $F(1,82) = 4.2$, $p < .05$, $\eta^2 = .049$. Mean startle response (magnitude expressed as a T-Score) was smallest in the context of positive pictures and greatest for negative pictures. Error bars represent standard deviations.

Research Question 2: Picture Ratings

Three *t*-tests were conducted to determine if subjects rated the images differently than the normative sample on valence, arousal, and dominance (Table 2). There were significant differences between the current sample and the normative sample for positive valence, positive, negative and neutral arousal, and positive, negative, and neutral dominance. The current sample rated the positive picture condition significantly lower in happiness and arousal than the normative sample and the neutral and negative picture conditions significantly higher than the normative sample. On dominance, the current sample rated the positive and neutral picture conditions as significantly lower than the normative sample, but the negative picture condition higher than the normative sample.

Table 2

IAPS Ratings: Mean Differences Between Samples

	Current		**Normative**		
	Mean	**SD**	**Mean**	**SD**	***t***
VALENCE					
Positive	**6.94**	**1.07**	**7.58**	**.34**	**-5.29****
Neutral	**4.97**	**.95**	**5.05**	**.16**	**-.73**
Negative	**1.97**	**1.13**	**1.98**	**.43**	**-.025**
AROUSAL					
Positive	**4.96**	**1.35**	**5.74**	**1.28**	**-5.15****
Neutral	**4.52**	**1.01**	**3.65**	**1.60**	**7.60****
Negative	**6.66**	**1.39**	**6.02**	**.81**	**4.06****
DOMINANCE					
Positive	**5.29**	**1.31**	**5.90**	**.64**	**-4.20****
Neutral	**4.86**	**.99**	**5.59**	**1.01**	**-6.50****
Negative	**4.18**	**1.71**	**3.07**	**.51**	**5.77****

**$p < 0.05$

To investigate the general trends of the data in this sample, 4 parallel, repeated measures ANOVA's were conducted using viewing time and the valence, arousal, and dominance ratings as dependent measures with the a-priori valence category as the single repeated factor with three levels: valence, arousal, or dominance. A significant quadratic trend was found for viewing time (Fig. 2), $F(1,72) = 11.09$, $p < .001$, $\eta^2 = .133$. Participants' self-paced viewing times for both positively valent and negatively valent pictures were longer than neutral pictures. This result replicates the common result for IAPS viewing times in which viewing times are associated with the arousal value of the image (reference). Second, a significant linear trend $F(1,78) = 691.03$, $p < .001$, $\eta^2 = .899$ was found for valence rating as well as a significant quadratic trend $F(1,78) = 20.116$, $p < .001$, $\eta^2 = .899$ (Fig. 3). Participant's reported higher levels of subjective happiness when viewing the positive slides, lower levels for neutral slides, and the lowest levels of happiness (or highest levels of sadness) when viewing the negative pictures. Third, a significant linear trend $F(1,78) = 67.79$, $p < .001$, $\eta^2 = .465$ was found for arousal rating (Fig. 4) In addition, a significant quadratic trend $F\ (1,78) = 137.25$, $p < .001$, $\eta^2 = .638$ was also found for arousal rating. Subjects rated the negative pictures as highest in arousal. The positive pictures, which have been similar to negative pictures on arousal levels in previous research (source), were more similar to the neutral pictures in arousal. Hence the expected U-shaped graph that has been found for self-reported arousal in the IAPS ratings system was slightly distorted. Finally, a significant linear trend $F(1,78) = 14.89$, $p < .001$, $\eta^2 = .160$ was found for dominance rating (Fig 5). Subjects felt more in-control when viewing positive pictures and least in control (or the most controlled) while viewing the negative pictures.

