INDIVIDUAL DIFFERENCES OF THE STARTLE RESPONSE:
IMPLICATIONS OF ATTENTION AND AROUSAL

by

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Thesis submitted to the faculty of the
Virginia Polytechnic Institute and
State University
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
in
Psychology

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December 1996
Blacksburg, VA

Key words: Startle Response, Attention, Arousal
and Individual Differences
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ABSTRACT

This study investigated the electromyogram eyeblink startle response in relationship to individual differences in dimensions of attention and arousability as assessed by the Cognitive Failures Questionnaire (Broadbent, Cooper, Fitzgerald & Parkes, 1982) and the Arousal Predisposition Scale (Coren, 1990). Individuals (n=48) fulfilling the cutoff criteria of the questionnaires compiled three groups: High Arousal/High Cognitive Failures, High Arousal/Low Cognitive Failures and Low Arousal/Low Cognitive Failures. The eyeblink startle response was examined in two conditions, one in which participants were instructed to attend to loud, startling acoustic stimuli and a second in which they were instructed to ignore the startling stimuli by mentally counting backwards by threes. It was hypothesized that groups would differ from each other in both amplitude and latency of their startle response. More specifically, if top-down controlled attentional processes mediated the startle response under such conditions, it was expected that those with less distractibility would exhibit less startle during the ignore task than those who were more distractible. If arousal level mediated the startle response, it was expected that those with high arousability would exhibit increased overall startle response. If the ignore condition was more arousing, it was expected that those with high arousability would exhibit more startle during the ignore condition than those with low arousability. It was expected that the startle response between men and women would differ significantly. Furthermore, it was hypothesized that those participants reporting high distractibility would demonstrate a larger Stroop Effect than those reporting low distractibility.
Results indicated that for mean startle response amplitude there was a significant Attention Group X Condition interaction but not an Arousal Group X Condition interaction. Post hoc tests did not reveal one condition to be greater in mean amplitude than another. When including sex as a factor, for mean onset latency there was a significant Attention X Gender interaction and a significant Arousal X Gender interaction. High arousal and high distractible men showed significantly more overall startling than low arousal men and low arousal women. High arousal and high distractible men also showed significantly more startling than low distractible men and low distractible women. There were no significant differences of the Stroop Effect found between high and low distractible participants. Taken together, it appears that controlled top-down processing can influence the startle response when manipulations of the direction of attention are given. It also appears that men are more extreme in their responsivity than women. Implications for future research are discussed.
ACKNOWLEDGMENTS

I gratefully thank my advisor, Dr. Helen Crawford, for all her wonderful advice and support. I thank my committee, Dr. David Harrison and Dr. Al Prestrude, for their patience and input. I would also especially like to thank Dr. Prestrude for generously allowing me to use his Audio Mixer and for having long ago purchased the Audio Generator. Without those two pieces of equipment this project would not have been possible. Thanks also to Dr. Juan Lamas and Dr. Bruce Friedman for suggested readings, Dr. Bruce Cuthbert for his input about the consent form and Dr. Terry Blumenthal for his input, and for showing me his laboratory and Coulbourne set up. I thank Dr. Warren Meck and Dr. Tina Williams for generously allowing me use of their computer facilities. I thank Chris L'Hammedieu for writing the white noise gating program, explaining a bit of bioengineering and helping me understand the Dataq software. Appreciation goes to assistants Shannon Powell, Chris Fox, Sheeba Moshterifi and Josh Cohen. Finally, gratitude to Matt Matell for love, patience and support.
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OVERVIEW

The purpose of this study was to answer the question, "why is it that some people startle much more than others?" In our laboratory experiments involving painful somatosensory stimuli, we have noticed that some individuals startle to the stimulus whereas others do not. Within laboratories some individuals have been noticed to show excessive startle but others immediate habituation (Graham, 1979; Landis & Hunt, 1939). There are also intriguing ethnographic observations from areas of Southeast Asia suggesting that a form of exaggerated startle response could be a product of cultural elaboration (Simons, 1985, 1996). In order to better understand the mechanisms that mediate the startle response we chose to examine individual differences in both attentional processing and arousability as assessed by self report questionnaires. We examined the eyeblink startle response among these individuals during two counterbalanced attentional conditions. We expected that those individuals with better attentional abilities or those who were less easily aroused would have an attenuated startle response when directing attention away from the startling noises. With a Stroop Color-Word interference task, we expected that the individuals with better attentional abilities would exhibit less of a Stroop effect.

INTRODUCTION

Theory of Controlled Attention

Controlled attentional processes take place when "deliberate, conscious control of activity is desired" (Norman & Shallice, 1986, p. 1). This deliberate process is used when certain stimuli are given preference while other stimuli are being selectively filtered out (Kahneman, 1973; Schneider, Dumais, & Shiffrin, 1984). Focused attention is the filtering out of irrelevant stimuli while one relevant stimulus continues to take precedence (Schneider et al., 1984). Norman and Shallice (1986) suggested that this "activation and inhibition" of stimuli are indirectly controlled by the figurative Supervisory Attentional System (SAS) which biases its activation and inhibition. The SAS is thought to be responsible for controlled processing such as deliberate attention, discrimination between
relevant and irrelevant information, error correction, and learning novel tasks (Norman & Shallice, 1986; Dempster, 1991). Two attentional systems, top-down processing and bottom-up processing, have been expressed in terms of anterior and posterior neuroanatomical processing respectively (Posner & Peterson, 1990). The posterior, or bottom-up, attentional system is thought to be responsible for shifting attention (orienting) to a new target. The anterior, or top-down, attentional system is thought to be more involved with effort and focused, controlled attention.

In order for the SAS to be responsible for this effortful "paying attention" to relevant information it must also be responsible for ignoring, or inhibiting, irrelevant information (Norman & Shallice, 1986). Such cognitive inhibition may be evidenced by decreases or elimination of a behavior by "reducing or blocking the activation level" (p.5). It may be also be evidenced by an improvement in behavior by blocking the pathway that would otherwise interfere with that behavior (Klein & Taylor, 1994). There has been both physiological and behavioral support for activation and inhibition of attention (Houghton & Tipper, 1994; Moran & Desimone, 1985).

Physiological and behavioral studies have indicated that individuals differ from each other in attentional processing. Physiologically, the N1 component of the auditory event-related potential is thought to represent the first stage of selective attention because N1 amplitude increases and latency decreases as an attended stimulus becomes more intense (Hackley, Woldorff, & Hillyard, 1987). In an extensive review, Näätänen (1992) noted individual differences in the N1 component without any resolution to possible moderating influences. As intensities increased some individuals showed an increase in amplitude and others showed a decrease.

Behaviorally, the Stroop effect has been found to differ as a function of individual differences of attention. The Stroop effect occurs when a person’s responses to a task become slowed or impaired when automatic processes conflict. For example, if an individual is required to say the color that a word is printed in, such as blue, but the word
spells "green", then the individual experiences response conflict which results in longer response time or an increased number of errors. Thus, the automatic processes of reading and naming a color conflict. The case would not be so if the blue color also spelled "blue."

Because individuals vary in the degree to which the Stroop effect is demonstrated, it has been suggested that those who exhibit a larger Stroop effect might not have as efficient strategies employed to "actively inhibit" against distracters (Houghton & Tipper, 1994).

Tipper and Baylis (1987) found that those individuals scoring high on the Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, Fitzgerald. & Parkes, 1982) showed a stronger Stroop interference effect than those who scored low. The CFQ was originally devised to assess the degree to which an individual chooses inappropriate implementation strategies and "departs from the normal smooth flow of function, and events do not proceed in accordance with intention" (Broadbent et al., p. 1). The inappropriate implementation strategies are manifested by lapses in perception, memory and misdirected action. In a day to day application, the questionnaire is thought to measure the extent to which an individual is distracted and absentminded (see Appendix A). Broadbent’s intention was to apply such knowledge to the work place, in the hopes of placing employees within a work setting they could excel in. The present study screened individuals with extreme CFQ scores and examined performance on the Stroop Color-Word Interference task (Trenerry, Crosson, DeBoe, & Leber, 1989) as well as physiological indicators of individual differences of attention. If top-down attentional processing involves inhibition to distracters, it was expected that those individuals who do not report inappropriate implementation strategies would exhibit a smaller Stroop effect.