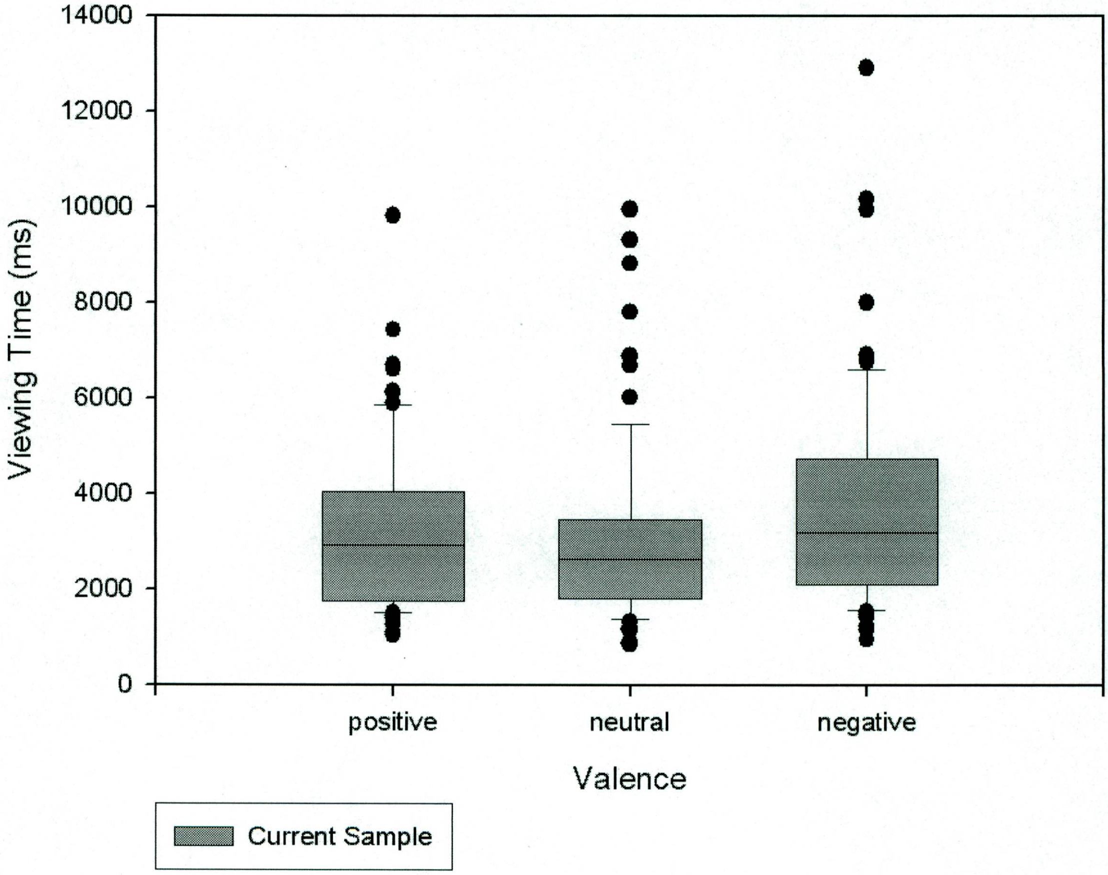

Figure 2. Average viewing time, all subjects per valence category. A significant quadratic trend was found for viewing time $F(1,72) = 11.09$, $p < .001$, $\eta^2 = .133$. Participants' self-paced viewing times for both positive and negative pictures were longer than neutral pictures. Error bars represent standard deviations.

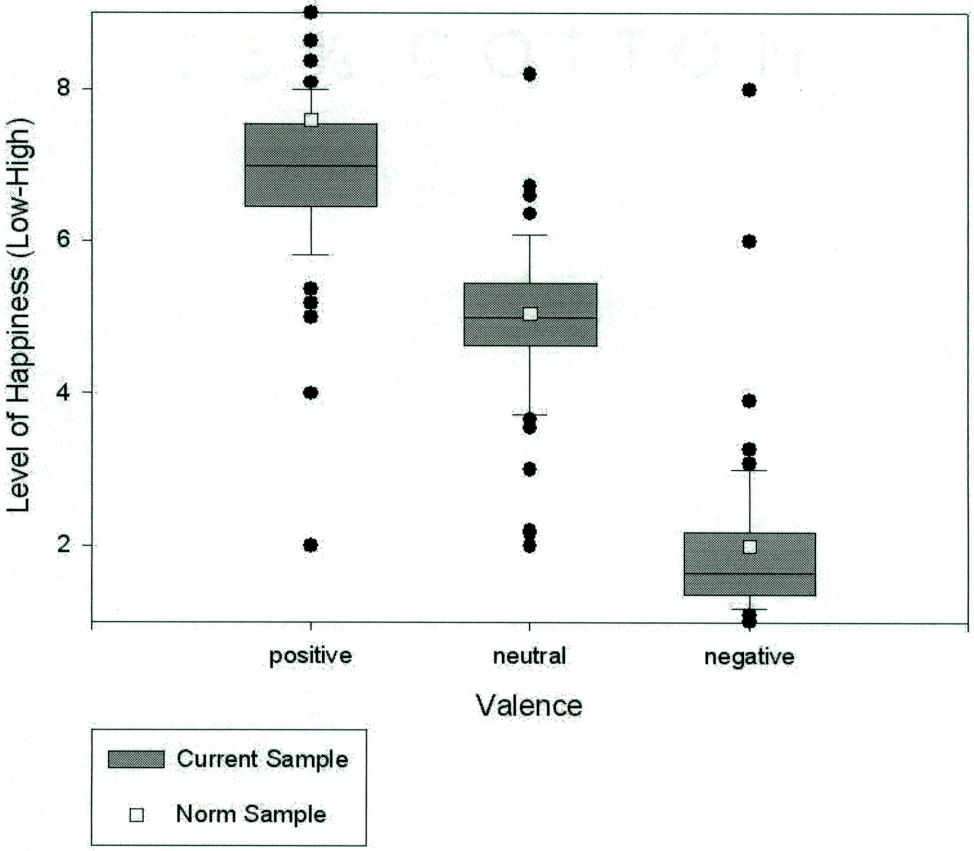

Figure 3. Average valence ratings, all subjects per category. A significant linear trend $F(1,78) = 691.03$, $p < .001$, $\eta^2 = .899$ was found for valence rating as well as a significant quadratic trend $F(1,78) = 20.116$, $p < .001$, $\eta^2 = .899$. Participant's reported higher levels of subjective happiness when viewing the positive slides, lower levels for neutral slides, and the lowest levels of happiness when viewing the negative pictures.