Furthermore, if top-down attentional processing involves inhibition to distracters, then might brain stem reflexes be attenuated when attention is directed to another target? Indeed, one brain stem reflex, the startle response (SR), has been found to reflect differences in attentional processes. Nevertheless, researchers have not addressed SR mediation within the context of the theory of controlled attentional processing.
Theory of Arousal and the Interaction With Attention

The startle response has also been found to be mediated by arousal. Arousal processes involved with orienting are often defined as input causing a “measurable brief (several seconds) change in a physiological indicator over baseline” (Pribram & McGuinness, 1992, p. 69). Attention is defined as a multidimensional process that involves information processing, selectivity, preparation and vigilance (Posner & Peterson, 1990). It has been suggested that arousal and attention mediate each other (Posner, 1993; Posner & Peterson, 1990; Pribram & McGuinness, 1992). As Pribram and McGuinness (1992) say:

The organism is not just a switchboard for incoming stimuli....In the absence of control, behaving organisms would be constantly aroused by their movements and moved by their arousing inputs. There must be some long range, or sustained control process that involves both generalized arousal and active selection. (pp. 69-70).

This long ranged control process can be seen as being influenced by arousal processes and also influencing arousal processes.

Similarly, Lacey (1967) argued that arousal processes are "multidimensional." Arousal processes are reflected by the level of activation of the organism as well as its intended goal of the behavior. As such, arousal is the result of "the nature of the transaction between the organism and its environment" (p. 25). Heart rate (HR) acceleration, which is typically thought to be a marker for the degree of sympathetic arousal, may occur more strongly in some individuals but not in others. For example, cognitive tasks, such as difficult math problems, generally cause HR acceleration. However, it is often noted that some individuals show HR decelerations (Lacey, Kagen, Lacey, & Moss, 1962; Lacey & Lacey, 1974). Thus, the environment interacts with the "nature" of the individual (intended goal, level of activation) to produce different physiological outcomes.

Eysenck (1982) suggested that to observe arousal at a given time, one must be aware of a complex interaction between the internal and external states of an organism, such as the
organism's level of attention, the environment and the level of arousal. At any given time, a person has a "spare" processing capacity that is allotted to monitoring the external environment. Individuals differ in the degree to which they monitor their environment. Should a sudden event occur, this processing system is "alerted" to allocate more attention to that event. In other words, an external stimulus may arouse or alert an organism to enable it to devote more attention to that stimulus, but the degree to which the organism is alerted may be a function of the degree to which an organism is already monitoring the environment.

Graham (1979) suggested that the characteristics of the external stimulus also influence the degree to which an organism is alerted to the environment. For example, the presentation of a novel, low intensity stimulus causes stimulus bound HR deceleration and inhibited motor movement (as well as a gamut of other responses such as increased galvanic skin response and pupil dilation). This pattern of responding is called an orienting response. As such, these physiological orienting responses allow an organism to process the external environment (Graham, 1979). On the other hand, an intense, sudden stimulus causes stimulus-bound HR acceleration and facilitated motor movement which allows the organism to "reject" the potentially threatening external environment (Graham, 1979). If HR accelerates and then decelerates after approximately four seconds, then the individual is showing a startle response (Graham, 1979; Turpin, 1986). If the HR does not decelerate but continues to accelerate, then the individual is showing a defense response.

Biochemical and neuroanatomical evidence provides further support that arousal and
attention mediate each other. Neuroanatomical circuits, including cortical projections, mediate the primary acoustic startle circuit which involves norepinephrine (NE) release from the locus coeruleus. Posner and Peterson (1990) have suggested that the frontal "focused" attentional system is dependent upon this "alert" state which arises from the locus coeruleus NE. This alerted, aroused state is also dependent upon the degree to which an organism is already focused. Thus, patterns of physiological responsivity appear to be a function of individual differences in arousal and attentional processes interacting with the situation at hand.

If arousal is reflected by physiological responsivity, then might the startle response (SR) be facilitated if there is increased arousal or attenuated if there is decreased arousal? To assess individual differences of arousability, Coren (1990) devised a twelve question Arousal Predisposition Scale (APS; see Appendix B). It has been physiologically validated (Coren & Mah, 1993) by assessing the medial frontalis electromyogram (EMG) and electrodermal response (EDR) to stimuli of 105 dB white noise with two second durations. Those scoring high on the APS showed significantly more EMG and EDR than those scoring low. Thus, it was concluded that higher muscle activity was an adequate assessment of increased physiological arousal. Because the stimuli used were intense, one would expect that Coren and Mah were additionally assessing individual differences of the SR. To explore this, the present study examined whether similar differences between Low and High APS participants would also be observed with the startle response.

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1 The primary acoustic startle circuit within rats includes norepinephrine (NE) projections from the locus coeruleus and superior colliculus (Davis, 1984). NE from the locus coeruleus is typically used in discussion of arousal (Pinel, 1993). Lesions at sites other than the circuit, such as the reticular formation or amygdala, which have ascending projections of dopamine (DA) and NE, alter the startle response (Davis, 1984; Clark, Geffen & Geffen, 1987). The reticular formation is thought to maintain cortical arousal levels in order to modulate different attentional states (Cohen, 1993). When an animal is not actively attending to its external environment and is focused on certain activities such as eating, sleeping or grooming, a startle probe causes the locus coeruleus to release abundant amounts of NE. When an animal's attention is directed to the external environment (e.g. foraging for food) then DA pathways (perhaps of the reticular formation) become regulatory for the SR.
The Startle Response - A Description

The startle response (SR) is a very plastic, or modifiable, reflex that occurs within almost all species in response to a novel, sudden stimulus that has an instantaneous rise time and intense onset. There are individual variations of the SR, but among humans the "distinctive flexor pattern" is a 20 -200 msec response beginning at the head with an eyeblink, a characteristic facial pattern, increased muscle tone, a jerk of the head, a hunching of the shoulders, a bending of the elbows, a flexing of the fingers, a contraction of the abdomen, a forward movement inwards of the trunk and a bending of the knees (Anthony, 1985; Graham, 1979; Landis & Hunt, 1939). If the stimulus is slight or habituation has occurred then only a rapid contraction of the muscles near the eyes can be detected (Landis & Hunt, 1939; Graham, 1979). These facial muscles are enervated by the VII cranial nerve which is the final synapse in the SR circuit (refer to Figure 1 below).

![Diagram of the acoustic startle response circuit]

Figure 1: The Primary circuit of the acoustic startle response - The circuit begins with the posteroventral cochlear nucleus, and synapses onto the dorsal and ventral nuclei of the lateral lemniscus, the ventromedial region of the nucleus reticularis pontis caudalis (RPC) (which forms the reticulospinal tract) and finally ends with enervation of the VII cranial nerve and spinal cord (Davis, 1984, p. 293).
Figure 2: Orbicularis Oculi - inferior orbital portion (constricts the eye fissure). The first electrode is affixed 1 cm inferior to the exocanthion (outer commissure of eye fissure). The second electrode is placed 1 cm medial to and slightly inferior to the first, so that the electrode pair run parallel to the lower edge of the eyelid Response (Fridlund & Cacioppo, 1986, Hugdahl, 1996, p. 348)

Human SR electromyogram (EMG) recordings are conducted from the orbicularis oculi muscles (Anthony, 1985; refer to Figure 2 above). There are different methods by which researchers examine this EMG startle response. They are: 1) the response amplitude - peak of EMG after stimulus onset, 2) the response latency - the delay from stimulus onset to response peak 3) the response probability - the number of actual EMG responses divided by the possible number of responses and 4) prepulse inhibition - the degree to which the SR is attenuated due to a quiet tone that is presented immediately prior to the startle probe. The latter method is thought to reflect sensorimotor gating (Anthony, 1985; Blumenthal & Goode, 1991). A "facilitated" SR typically refers to at least one of three EMG patterns: there is increased amplitude, shorter onset latency or increased response probability (Blumenthal & Goode, 1991). Refer to Figure 3 below.
Figure 3: *Orbicularis Oculi* EMG Startle Response amplitude and latency (bottom line is a 50 msec white noise startle probe)

The "startle probe" that elicits the SR may be a sudden flash of light, a loud, sudden noise, a sudden movement, an airpuff, or a tap or shock to the skin (Anthony, 1985). Typically, researchers use the acoustic probe because it elicits the SR with a much shorter onset latency as reflected by a quicker motor response. An adequate acoustic stimulus that elicits the EMG startle response occurs with a 1000 Hz tone ranging from a 87 - 100 dB with an immediate rise time. Graham and Slaby (1973) found that white noise of equal intensity elicited a larger startle response amplitude, thus, white noise has become the preferred probe. Unless otherwise stated, all references to the SR will be to those elicited by white noise.