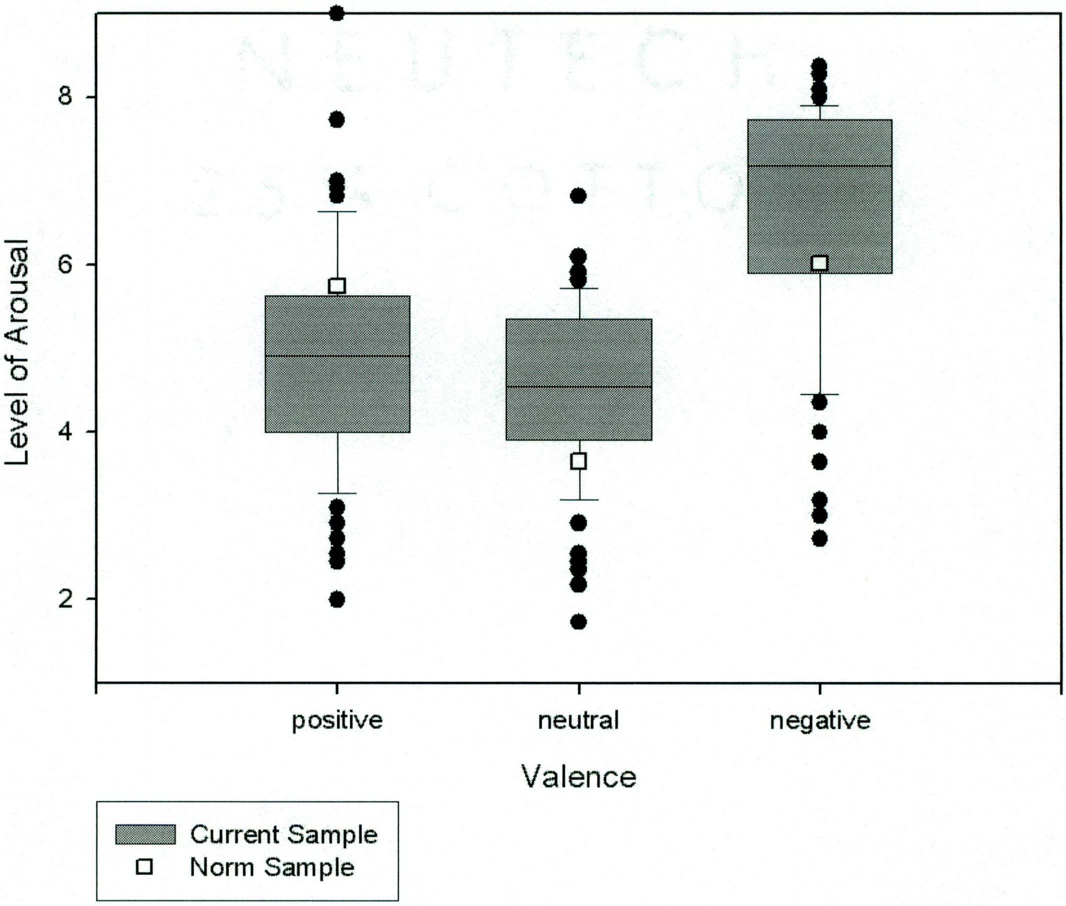

Figure 4. Average arousal ratings, all subjects per category. A significant linear trend $F(1,78) = 67.79$, $p < .001$, $\eta^2 = .465$ was found for arousal rating. In addition, a significant quadratic trend $F\,(1,78) = 137.25$, $p < .001$, $\eta^2 = .638$ was also found for arousal rating. Subjects rated the negative pictures as highest in arousal.