The Startle Response Mediated by Directed Attention

Facilitation of SR amplitude and onset latency has been found to occur in paradigms requiring participants to attend to the same modality in which the startle probes were presented (Bohlin & Graham, 1977; for a review, see Anthony, 1985). For example, participants were instructed to judge the duration of a target stimuli only when they received a lead warning tone presented 2 sec prior to the target stimuli. Half of the target stimuli were quiet tones and the other half were startling white noise probes. An additional eight probes were presented without a lead warning. After each target they were to say out loud
if the target stimulus was a short or long tone. Onset latency of the SR was significantly shorter when participants were presented with a lead warning tone in the same modality as the acoustic startle probes than when they were presented with the control startle probes without the lead warning tone (Bohlin & Graham, 1977). Similarly, other studies have found that attenuation of the SR amplitude or latency occurs when attention was directed to another modality, such as a visual foreground, and thus, away from the startle probe (Anthony, Butler & Putnam, 1978; Hackley & Graham, 1983).

However, explanations other than that of a mismatch between the startle probe modality and the foreground modality may account for the SR modulation. The foreground may have to be "interesting" to have attenuating effects in which more attention is allocated to the foreground and less is allocated to the startle probes (Simons & Zelson, 1985). Furthermore, instructions to "ignore" the startle probes when attending to a foreground may accentuate this attentional allocation (Blumenthal & Flaten, 1994). Finally, from a different perspective, the foreground may have to be less "arousing" to an individual to prevent them from having a facilitated SR (Blumenthal & Flaten, 1994).

Slides of nude men and women were "interesting" foregrounds that had attenuating effects on college students' acoustic SR by slowing their onset latency. When participants were presented slides of nudes as compared to slides of either a waste paper basket or a wicker basket, their SR decreased in amplitude and slowed in onset latency (Simons & Zelson, 1985). Participants were presented with 20 slides in two different blocks. Both blocks included 10 presentations of the neutral stimulus interspersed between 10 different images of a nude man or nude woman (alternating the sex with each new presentation). During the last 3.5 seconds of the 6 second slide presentation, a startle probe was given. An interview conducted afterwards confirmed that the nude slides were more interesting and provoked "happiness, anxiety, interest, liking and attentiveness." However, only during the first block of slides were the findings significant, suggesting that in the second block participants had become accustomed to the slides and found them less engaging.
This provides evidence that simply directing attention to another modality does not in and of itself produce SR attenuation.

Contrary to previous research, verbal instructions of ignoring the startle probes and directing attention to another modality has caused SR facilitation (Blumenthal & Flaten, 1994). Participants were presented three types of stimuli: an acoustic startle probe with a tone presented immediately after, an acoustic startle probe with a tactile stimulation to the hand (a vibration in Exp 1 and an airpuff in Exp 2), and a startle probe presented alone. These three types of stimuli were presented in four different conditions in which the participants were instructed to: attend to the tone following probe offset, attend to the tactile stimuli following probe offset, attend to the probes alone, or ignore all the stimuli. In the condition in which participants were instructed to attend to the stimulus in the auditory modality (the tone), they showed a facilitated SR amplitude as compared to the condition in which they were instructed to ignore all the stimuli. In the condition that participants were instructed to attend to the stimulus in another modality (tactile) as compared to the condition in which they were instructed to ignore all the stimuli, participants actually showed a facilitated SR (larger amplitude in Exp 1 and shorter latency and higher response probability in Exp 2) instead of the predicted attenuated SR. Blumenthal and Flaten attributed this unexpected finding of facilitation to the tactile stimulus as possibly being because the nature of "shifting attention from the auditory to the tactile modality" posed "greater task demands" to the subject, and therefore "greater arousal" (p. 345).

The SR appears to be facilitated when attention is directed to the same modality as the startle probe. It appears to attenuated only when the foreground modality is more interesting or less arousing. The present study examined the SR when instructions were given either to attend to the probes or to ignore the probes by directing attention instead to a cognitive task.
Individual Differences of the Startle Response

Not only has the direction of attention been found to mediate the SR, but differences in the SR have been found between individuals performing the same task. Graham (1979) noted that humans "show variation, some subjects consistently do not show a startle response, while others never habituate" (p. 158). Some individuals appear to have an extremely slow rate of habituation to a startle probe while others rarely show a SR or habituate more quickly than the average (Landis & Hunt, 1939; Thorne, 1944, cited in Davis, 1984). Even among female Sprague-Dawley rats, only half exhibited a "freezing" behavior which was accompanied by an increased SR whereas the other half exhibited a "nonfreezing" behavior (Plappert, Pilz, & Schnitzler, 1993).

Excessive startle responders were first noted by Landis and Hunt (1939). They described secondary behaviors that sometimes occurred amongst these non-habituators as being "highly stylized, socially stereotyped facial expressions of amusement, surprise, disgust, and the like...which serve as voluntary, unverbalized comment upon the situation" (p. 136). They subgrouped these secondary responses into curiosity, fear, annoyance and overflow effects:

People will also approach the stimulus with curiosity or attempt to escape the stimulus...they are understandable reactions under the circumstances; [however] other responses appear much less logical and seem not to be directed toward the stimulus but to be mere overflow phenomena. In these latter instances it is as though the motor tensions aroused by the sudden loud sound were not resolved by the bodily movement of the startle pattern and needed some further outlet. Thus some subjects will change their position; others will smile aimlessly...[have] nervous giggles or [make] inconsequential remarks to the experimenter....The noticeable difference between animals and man comes in the absence of stylized behavior and communicative expression. (pp. 138-139; 143)

Clinical groups, such as those diagnosed with Post Traumatic Stress Disorder (Morgan, Gillon, Southwick, & Davis, 1996) and Huntington’s disease (Swerdlow, Paulsen, Braff, & Butters, 1995) have shown more SR when compared to non-clinical populations. Furthermore, two diseases, hyperekplexia and startle epilepsy, are associated
with abnormal startle responses (Howard & Ford, 1992). Despite this, criteria have not been set to determine when a SR is abnormal (Chokroverty, Walczak, & Henig, 1992).

Exaggerated SRs have also been found within non-clinical individuals, such as those with high social anxiety (Britt & Blumenthal, 1993), psychosis-prone college students (Schell, Dawson, Hazlett, & Filion, 1995), introverts (Britt & Blumenthal, 1991) and Type B personalities (Zelson & Simons, 1986). Some recent experimental studies have eliminated from analysis those people who consistently did not show a startle response or showed "excessive" startle responses (e.g. Bradley, Cuthbert, & Lang, 1990; Bradley, Lang, & Cuthbert, 1993; Schell, et al., 1995). Yet, it is these rejected individuals who are extreme in their excessive startling or rapid SR habituation who could shed light onto the mechanisms involved in startling. It is possible that these extreme startle responders differ in their processes of attention and arousal. For this reason, the present study did not exclude extreme responders.

People in the United States who exhibit these exaggerated response behavior patterns are termed "hyperstartlers" (Simons, 1985, 1996). Ethnography conducted in rural areas of Southeast Asia, such as Malaysia and Indonesia, and elsewhere has reported on individuals, termed “Latah”, who exhibit these exaggerated responses (Simons, 1985). These Latah are usually middle aged women. Simons observed, "the phenomenology of their experiences are strikingly alike [to Americans]" (p. 47). With Latah, however, "this behavior pattern has been named and institutionalized" and the response becomes "culturally elaborated upon" by becoming a form of entertainment within their villages (Simons, 1985, p. 45). Villagers will startle a Latah and she does not easily habituate. She might make inconsequential remarks, change her posture, giggle, shout out taboo words, and mimic the person that startles her. To date, no studies have examined the physiological manifestation of the Latah and their "startle response."

While anthropologists have noted that the Latah phenomena and hyperstartling in the United States is more commonly observed in women than in men (Simons, 1996), whether
there are any sex differences in susceptibility to startle is relatively unknown. Two studies (Swerdlow, Auerbach, Monroe, & Hartston, 1993; Swerdlow, et al., 1995) examining the prepulse inhibition (the extent to which a quiet tone presented immediately prior to the startle probe inhibits the SR) found that men showed more prepulse inhibition than did women. Surprisingly, sex differences have not been evaluated in most laboratory studies of the SR. The present project explored the data for possible sex differences in the SR.

More generally, we can ask: Why is it that some individuals startle more easily and excessively than others? Some studies approach individual differences of the SR by examining individual differences of attention. Others examine individual differences of arousability. The present study assessed both dimensions using self report measures.

The Startle Response Mediated by Individual Differences of Attention

Variations of the SR has been found among people who exhibit individual differences in attentional processing. When "normal" college participants were presented with a prepulse tone at lead times of 50-800 msec prior to the startle probe they typically showed an inhibited SR. This prepulse inhibition is thought to be a protective "preattentive" process that allows the first stimulus to be processed adequately (Acocella & Blumenthal, 1990). However, schizophrenics showed less prepulse inhibition which is suggestive of deficits in attentional processing (Dawson, Hazlett, Filion, Nuechterlein, & Schell, 1993; Schell et al., 1995).

Of particular theoretical relevance is the study (Zelson & Simons, 1986) in which Type As and Type Bs differed in their SR when required to perform a cognitive task requiring focused attention. Type A individuals are thought to have a "hypervigilance" to task-relevant stimuli. They seem to be able to better "ignore peripheral stimuli which may interfere with successful performance" and "actively inhibit their attention to task-irrelevant stimuli" (Zelson & Simons, 1986, p. 385). To assess SR differences, all participants were required to detect infrequent target digits interspersed within a long series of digits. In two blocks, startle probes were presented during an easy trial, a difficult trial (digits were
degraded and harder to see) and a no-task control. No difference in SR was found between the easy and difficult tasks. However, during the second block of trials, participants showed a significant attenuation of the SR amplitude during the task conditions as compared to the control. Furthermore, although Type As did not show more attenuation than Type Bs during no-task control, during task performance the SR of Type As attenuated significantly more than the SR of Type Bs. The authors concluded that "Type As inhibited their attention to task irrelevant probes more than Type Bs...Type As remained centrally vigilant...whereas Type B subjects became less task attentive or performance oriented as time progressed" (p. 390). Thus, from an attentional perspective and using individual differences as assessed by a questionnaire, it was found that Type As were more attentive to the task over time so that less attention was allocated to the task irrelevant startling stimuli.

The Startle Response Mediated by Arousal

A scant number of studies have been successful in demonstrating that increased arousal facilitates the SR. As previously mentioned, because of the intense stimuli used, Coren and Mah (1993) might have been examining the SR of High and Low Arousal Predisposition (APS). However, they did not record EMG from orbicularis oculi, but from medial frontalis. Under the assumption that caffeine increases sympathetic arousal, Schicatano and Blumenthal (1994) found that individuals who had consumed caffeine had significantly slower SR habituation than individuals who had consumed a placebo.

In another study, Britt and Blumenthal (1991) examined the SR of individuals who differed in dimensions of arousability. Extroverts are thought to have a "poorly functioning" ascending reticular activating system and therefore seek out stronger stimulation to "attain a satisfactory level of cortical arousal." Introverts are thought to have an "overactive" ascending reticular activating system and therefore avoid "strong stimulation that would create painful overarousal" (Eysenck, 1994, p. 157). They found that introverts, although not showing amplitude differences in the SR, exhibited a shorter
onset latency and higher response probability than extroverts. They concluded that the more easily aroused introverts showed higher levels of physiological responsivity as evidenced by the SR.

As mentioned above, Blumenthal and Flaten (1994) suggested that the increased acoustic SR found during attentional direction to the tactile modality could be attributed to the arousal caused by greater task demands. Zelson and Simons (1986) readily addressed the alternative hypothesis that their findings could be interpreted from an arousal perspective: Type As are thought to have more sympathetic arousal than Type Bs during task performance, therefore, the SR differences could be attributed to differences in arousability between the two groups of participants. However, if arousability were parsimonious in accounting for mediation of the SR, it would be expected that Type As would show facilitated SR, not attenuated. However, it was the Type As who showed more attenuation during task demand, not the Type Bs.

Why is it that some individuals startle more easily and excessively than others? Simply directing attention to another modality does not in and of itself produce SR attenuation, as in the example of when participants looking at neutral photos did not show much SR attenuation but did when looking at nude photos (Simons & Zelson, 1985). In fact, directing attention to a modality other than the startling probe may even cause SR facilitation, as found with a tactile stimulus (Blumenthal & Flaten, 1994). This was attributed to the possibility that the shifting of attention to the tactile stimulus increases arousal. However, this interpretation of facilitation due to arousal does not suffice assuming that the nude photos might also be arousing. Furthermore, if arousability were parsimonious in accounting for mediation of the SR, it would be expected that Type As, who are more easily aroused, would show facilitated SR when performing a task, not attenuated. Thus, it becomes necessary to examine more thoroughly the interaction of arousal and attention as it relates to the SR.
PURPOSE AND HYPOTHESES

The purpose of this study was to evaluate the moderating effects that individual differences of attentional processing and arousability as assessed by two self-report questionnaires, the Arousal Predisposition Scale (APS; Coren, 1990) and the Cognitive Failures Questionnaire (CFQ; Broadbent, et al., 1982), had on the startle response (SR) during two manipulations of directing attention towards and away from the startle probes. In addition, an attempt was made to replicate the findings of Tipper and Baylis (1987) that a larger Stroop Effect was related to higher cognitive failures, as assessed by the CFQ.

The Startle Response

The SR was examined in two counterbalanced conditions with different attentional instructions: (1) participants were instructed to pay attention to the probes, and (2) participants were instructed to ignore the probes and instead pay attention to a mental counting task (subtracting by threes starting with 500). Reaction time tasks or any other task requiring motor movement were not chosen for this study because tasks requiring motor movement could affect HR and motor responsivity (Graham, 1979; LeDoux, 1990; Roland & Friberg, 1985). The dependent variable was orbicularis oculi EMG activity (response amplitude, latency and response probability). A "large" or "facilitated" SR is defined as increased amplitude, faster onset latency or higher response probability. An "attenuated" or "inhibited " SR is defined as decreased amplitude, slower onset latency or lower response probability.

The Startle Response Mediated by Individual Differences of Attention and Arousal

Given that the direction of both attention and arousal mediate the SR, it was

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2 For example, in a study examining animal startle with the presentation of a negative stimulus, the animal that was free moving, and not stationary, showed HR acceleration (LeDoux, 1990). Similarly, if a person is experiencing high physical activity then they are more likely to show HR acceleration than deceleration to an aversive stimulus (Graham, 1979). Roland and Friberg (1985) required subjects to perform purely mental tasks, such as the right, left corner-turning task because the dependent variable they were examining, regional cerebral blood flow (rCBF) is also confounded by motor movement. Across all tasks they found increased rCBF to the superior prefrontal cortex as well as an increase in pulse in the 50-3 and route finding conditions.
hypothesized that self-reported individual differences in attentional processing and arousal level would be reflected by differences in SR. In addition, given that there might be an interaction between arousal and attentional processes, it was hypothesized that the two conditions of directed attention would have different outcomes of the SR as a function of individual differences of attention and arousal.

If there was an interaction between arousal and attention as it mediates the SR, in which arousal was necessary in order to provide more allocation of attention, then it was expected that individuals with more controlled attention to target and less distractibility and high arousability (High APS/Low CF) would have less SR during the ignore condition than those individuals with low distractibility and low arousal (Low APS/Low CF).

If both attention and arousal influence the SR, then there should be differences in overall SR and between conditions when comparing High APS/High CF with Low APS/Low CF.