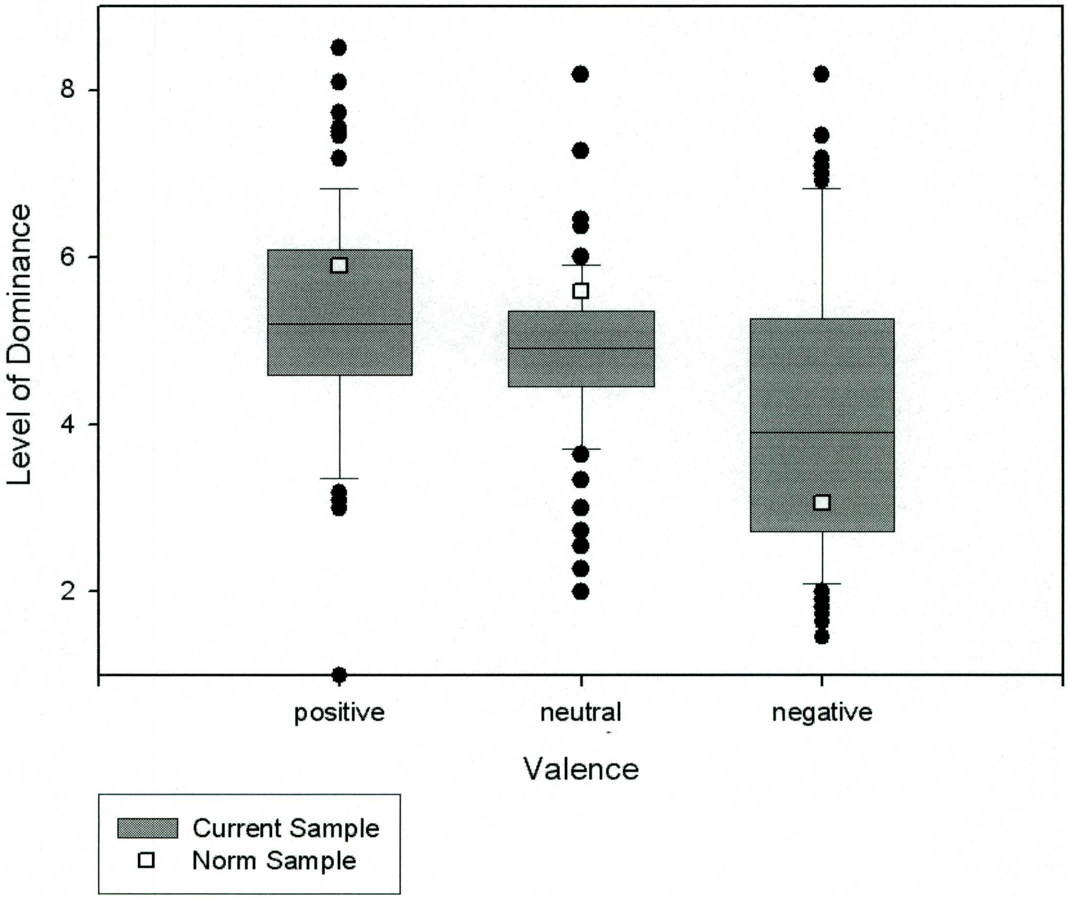

Figure 5. Average dominance ratings, all subjects per category. A significant linear trend $F(1,78) = 14.89$, $p < .001$, $\eta^2 = .160$ was found for dominance rating (Fig 5). Subjects felt more in-control when viewing positive pictures and least in control (or the most controlled) while viewing the negative pictures.

Research Question 3: Comparing Harm Avoidance and Average Maximum Magnitude

A one-tailed bivariate correlation was conducted to determine if there was a significant positive linear correlation between Harm Avoidance and average startle response magnitude evoked during negative valence images. This relationship was not found to be significant. $r^2 = .021$, $r = 0.15$. Subjects who scored high on Harm Avoidance did not necessarily have a higher average startle response magnitude while they were viewing the negative valence images.

Research Question 4: Character Variables

A correlation analysis was conducted to determine if there was a significant relationship between average startle response magnitude and the three TCI character variables of Self-Directedness, Cooperativenss, and Self-Transcendence, (Table 3). The three character variables were entered in as predictors and the criterion was the average startle response magnitude. All Pearson correlations were negative, except in the neutral valence condition, and none were significant. Level of character scores was not found to be significantly associated with average startle response magnitude.

Table 3

Correlations of Character Variables and Average Maximum Magnitude, 3Conditions

	PosMag	NeutMag	NegMag	SlfDirect	Cooperat	SlfTrans
PosMag	**1.00**	**-2.68****	**-.41****	**-.04**	**-.12**	**-.05**
NeutMag	**-**	**1.00**	**-.39****	**.02**	**.13**	**.08**
NegMag	**-**	**-**	**1.00**	**-.07**	**-.09**	**-.05**
SlfDirect	**-**	**-**	**-**	**1.00**	**.51****	**-.03**
Cooperate	**-**	**-**	**-**	**-**	**1.00**	**.19***
SlfTrans	**-**	**-**	**-**	**-**	**-**	**1.00**

Note. PosMag=positive magnitude; NeutMag=neutral magnitude; NegMag=Negative Magnitude; SlfDirect=Self Directedness; Coop=Cooperativeness; SlfTrans=Self Transcendence
**$p < .01$. *$p < .05$

Discussion

The objective of this research study was to both replicate and explore the effects of individual personality differences on the human startle response, in the context of an emotionally charged experimental situation. As such, the study can be broken down into several research questions. The first question investigates the effects of emotionally charged pictures on the startle reflex, which has been frequently studied in the psychophysiological literature (Corr et al., 1996, 1997, 2002; Lang, 1993, 1994; Lang et al., 1997, 2000; Vrana et al., 1988). The consensus of this literature is that emotions do modify the startle response in humans. In this study, it was found that across valence categories, the startle response significantly increased from positive to neutral, and finally was highest during negative picture conditions. This implies that when subjects view stimuli designed to provoke negative feelings such as fear, they will respond to auditory stimuli from the environment in the form of a heightened reflexive response, in this case quantified by eyeblink magnitude. These results support a long line of literature that suggests emotions can and will affect physical processes.

The second research question attempted to determine if there was a significant relationship between the personality variable Harm Avoidance and average maximum blink magnitude. High scorers on Harm Avoidance, as defined by Cloninger's theory, tend to be worrying and pessimistic, fearful and doubtful, shy, and fatigable. Low scorers tend to be relaxed, optimistic, bold, confident and outgoing. Theoretically, those individuals who have higher Harm Avoidance scores might be also prone to heightened startle responses. Empirically, the relationship between high Harm Avoidance and increased startle response has been supported by Corr's research (1997). Whereas Corr and colleagues found a significantly higher startle response in individuals who scored high on the Harm Avoidance, the current results, which looked at the relationship between startle magnitude and Harm Avoidance, did not find a significant relationship. The fact that the significant correlation of this relationship could not be demonstrated in the current study is interesting, and could have several explanations.

First, Corr's study in 1996 did not find significant relationships between Harm Avoidance and startle response. It was only in the replication study (1997) that the findings were significant. The explanation for this is that during the former study, the amplification gain control was not held constant and was in fact altered for every subject. In the latter study, the gain control was held constant at 3, thus allowing for individual differences to show up. Also, Corr et al. (1997) maintain that the strongest startle responses to negative stimuli likely occur during the first blocks of stimuli and rapidly dissipate afterwards. In this study, as in the replication study (Corr et al., 1997), there was one block of stimuli with a randomly determined order of positive, negative, and neutral slides. Yet, there was still no effect found for individuals high in Harm Avoidance.

There are two methodological differences between this study and Corr's previous study (1997). First, the dependent measure in this study was magnitude wheras Corr's study reported amplitude. Amplitude is a measurement that incorporates only those trials that have actual blinks, and does not take into account trials without blinks, and therefore, a measure of zero is impossible. Magnitude, however, is a measure that takes into account both trials with a blink response and those without, and thus a trial with magnitude equal to zero is entirely possible. It is thought that magnitude might be a better measure when considering the design of the current experiment, which is considering the startle response data on a continuous scale. Thus, including measurements of zero might be a truer reflection of the continuous nature of the data and rather than eliminating these trials, including them is a better way of understanding differences between individuals. If a particular individual is not responsive to startle stimuli at all, this data remains individual difference data. Despite these arguments, the data from the current study would need to be recalculated using the outcome variable of amplitude to settle this question.

The second difference between this study and the previous research designs is that a median split MANOVA data analysis procedure was used in the previous research. The current study used a correlation matrix during statistical analysis. It is not likely that the median split MANOVA made a large difference in the results of Corr et al. (1996) however. To verify the usefulness of the median split MANOVA in the current data set, the analysis was repeated using the exact same statistical procedure to determine if a median split MANOVA caused differential results. This procedure did not reveal any significant differences between those grouped "high" in Harm Avoidance and those grouped "low" with the outcome variable of startle response magnitude.

The current findings could be also explained by the differences in samples. For example, it is entirely possible that the significant findings of Corr et al. (1997) reflect a population that contained more individuals that were high in Harm Avoidance. However, the size of the current sample was much larger (n = 79) than the sample of the previous study (n = 23). Therefore, there was likely to be sufficient power to detect any relationships or differences within the current sample. The previous study was conducted

10 years ago in a different country (England) with subjects that had a mean age of 33 years old. The current study population had a mean age of 26, with more females (n= 58) than males (n=15). Gender differences in emotionally modulated startle response research suggest that females are likely to respond to negative stimuli more intensely (Bradley, Codispoti, Sabatinelli & Lang, 2001). The previous study included a nearly equal number of males (n=10) and females (n=13). If there were any temporal or geographical effects on levels of Harm Avoidance in the general population, these phenomena might have had an influence on the current results. Further studies investigating the levels of this variable in separate populations might lead to insights. It is not likely that the mean age difference between samples had any large effects, as the TCI and the TPQ have been accepted in the literature as a measure for adults.

In addition to the above question concerning Harm Avoidance, this study was designed to assess whether or not the newest addition to Cloninger's model, the character variables of Self-Directedness, Self-Transcendence and Cooperativeness, could also have a viable relationship with the emotionally modulated startle reflex. Research suggests that individuals who possess these three characteristics in greater amounts (as measured by the TCI) tend to have a more "centered" approach to life and are less prone to anxiety and depression (Cloninger, 1993). There have been multiple studies that have suggested that the character scales are influenced by different neurotransmitter effects (Gillespie, 2003; Tse & Bond, 2001; Peirson et al., 1999; Allugulander et al., 1998; Black & Sheline, 1997; Cloninger, 1993). These neuropsychological studies, supplemented with certain psychophysiological measures such as EEG and ERP, and psychophysiological experiments in their own right have found interesting relationships between certain character profiles and psychopathology. In general, the consensus is that individuals who score high on the character dimensions of the TCI are less susceptible to psychopathology and excessive anxiety and tend to have neurochemical profiles that are not consistent with depressive or anxiety disorders. The findings of other studies suggest that individuals who have these syndromes also have an increased startle response to negative picture stimuli (Lang, 1994) and presumably, to other negative stimuli in their environment. It was thus hypothesized that those who scored low on the character scales in this study would also tend to have higher startle amplitudes, at least in the negative picture condition. However, the correlation between average maximum startle response magnitude and level of Cooperativeness, Self-Transcendence, and Self-Directedness was not found to be significant. Perhaps character differences and the impact of differing personalities on the startle response might be only important in clinical populations. Further research concerning the relationship between the character variables and emotion modulated startle with a severely mentally ill population might clarify this question.