Based on the observation that hyperstartlers and Latah were predominantly women (Simons, 1985, 1996), the possibility that men and women differed in their SR was explored in post hoc analyses.

The Startle Response Mediated by Individual Differences of Attention

Cognitive inhibition may be evidenced by decreases or elimination of a behavior by "reducing or blocking the activation level" (Klein & Taylor, 1994). The Stroop effect is thought to be behavioral evidence of cognitive inhibition interference that happens when attempting to actively block the distracting stimuli. The Stroop effect occurs when a person is attempting to name the color of a word printed in red but spelling "green," the color name interferes with the naming of the printed color. The Stroop effect measures the extent to which a person is able to "shift between conflicting verbal response modes" (Trenerry, et al., 1989, p. 1). Tipper and Baylis (1987) observed that individuals who exhibited a larger Stroop effect reported higher distractibility, i.e., scored higher on the Cognitive Failures Questionnaire (CFQ; Broadbent ,et al., 1982). The CFQ is thought to assess the degree to
which an individual chooses inappropriate implementation strategies. Inappropriate
implementation strategies are manifested by lapses in perception, memory and misdirected
action which may be evidenced by distractibility or absentmindedness in day to day
activities (Broadbent et al., 1982). Tipper and Baylis (1987) maintained that one example
of an inappropriate perceptual implementation strategy is not being able to successfully
inhibit against to distracting, irrelevant stimuli (Tipper & Baylis, 1987). Because the SR
has been shown to be mediated by attentional processing, it was expected that perceptual
implementation strategies of attending or ignoring startling noises would be reflected by
individual differences of attentional processing. In other words, it was expected that the
degree to which a person would startle would be related to the degree to which that person
would be able to attend to a certain stimulus and ignore other task irrelevant stimuli.

For this study, participants were chosen to be high and low scorers on the CFQ. In
comparison to those who scored low, it was expected that those who reported substantial
cognitive failures would show less inhibition to task-irrelevant stimuli because they have
more difficulty cognitively inhibiting against distracters. For example, Tipper and Baylis
(1987) found that those with high cognitive failures exhibited a larger Stroop effect. It was
expected that in the present study, those participants scoring high on the CFQ would
have a facilitated SR when trying to direct attention away from the probes to a mental task.
In comparison to those who scored high, it was expected that those who reported low
cognitive failures would show a facilitated SR while attending to the startle probes due to
their more focused attentional abilities. These Low CF participants should show more
attenuated SR in the ignore condition as compared to the attend condition. The High CF
participants should exhibit facilitated SR in the ignore condition as compared to the attend
condition. When looking at specific groups, it was expected that those individuals scoring
high on arousal and low on distractibility (High APS/Low CF) would show less of a startle
during the ignore condition and more of a startle during the attend condition than those
individuals scoring high on arousal and high on distractibility (High APS/High CF).
The Startle Response Mediated by Individual Differences of Arousal

Arousalability is thought to be a multidimensional process associated with an increase in sympathetic functioning. The Arousal Predisposition Scale (APS; Coren, 1990), used to screen for degree of arousability, has been physiologically validated with medial frontalis EMG and EDR (Coren & Mah, 1993). Because the SR reflects individual differences of arousability, the degree to which a person startles may be related to the degree to which they are aroused by an external startling stimulus. For this study, participants were chosen for high and low scores on the APS. In comparison to those who scored low, it was expected that those who scored high would experience more arousal and therefore have a facilitated SR. If the cognitive mental task caused greater arousability (Roland and Friberg did find an increase in HR in two of their mental tasks, one being the subtract by three task), then it was expected that High APS participants would have a facilitated SR during cognitive task-ignore probe condition than in the attend condition. Similarly, they were expected to have a more facilitated SR in the ignore condition than the Low APS participants. When looking at groups it was expected that those scoring low on arousal and low on distractibility (Low APS/Low CF) would show less overall startle response than those scoring high on arousal and low on distractibility (High APS/Low CF).

Heart Rate

Individuals have been found to show different heart rate (HR) patterns when performing the same task (Lacey, et al., 1962; Lacey & Lacey, 1974) With the presentation of a novel, low-intensity stimulus, an individual typically has an orienting response, which is indexed by a HR deceleration. With the presentation of a novel, intense and non-threatening stimulus an individual has a startle response indexed by a phasic acceleration (Graham, 1979; Turpin, 1986). Because individuals also have been found to differ in SR (Landis & Hunt, 1939; Graham, 1979) this study used HR as a manipulation check to insure that individuals were startling and not orienting.
Stroop Task

Extreme scores of the CFQ have been found to be related to differences found in the Stroop effect, with those with less distractibility showing less of a Stroop effect (Tipper & Baylis, 1987). Thus, it was expected that individuals who scored low on the CFQ would have less of a Stroop Color-Word Interference Effect than those who scored high on the CFQ.

METHOD

Participants

Participants 18 years in age or older were recruited from Virginia Polytechnic Institute and State University (VPI&SU) via course credit for psychology. A series of questionnaires were administered to 286 participants. Questionnaires included a health questionnaire, the Cognitive Failures Questionnaire (CFQ; Broadbent, et al. 1982; see Appendix A), the Arousal Predisposition Scale (APS; Coren, 1990; see Appendix B) and others. Of those participants, 57 were asked back to the laboratory for startle response and Stroop task assessment.

Screening Procedure

A consent form (see Appendix C) was given providing information to participants that they were being screened for a future physiological study. Participants were informed that they might be contacted by the experimenter for further study and asked to include their phone number if they would be willing to participate in further study.

After 182 participants completed the questionnaire packet, the top and bottom 30% of APS and CFQ scores were set for screening and participants began to be contacted for the main experiment. The cutoff scores of the CFQ were below a 42 and above a 46 and the cutoff scores of the APS were below a 30 and above a 36. After 286 participants were

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3 These questionnaires, Weinstein's (1978) Noise Sensitivity Scale, the Tellegen Absorption Scale (Tellegen & Atkinson, 1974), the Differential Attentional Processes Inventory (Grumbles & Crawford, 1981; Crawford, Brown & Moon, 1993), Eysenck Personality Questionnaire (Eysenck & Eysenck, 1975) and a maze tracing test (Ekstrom, French, Harman with Derman, 1976), will be used for future research.
screened, the sample used no longer constituted the top and bottom 30%. Rather the CFQ scores compiled the top 45% and the bottom 25% and the APS scores compiled the top 30% and the bottom 23%.

The CFQ consists of 25 questions all scored positively on a scale from 0 - 4. The CFQ has since been found to have good test-retest stability ($r = .82$) with an average interval of 21 weeks (Broadbent et al., 1982; Merckelbach, Muris, Migman & de Jong, 1996). All questions were found to be positively correlated and the CFQ has been found to be relatively independent of other measures such as the Spielberger trait anxiety scale and the Rotter external control (Broadbent et al., 1982). It also has external validity due to the significant correlations of a respondent's score with the spouse's score on the respondent (Broadbent et al., 1982). For the present study, a correlation between the APS and CF of 286 subjects revealed $r = .39$, ($p < .05$).

The APS consists of twelve questions scored positively (except for #1) on a scale from 1 - 5. The tenth question asks the person to assess how easily he or she startles. As mentioned previously, the APS has been validated with medial frontalis EMG and electrodermal response (EDR) (Coren & Mah, 1993). Those that rated themselves high in arousability had larger EMG and EDR responsivity to loud stimuli. It has also been validated against stress-related physical symptoms (Hicks, Conti, & Nellis, 1992). Those that rated themselves having high arousability also reported more stress-related symptoms and poorer health.

For the participant sample, 57 participants were recruited based on the cutoff scores (see below) of the APS and CFQ and on the absence of smoking, any known neurological, physiological (specifically hearing or heart problems) and psychological disorders (specifically claustrophobia because of the soundproof chamber), skin allergies, and prescription medications. For EMG and HR, four participants were eliminated due to equipment failure or experimenter error (recording failure) and one because of hearing problems (see criteria for hearing below). Participants scoring below a 30 on the APS and
above a 46 on the CFQ were difficult to obtain; only two men and two women qualified out of 286 college students and therefore were not included in analysis of the SR.