Aside from the main study findings, a common validity check for emotionally modulated startle reflex research was conducted using a picture ratings procedure. This procedure used emotionally charged pictures from the IAPS, (Lang, 1997), and individuals rated them on three different dimensions, valence, arousal and dominance. The results of this procedure indicate that some of the mean rating scores for this particular sample were significantly different than the IAPS ratings normative sample. Generally, individuals from the current study rated positive pictures as less positive than the normative sample. In contrast, there were no significant differences between this sample and the normative sample on negative or neutral valence: individuals rated the negative pictures as equally negative and the neutral pictures as equally neutral with the normative sample.

When checking the validity for the variable of arousal, subjects viewed the positive pictures as less arousing than the normative sample, yet they rated neutral and negative pictures as higher in arousal than did the normative sample. The findings for arousal and valence suggest that even though pictures were viewed as similarly negative in both samples, they were still viewed as more arousing by the current sample. In contrast, the positive pictures were viewed as both less positive and less arousing in the current sample when compared to the normative sample.

On dominance, this sample rated the positive and neutral picture conditions as significantly lower than the normative sample, but the negative picture condition higher than the norm sample. Generally, the findings in the literature on dominance do not suggest an effect size that is very large. Here, a significantly negative linear trend was found, suggesting that negative pictures make subjects feel less in-control than positive pictures, however the effect was not very large.

The overall purpose of the validity checks is to determine if there is anything about how the individuals in the current sample perceived the stimuli that would suggest they were not feeling the emotion that corresponds to each picture viewed. For example, if the current sample had rated the negative pictures as highly positive, and their subsequent startle reflexes were not modified to a great degree in the negative picture viewing condition, the results would not reflect the findings in the literature, and would likely be due to unique characteristics of the sample. Although there were some significant differences between the current sample and the norm sample with regard to picture ratings, none of these differences were likely to adversely impact startle reflex results. For instance, in the current sample the negative pictures were rated equally negative but significantly less arousing and dominant when compared to the norm sample. Despite this, the norm sample's mean arousal and dominance ratings for the negative pictures fall within the range of error for the current sample (Fig. 2).

Several exploratory analyses were conducted with other TCI variables to investigate areas for further study. Exploratory Excitability (.203*), Sentimentality (.199*), and Self-Acceptance (.234*) were positively correlated with startle response magnitude in the positive picture condition, meaning that the qualitative features of these personality variables in some way interact to facilitate stronger startle reflexes when these individuals encounter positive or appetitive stimuli in their environment. Secondly, Novelty Seeking (-.216*) and Disorderliness vs. Regimentation (-.243*) were significantly correlated with startle magnitudes during negative pictures. These data suggest that these two personality variables are lower in individuals who have a stronger startle reflex response to negative stimuli in the environment. These data are purely correlational, and thus any strong conclusions cannot be drawn from them, but they may indicate areas for further research with those using the TCI. Individuals who are low in Novelty Seeking can be described as slow tempered, indifferent, unenthusiastic, stoical, tolerant of monotony, reflective, frugal, detached, orderly and regimented. Disorderliness vs. Regimentation is a sub-variable of Novelty Seeking. Low scorers on this variable tend to be particularly organized, orderly, methodical, and systematic (Cloninger, 1994). It is possible that individuals who tend to be more guarded and regimented are compensating for some element in their physiological response to stressful and negative events in the environment that causes their bodies to over-react. As startle magnitude in response to negative stimuli are generally higher in populations with clinical levels of anxiety, these data suggest that there may be potential hyper-reactivity to stressful events that a regimented and reserved personality has been constructed to cope with. Perhaps individuals high in Harm Avoidance do not have this element of regimentation constructed into their personality. Future experiments might look at levels of reserve in individuals with clinical levels of anxiety to further investigate this hypothesis.

Table 4

TCI Variables and Average Maximum Magnitude, All Valence Conditions

	Pos	Neut	Neg	Nvlt	Xplo	Xtra	Diso	Sent	Resp	Coo	SlfA	Emp
Pos	**1.0**	**-.3****	**-.4****	**.1**	**.2***	**-.1**	**.1**	**.2***	**-.1**	**.1**	**.2***	**.2**
Neut	**-**	**1.0**	**-.4****	**.2**	**.01**	**.2***	**.1**	**-.2**	**-.2***	**-.2***	**-.3***	**-.3****
Neg	**-**	**-**	**1.0**	**-.2***	**-.1**	**-.2**	**-.2***	**.01**	**.1**	**.1**	**.1**	**.2**

Note. Pos=positive; Neut=neutral; Neg=Negative; Nvlt=Novelty Seeking; Xxplo=Exploratory Excitability; Xxtra=Extraversion; Diso=Disorderliness; Sent=Sentimentality; Resp=Responsibility; Coo=Cooperativeness; SlfA=Self Acceptance; Emp=Empathy
$^{**}p < .01$, one-tailed. $^{*}p < .05$, one-tailed.