The 48 remaining participants, 21 men and 27 women, compiled three groups: (1) Low APS/Low CF (below 30 on APS and below 42 on CFQ; n=16, 8 men, 8 women) - those who reported neither being easily aroused nor easily distracted; (2) High APS/High CF (above 36 on APS and above 46 on CFQ; n=16, 7 men, 9 women) - those who reported being both easily aroused and easily distracted and; (3) High APS/Low CF (above 36 on APS and below 42 on CFQ; n=16, 6 men, 10 women) - those who reported being easily aroused but not easily distracted. Means and standard deviations are reported in Table 1 below. T-tests showed there were no significant differences between men and women.

Table 1
Arousal Predisposition Scale (APS) and Cognitive Failures Questionnaire (CFQ): Means, standard deviations and t tests (p < .05) comparing men and women

<table>
<thead>
<tr>
<th>Group</th>
<th>Total</th>
<th>Men</th>
<th>Women</th>
<th>t tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>Low APS</td>
<td>25.26</td>
<td>2.95</td>
<td>16</td>
<td>25.88</td>
</tr>
<tr>
<td>High APS</td>
<td>39.61</td>
<td>3.01</td>
<td>32</td>
<td>39.91</td>
</tr>
<tr>
<td>Low CFQ</td>
<td>33.52</td>
<td>4.11</td>
<td>32</td>
<td>33.64</td>
</tr>
<tr>
<td>High CFQ</td>
<td>50.64</td>
<td>7.89</td>
<td>16</td>
<td>50.50</td>
</tr>
</tbody>
</table>

It is of interest to note that an adequate fourth group, Low APS/High CF, was not obtained from this sample. This could be due to the possibility that the APS and CFQ questionnaires are related. Thus, there does not appear to be many people within the college population who report high cognitive failures and low arousal. Research from both questionnaires suggest that stress may be a contributing factor, so, for example, those that are experiencing stress may experience greater arousal levels (Hicks et al., 1992) and that stress may interfere with implementation strategies used in day to day living (Merckelbach et al., 1996). Because the group High APS/Low CF was adequately obtained, this suggests that either stress is not necessary to report high arousal or that stress does not necessarily interfere with the report of cognitive failures.
Main Procedure

Qualifying participants were contacted by telephone after the screening and provided with detailed information of the study in which they were asked to participate. They were told that the entire procedure would last approximately 50 minutes. It was explained that the experimenter desired to understand how individuals differ in physiological reactivity by monitoring both heart rate and electrical muscle activity around the left eye area while they would be presented with several short, loud bursts of loud noise. Care was taken to inform the potential participants that such short, loud bursts of noise do not cause any damage to the auditory system and such methods are used quite frequently in medical, physiological and psychological studies. (Noise that does cause damage must be over 100 dB and for a longer duration). It was then explained that because of the physiological measurements it was important that they not have alcohol or caffeine in their system, which can affect heart rate and muscle tone. Participants were asked to refrain from for at least four hours prior to the experiment, and from alcohol consumption and over the counter medication 24 hours prior to the experiment. They were asked to wear a loose fitting shirt for the placement of the electrode to the stomach (see below).

All participants arrived at the laboratory between noon and 6:00 p.m. with the mean time being 3:00 p.m. Upon arrival they were shown the sound attenuated room and the equipment used. It was explained that the sound would be routed by the computer and would be monitored by the experimenter. Special care was taken to assure the participants that they could withdraw at any time during the experiment without any penalty. The subject was shown the areas on which the electrodes were to be placed. Questions were answered honestly and openly but without mention of the word "startle". They then read and signed a consent form (see Appendix D).

The participants were seated in a 40 dB constant Industrial Acoustic Co. sound attenuated room. To make sure that there were no hearing deficiencies, hearing in both ears
was checked separately with a Qualitone Acoustic Appraiser Audiometer. The rejection criteria for participants' hearing for 1500 Hz was below 10 dB for each ear.

In accordance with FDA regulation and the company's suggestions, electrodes used in the experiment were sanitized prior to application. The experimenter wore rubber gloves during cleaning and application of electrodes in order to insure against transmission of human germs and diseases. Because the oils in the skin impede the electrical conductance to the electrode, the areas of electrode placement were cleaned in a standardized manner with cotton and Nuprep, a mild cleansing lotion used for electrode application, and then with an alcohol swipe. For Orbicularis oculi EMG assessment, one 1 cm Ag/Ag electrode was placed 1 cm below the outer commissure of the eye fissure and another 1 cm Ag/Ag electrode placed 1 cm medial to and slightly inferior to the first (Fridlund & Cacioppo, 1986; refer back to Figure 2). For a ground, an electrode was placed on the center of the forehead. For heart rate assessment, a Lead II placement was used in which one 1.5 cm Ag electrode was placed just below the left clavicle and another was placed on the left arm. To avoid any uneasiness, the subject placed the third electrode to the right of the navel. Impedance was less than 5 kohms.

The participant waited while a 30 second baseline HR recording was made. The participant was then instructed to put on the headphones and sit still looking at the checkerboard poster in front of them while they were presented with the two calibration startle probes. There were a total of fourteen startle probes presented to each participant. The first two calibration startle probes with a 25 sec ISI were given to allow for SR recording calibration to be made (see below) and to allow for participants to become familiar with the procedure. There were two counterbalanced conditions of six startle probes with an averaged 40 sec ISI, ranging from 38 sec to 42 sec. Both conditions lasted four minutes.

After a two minute rest period, for the attend condition participants were told: "Please pay attention to the characteristics of the noise that you will hear over the headphones. To
help you pay attention to the sounds, count how many of them there are and when we come back in the room we will ask you to describe the sound, report how many of them there were, and report if they got louder, softer or stayed the same. Keep your eyes on the checkerboard in front of you until we come back in the room." Afterward, the door was opened and subjects were asked to describe the sound, how many of them there were and if they got louder, softer or stayed the same.

After a two minute rest period, for the ignore condition participants were told: "Please ignore the sounds as best as you can. To help you ignore the noise we would like you to do a mental task of counting backwards by threes as continuously as possible so you can pay attention to that and ignore the sounds. First, practice out loud so you can get used to the task: start with 50 and subtract by 3's out loud until I say stop (timed for approximately 20 sec). OK, when I close the door you can begin to do the same task in your head, not out loud, to help you ignore the noise. This time, start with the number 500 and subtract by 3's. Afterwards, I will ask you to report the number you have reached. Keep your eyes on the checkerboard in front of you until we come back in the room." This task is similar to the 50-3 mental math task used by Roland and Friberg (1985). Afterward, the door was opened and subjects were asked what number they reached.

After removing electrodes and headphones, while still in the sound attenuated room, participants were given the Stroop Color-Word Interference task (Trenerry, et al., 1989). First, they were given a Color list with the words of colors printed in colors that did not match color of the words (e.g. a word spelled "green" was printed in blue ink and they said "green"). They were instructed to read the written words aloud starting at the top of the page and going down the columns until the experimenter said stop. They were instructed that if they made a mistake they could correct it and go on. Trenerry, et al. (1989) indicate that the first list, although not interpreted, is given with the premise that it primes the participant for the second list. Secondly, the participants were given a Color-Word list similar to the first. They were instructed to read aloud the color that the word was printed
in (thereby ignoring the written word) starting at the top of the page and going down the columns until the experimenter said stop (e.g. a word spelled "green" was printed in blue ink and they said “blue”). They were instructed that if they made a mistake they could correct it and go on. Participants were given 1 min 20 sec to read each list.

Participants were debriefed about the experiment (i.e., they were told that the present study was examining a phenomenon called the startle response). They were asked several questions about past startle experience and evaluation of their startling in the lab (See Appendix E).

Experimental Stimuli

Startle probes produced by an Audio Generator were 96 dB SPL (relative to .0002 dynes/cm²) white noise bursts with immediate rise time and gated by a PC noise program to be 50 msec in duration. The probes were amplified by the S82-24 Coulbourn Audio Mixer-Amplifier. A lead into the input port of the L19-01 Coulbourn High Speed Videograph I/O Port allowed for digital representation of the startle probe presentation. The probes were presented binaurally through Qualitone mono headphones. To insure consistency of the dB level of the startle probes, just before each participant was run, the dB 307 Memologger was used to test the dB level of the white noise. The door to the sound proof chamber was closed and the sound input cable of the Memologger was placed directly over a headphone noise output. If the noise level was above or below 96dB, adjustments on the S82-24 Audio Mixer-Amplifier were made until the white noise reached 96dB.