In conclusion, the findings of this study do support the literature that has found evidence for the emotionally modulated startle reflex. There was a significant linear trend in the data that show negative pictures cause more intense startle reactions in a non-clinical population of adults. However, the findings do not support the literature that has found evidence for the relationship between Harm Avoidance and increased magnitude of the startle response. Additionally, there was no evidence of a relationship between startle reflex response and levels of Cloninger's three character variables.

The review of the literature suggests that there is at least a viable relationship between temperament and the startle reflex. Lang has proposed that organisms in an environment have emotions which produce “dispositions” that cause them to avoid or approach certain stimuli in the environment. Thus, emotions can be viewed evolutionarily as a survival mechanism. An individual’s temperament has been suggested to be an abstract representation of emotion with emotions being more acute and temperaments being more stable over time (Grigsby & Stevens, 2000). Presumably, it would be advantageous to have an in-depth understanding of the physiology of the various brain networks and the neurotransmitters that work within them in order to more effectively understand what one means when one describes temperament or character. The emotion modulated startle reflex paradigm, which demonstrates the effects of emotions on physical processes, is probably better apt to describe simple reflex patterns which use networks that inform the organism about his or her environment quickly and efficiently rather than the more complex networks that support personality.

Emotion modulated startle research that looks at the differences between non-clinical individuals and individuals with rare types of personality patterns such as those that can be clinically diagnosed might be advantageous. The TCI is also used as a clinical instrument to diagnose personality disturbance. Abnormal levels of the Harm Avoidance variable would likely be found more frequently in clinical populations so a future direction for this research might be to replicate the above experiment in a clinical population. It may be that personality differences influence the emotionally modulated startle reflex in patients with clinical pathologies. This would be clinically useful information when working with highly anxious or even phobic patients, for example.

Therapies used with individuals who have an abnormally sensitive startle reflex and are highly anxious could emphasize self-understanding and self-awareness into certain personality traits in combination with the traditional phobia and anxiety treatments.

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Appendixes

Appendix A: IAPS Identification Numbers and Picture Descriptions

Positive

8030 Skier
2150 Baby
8490 Roller Coaster
4660 Erotic Couple
4220 Erotic Female
1920 Porpoise
4520 Erotic Male
1620 Spring Brook
5621 Skydivers
7330 Ice Cream
5830 Sunset

Neutral

7090 Book
5920 Volcano
7640 Skyscraper
7000 Rolling Pin
7182 Checkerboard
7175 Lamp
7160 Fabric
7130 Truck
5510 Mushroom
7950 Tissue
6910 Bomber

Negative

2800 Sad Child
6360 Attack
2205 Hospital
9040 Starving Child
3102 Burn Victim
9421 Soldier
6212 Soldier
6350 Attack
3053 Burn Victim
6370 Attack
9920 Car Accident

Appendix B: Temperament and Character Inventory Sample Questions

Directions: The computer will present statements people might use to describe their attitudes, opinions, interests and personal feelings. Each statement can be answered TRUE or FALSE. Read each statement and decide which choice better describes you. Try to describe yourself the way you usually or GENERALLY act and feel, not just how you are feeling right now. To answer you only need to push either the 'T' or the 'F' key. If you push the wrong key, you can use the BACKSPACE key to see your last answer and reanswer the question.

1. I often try new things just for fun or thrills, even if most people think it is a waste of time. TRUE FALSE

2. I usually am confident that everything will go well, even in situations that worry most people. TRUE FALSE

3. I am often moved deeply by fine speech or poetry.
TRUE FALSE

4. I often feel that I am the victim of circumstances.
TRUE FALSE

5. I can usually accept other people as they are, even when they are very different from me. TRUE FALSE

6. I believe that miracles happen.
TRUE FALSE

7. I enjoy getting revenge on people who hurt me.
TRUE FALSE

8. Often when I am concentrating on something, I lose awareness of the passage of time.
TRUE FALSE

9. Often I feel that my life has little purpose or meaning.
TRUE FALSE

10. I like to help find a solution to problems so that everyone comes out ahead.
TRUE FALSE

Appendix C: Participant Instructions for Startle Segment and Ratings Segment

I. Instructions Before Startle Segment

In this part of the experiment, you will be asked to view different pictures displayed on the computer screen in front of you.

It is important that your eyes be directed towards the screen when the pictures are shown to you. You will have a few seconds to view each picture. Please remember to view the picture for the **entire** time it is displayed.

While you are viewing each picture, try to imagine yourself actually being in the setting or encountering the object you see. Imagine how you would feel if you encountered the object or situation in real life.

While you are viewing the pictures, please ignore the sounds you may hear through your headphones.

If you have any questions, please ask the experimenter at this time.

II. Instructions Before Ratings Segment

In this part of the experiment, you will be viewing the same pictures as in the first section. They will be presented in the same order.