Measurement

The Orbicularis Oculi integrated EMG signal was amplified by the S75-01 Coulbourn Bioamplifier with filters passing 90-250 Hz recorded at a gain of 1000. The signal was then directed into the S76-01 Coulbourn Contour Following Integrator using a 20 msec time constant. The EMG signal was directed to the input port of the L19-01 Coulbourn High Speed Videograph I/O Port allowed for digital representation of EMG. The signal was digitally sampled every msec and stored on a Gateway 2000 computer.
For heart rate, the three electrodes led into the S77-26 Coulbourn Tachometer and were directed into the S75-07 Coulbourn Direct Coupled Bioamplifier, recorded at a gain of 5000. The signal was directed to the input port of the L19-01 Coulbourn High Speed Videograph I/O Port allowed for digital representation of the R wave. The signal was digitally sampled every msec and stored on a Gateway 2000 computer.

Data Analysis

All methods of SR analysis described below were adapted from Blumenthal and Goode (1991) and Blumenthal and Levey (1989). Dependent measures analyzed were startle response probability, onset latency, and amplitude (refer to Figure 4 below), heart rate and the Stroop Color-Word Interference task.

Startle response probability. Response probability was determined as the number of actual SRs divided by the number of possible SRs. If there was an absence of EMG phasic response within the 20-100 msec window, i.e. a microvolt change less than 20 arbitrary units, then it was noted that a SR did not occur.

Startle response latency. Latency was determined as the time between the peak response onset (within the 20-100 msec window) and stimulus onset. Peak response onset was the point of response at which the EMG stopped increasing and was followed by at least 15 msec of no further EMG increase. If more than 15 msec passed and a second peak of greater EMG was found, it was assumed to be a second independent response and thus was not scored as the peak EMG. If less than 15 msec passed and a second peak of greater EMG was found, then it was scored as the peak EMG (See Figure 4). For each condition, the response latencies were added and the total was divided by the number of responses to result in a mean latency.

Startle response amplitude. To control for individual differences in baseline EMG activity, response amplitude was determined as the difference between baseline EMG at 19 msec after stimulus onset and EMG at peak of response. If a second peak of greater EMG occurred 15 msec after the first peak then it was assumed to be a second, independent
response and thus was not scored as the peak (See Figure 4). With some participants, if the first two calibration probes indicated that the SR amplitude was too high for recording, the Bioamplifier gain was decreased and noted (starting with 100% gain and reducing accordingly). After scoring each response amplitude, if a gain change had been made during calibration, then the gain change was corrected for by dividing the response amplitude by the actual gain used during recording which then resulted in the corrected microvolt value. For each condition, the corrected microvolt values were added and the total was divided by the number of responses which resulted in a mean microvolt amplitude.

![Graph showing a peak with amplitude and latency](image)

**Figure 4: Example of Integrated EMG Startle Response signal**

**Heart rate.** HR was recorded five seconds before and after each startle probe. Three R wave interbeat intervals (IBI) were averaged separately before and after each startle probe and then added and the total was divided by the number of startle probes in a condition to give an averaged pre and an averaged post IBI for each startle probe. The formula for both the pre and post IBI was: \((\text{Time at 4th R wave} - \text{Time at 1st R wave})/#\) of IBI. (Each Pre IBI added)/# of startle probes = Av. Pre IBI. The same formula was used for the Post IBI. To achieve normalized percent change of the R wave pattern after startle probe presentation, for each startle probe the averaged post interbeat interval was divided by the averaged pre interbeat interval and then 1 was subtracted. A positive number indicated a HR deceleration
and a negative number indicated a HR acceleration. The formula for calculating accelerations and decelerations for each startle probe was: \((\text{Av. Post IBI/Av. Pre IBI}) - 1 = \% \text{ change}\).

Stroop Color-Word Interference task. The Stroop Color-Word Interference task was given to 52 participants (High CF = 29, 11 men and 18 women, Low CF = 23, 14 men and 9 women). The Color List was administered but scores were not interpreted (Trenerry, et al., 1989). The Color-Word List was administered and scores were determined as the number of colors that were correctly stated, or the number of items completed minus the incorrect responses. Participants had 80 seconds for each list.

RESULTS

Startle Response: Group and Sex

Data were analyzed in separate repeated measure analysis of variance (p < .05) for each dependent variable. The Greenhouse-Geisser adjustment to degrees of freedom (Geisser & Greenhouse, 1958) was used to correct for failures to satisfy the circularity assumption. (No corrections were needed for any statistical results). Post hoc comparisons of significant differences between more than two means were analyzed with Fischer's Least Significant Difference.

The individuals from three groups that were compared on orbicularis oculi startle response probability, amplitude and latency were chosen on the basis of scores of the Arousal Predisposition Scale (APS; Coren, 1990) and the Cognitive Failures Questionnaire (CFQ; Broadbent, et al., 1982). Three groups were compared: Low APS/Low CF, High APS/High CF and High APS/Low CF. Separate repeated measures ANOVAs were made for the hypothesized group interactions. Subsequent repeated measures ANOVAs were conducted to include sex as a factor. Low and high APS and low and high CF were compared separately in additional repeated measures ANOVAs.
Startle Response Probability

Response probability was 100% for all participants except two who were both from the Low APS/Low CF group. Those two participants, one man and one woman, both had 83% response probability for the ignore condition. Since response probability was 100% for all participants except two, there were no differences between groups or conditions.

Startle Response Amplitude

To assess the mean response amplitude, a 2 X 3 (condition X group) mixed design ANOVA with repeated measures for condition was conducted. There were no main effects for condition, F (1,45) = .30, or group, F (2,45) = .73. There was a nonsignificant trend for the condition X group interaction, F (2,45) = 2.69, p < .08. Refer to Figure 5 below.

![Image of bar chart](image)

**Figure 5:** Startle response mean amplitude - Differences in Attend and Ignore Conditions across three groups differing in arousability and attention (with standard error bars)

Since we had hypothesized specific group differences, contrast comparisons on the means revealed that only two of these groups, the High APS/High CF and the High APS/Low CF were significantly different from each other, F (1,45) = 5.34, p < .05.
When comparing these two groups, a 2 X 2 (condition X group) repeated measures ANOVA revealed there were no main effects for group, $F(1,30) = .02$ or condition, $F(1,30) = .27$. However, there was a significant group X condition interaction, $F(1,30) = 4.43, p < .05$ (refer to Figure 6 below). To assess possible differences between conditions across groups, Fischer’s Post Hoc revealed that there were no significant differences between Attend conditions. There were also no significant differences between Ignore conditions. An examination of the difference scores of the mean amplitude between the Attend and Ignore conditions revealed a main effect for group, $F(1,30) = 4.43, p < .05$ (refer to Figure 7 below). As hypothesized, the High CF group had a larger mean amplitude in the Ignore condition whereas the Low CF group had a larger mean amplitude in the Attend condition.
Figure 6: Startle response mean amplitude - Differences in Attend and Ignore Conditions across two groups differing in attention.

Figure 7: Difference score of startle response mean amplitude between Attend and Ignore Conditions across two groups differing in attention. + value indicates that the mean amplitude in the ignore is smaller than in the attend; - value indicates that the mean amplitude in the ignore is larger than in the attend.
Repeated measures 2 X 2 (condition X group) ANOVAs for the hypothesized
group comparison of High APS/Low CF and Low APS/Low CF group revealed
nonsignificant main effects for group, F (1,30) = .45, and condition, F (1,30) = .90 as
well as nonsignificant condition X group interaction, F (1,30) = 1.45. Repeated measures
2 X 2 ANOVAs for the hypothesized group comparison of High APS/High CF with Low
APS/Low CF group revealed nonsignificant main effects for group, F (1,30) = .56, and
condition, (1,30) = 2.09 as well as a nonsignificant condition X group interaction, F (1,30)
= 1.56.