However, during this part you will be asked to rate each picture, according to how it made you feel. You may view the pictures as long as you need to. Then **press the space bar**, after which you will be directed on how to rate the pictures.

There are three ways you will be asked to rate the pictures.

First, rate the picture on how **pleasant** or **unpleasant** it made you feel.
Second, rate the picture according to how **arousing** or **calming** it made you feel.
Third, rate the picture according to what degree you felt **dominant**, or **in control**, versus feeling **controlled** or **dominated** by the content in the picture.

If you have any questions, please ask the experimenter at this time.

Appendix D: Informed Consent Letter

Informed Consent

Temperament and Character Correlates of the Startle Reflex

Purpose

You are invited to participate in this research study to help me better understand an interesting psychological question. This question is about the interplay of individual differences in personality with human reflexes. I plan to investigate the way people respond to various pictures and sounds, and also to evaluate certain aspects of personality with a simple questionnaire. The pictures you will be viewing have been chosen to cover a variety of things you might encounter in your environment. Your responses on the personality questionnaire are true/false responses and will reflect whether or not you feel the statement accurately describes you.

Procedure

During this study, you will view a series of pictures depicting various subjects including (listed alphabetically): animals, guns, household objects, human nudes, nature scenes, mutilations, plants, rocks, snakes, spiders, sports scenes, etc. From time to time while viewing these slides, a brief, loud noise also will occur.

After viewing these slides once, you will be given the opportunity to rate each slide using a computer-based rating-questionnaire. In addition, you will be asked to complete a simple personality questionnaire, also administered by a computer, during which you will be asked to answer either true or false.

The sounds used in this study are similar in loudness and duration to a loud handclap, or a book being dropped. In no case will the sounds be louder than 110 dB, which, for the type of sounds used, has been determined by the Occupational and Safety Health Administration to be below the level that could cause temporary or permanent hearing problems.

This procedure also will involve collecting information regarding the activity of the heart and of the muscles involved in the eye blink. A small device that clips onto the end of one finger will measure heart rate activity.

Eye muscle activity will be measured by small, button-like sensors, which will be taped below your left eye. Finally, two larger sensors will be taped to the palm of your left hand. These sensors will be used to measure small changes in the amount of sweat being produced - an indictor of small changes in the activity level of part of the nervous system.

It should take approximately 60 to 70 minutes to complete your participation in this study.

Risks

There is no increased risk associated with participation in this study beyond that of everyday life. Therefore, the committees at both CSU San Bernardino and Loma Linda University that review human studies (Institutional Review Board) have determined that participating in this study exposes you to minimal risk. This approval is indicated by the official stamp of the CSUSB Psychology Department IRB Sub-committee.

Although this study has been deemed of minimal risk, you should be aware that some of the content of certain slides may lead to feelings of surprise or may make you feel uneasy or uncomfortable. Concerning the intensity of the auditory stimulus, though the noise you hear has been determined to be safe and within OSHA guidelines and will not cause hearing damage, the noise may still be relatively loud, and may cause surprise or a startle response.

Benefits and Reimbursement

You should not expect to receive any direct benefit from your participation in this research study other than the educational experience of participating in a scientific psychological research project. It is anticipated that the results of this study will help advance our understanding of how different people, with different personalities respond to emotional stimuli and situations. After participating in this study, you might gain some personal insight into the process of psychological research and data collection.

As compensation for your participation, you will receive a receipt for 5 units of extra credit and at the discretion of your instructor, you may receive extra credit points for your class.

Confidentiality

All of the information gathered during your participation in this research study is confidential and will be handled anonymously. That means that your name will not be attached to or stored with your responses. The information you provide will be grouped with that of other participants. Any publications or presentations resulting from this study will refer only to the grouped results.

Third Party Contact & Questions

If at any time you have any other questions regarding your participation in this study, you should feel free to contact Paul Haerich, PhD at the Department of Psychology, Loma Linda University. (phone: 909-558-8707).

If you wish to contact an impartial third party not associated with this study regarding any complaint about the study, you may contact the Office of Patient Relations, Loma Linda University Medical Center, Loma Linda, CA 92354 (phone: 909-824-4647), for information and assistance.

Participant's Rights

Participation in this study is voluntary. If, after signing this consent form, you decide to discontinue the session at any time, for any reason, you are free to do so. Discontinuing the session will not jeopardize your class standing or grade. You will receive extra credit for your participation whether you complete the session or not. If you have any questions regarding this study, we will be happy to answer them.

Consent Statement

I have read the contents of the consent form and have been given the opportunity to ask questions concerning this study. I have been provided a copy of this form. I hereby give my voluntary consent to participate in this study. Signing this consent document does not waive my rights nor does it release the investigators or institution from their responsibilities. I may call Dr. Paul Haerich at (909) 558-8707 if I have additional questions or concerns.

__________________________________ _______________
Signature **Date**

I have reviewed this consent document with the person signing above. An opportunity has been provided to ask any questions regarding this document and the research described in it.

__________________________________ _______________
Investigator **Date**