When sex was included as an additional factor, a 2 X 2 X 3 (condition X sex X
group) mixed design ANOVA with repeated measures for condition was conducted. There
were no significant main effects for sex, F (1,42) = 1.98, group (2,42) = .20, or
condition, F (1,42) = .19. There were no interaction effects for sex X group, F (2,42) =
.25, condition X sex, F (1,42) = 2.37, condition X group, F (2,42) = 2.37 or condition X
sex X group, F (2,42) = .47.

Startle Response Latency

To assess the mean startle response latency, a 2 X 3 (condition X group) mixed
design ANOVA with repeated measures for condition was conducted. There were no main
effects for condition, F (1,45) = .01, or group, F (2,45) = .49. There was no significant
interaction for condition X group, F (2,45) = .34.

When sex was included as an additional factor, a 2 X 2 X 3 (condition X sex X
group) mixed design ANOVA with repeated measures for condition was conducted. There
were no significant main effects for sex, F (1,42) = .17, group, F (2,42) = 1.25, or
condition, F (1,42) = .03. There were no interaction effects for sex X condition, F (1,42)
= .99, group X condition, F (2,42) = .52, or condition X sex X group, F (2,42) = 1.26.
There was a significant interaction for sex X group, F (2,42) = 5.02, p < .01; as shown in
Figure 8 below.
Figure 8: Startle response mean latency - Differences between men and women in Attend and Ignore Conditions across three groups differing in arousability and attention

Contrast comparisons between the means revealed that men of the Low APS/Low CF group had slower mean onset latency than women of the same group, F (1,42) = 4.71, p < .05. Contrarily, men in the High APS/High CF group had faster mean onset latency than women of the same group, F (1,42) = 5.12, p < .05. Furthermore, those men from both of the High APS groups had faster mean onset latency than did the women of both groups, F (1,42) = 4.01, p < .05.

Separate repeated measures ANOVAs for men only revealed a group main effect, F (2, 18) = 8.00, p < .01, but not for women, F (2,24) = .76 (refer to Figure 8 above). Fischer’s Post Hoc revealed the mean onset latency of the men from the Low APS/Low CF to be significantly slower than that of the men from the other two groups (p < .05).

Further contrast comparisons on the means revealed that men in the Low APS/Low CF
group had significantly slower onset latency than the men from the High APS/High CF group, F (1,18) = 16.00, p < .001.

Startle Response: Cognitive Failures and Sex

Startle Response Amplitude

Low and High Cognitive Failures participants, collapsed across arousal level, were compared on mean startle response amplitude. A 2 X 2 (condition X group) mixed design ANOVA with repeated measures for condition was conducted. There were no significant main effects for condition, F (1,46) = 1.49 or group, F (1,46) = .08. As shown in Figure 9, there was a significant interaction between condition and group, F (1,46) = 4.43, p < .05. Fischer's Post Hoc revealed that, contrary to the hypotheses, there were no significant differences between attend conditions for groups and there were no significant differences between ignore conditions for groups. As hypothesized, an examination of the difference score between the mean amplitude of the Attend and Ignore conditions revealed that High CF participants had a larger mean amplitude during the Ignore condition and the Low CF had a larger mean amplitude during the Attend condition, F (1,46) = 4.45, p < .05 (refer to Figure 10).
Figure 9: Startle response mean amplitude - Differences in Attend and Ignore Conditions across two groups differing in attention.

Figure 10: Difference score of startle response mean amplitude between Attend and Ignore Conditions across two groups differing in attention.  + value indicates that the mean amplitude in the ignore is smaller than in the attend; - value indicates that the mean amplitude in the ignore is larger than in the attend.
When sex was included as a factor, a 2 X 2 X 2 (sex X group X condition) repeated measures ANOVA revealed no significant main effects for sex, F (1,44) = 1.40. There were no significant interactions for sex X condition, F (1,44) = 2.55, or sex X group X condition, F (1,44) = .45.

**Startle Response Latency**

To examine mean startle response latency, a 2 X 2 (condition X group) ANOVA with repeated measures for condition was conducted. There were no significant main effects for group, F (1,46) = 1.72, or condition, F (1,46) = .04. There was no interaction effect for condition X group, F (1,46) = .65.

When sex was included, a 2 X 2 X 2 (condition X group X sex) repeated measures ANOVA was conducted and revealed that there was no significant main effect for sex, F (1,44) = 1.33. There were no significant interaction effects for condition X sex, F (1,44) = .21 or condition X group X sex, F (1,44) = 1.82. There was a significant interaction for group X sex, F (1,44) = 6.10, p < .01 as shown in Figure 11 below. Contrast effects on the means revealed that High CF men had significantly faster onset latency than High CF women, F (1,44) = 4.92, p < .05. High CF men had significantly faster onset latency than Low CF men, F (1,44) = 7.60, p < .01, whereas women did not differ significantly from each other, F (1,44) = .37.
Figure 11: Startle response mean latency - Differences between men and women in Attend and Ignore Conditions across two groups differing in attention

Startle Response: Arousal and Sex

Startle Response Amplitude

Low and High Arousal Predisposition participants were collapsed across CFQ and were compared on mean startle response amplitude. A 2 X 2 (condition X group) mixed design ANOVA with repeated measures for condition was conducted. There were no significant main effects for condition, F(1,46) = .18, group, F(1,46) = .64 or condition X group interaction, F(1,46) = .04.

When sex was included as a factor a 2 X 2 X 2 (sex X group X condition) repeated measures ANOVA showed a nonsignificant main effect for sex, F(1,44) = 1.85. There were no significant interaction effects for sex X group, F(1,44) = .00, condition X sex, F(1,44) = 2.07 or sex X group X condition, F(1,44) = .19.

Startle Response Latency

When a 2 X 2 (condition X group) ANOVA with repeated measures for condition was examined, there were no significant main effects for group, F(1,46) = .63, or
condition, \( F(1,46) = .07 \). There was no significant interaction effect for group X condition, \( F(1,46) = .32 \).

When sex was included a 2 X 2 X 2 (sex X group X condition) repeated measures ANOVA was conducted. It revealed that there was no significant main effect for sex, \( F(1,44) = .28 \). There were no significant interaction effects for sex X condition, \( F(1,44) = .01 \), or sex X group X condition, \( F(1,44) = .00 \). As shown in Figure 12 below, there was a significant interaction effect for arousal group X sex, \( F(1,44) = 8.87, p < .01 \). Contrast effects on the means revealed that Low APS men had slower onset latency than Low APS women, \( F(1,44) = 4.68, p < .05 \). High APS men had faster onset latency than High APS women, \( F(1,44) = 4.38, p < .05 \). High APS men had significantly faster onset latency than Low APS men, \( F(1,44) = 7.724, p < .01 \) but women did not differ significantly from each other, \( F(1,44) = 1.93 \).

![Figure 12: Startle response mean latency - Differences between men and women in Attend and Ignore Conditions across two groups differing in arousability](image)

Heart Rate: Group and Sex

Two participants were eliminated from this analysis due to observed irregular heart beat patterns. For the remaining 46 participants, acceleratory patterns were observed in
78% of the sample during the attend condition and in 65% during the ignore condition. A 2 X 2 X 3 (sex X condition X group) ANOVA with repeated measures was conducted with the dependent variable being the difference score of the averaged pre- and post-interbeat intervals. There were no significant main effects for sex, F (1,40) = .29, condition, F (1,40) = .19, or group, F (2,40) = 1.66. There were no significant interactions for condition X sex, F (1,40) = 3.15, condition X group, F (2,40) = .23, or sex X condition X group (2, 40) = .81.

The Stroop Effect: Cognitive Failures, Arousal and Sex

The Stroop Color-Word Interference scores were compared in a 2 X 2 X 2 (Cognitive Failures X Arousal X Sex) ANOVA. (This was possible because 52 subjects were run, four of which were Low Arousal/High CF). Contrary to the hypothesis, no significant main effects were found for Cognitive Failures group, F (1,44) = .51 (refer to Table 2 below). Other main effects were also nonsignificant for Arousal group, F (1,44) = .22, and sex, F (1,44) = .52. No significant interactions were found for sex X Arousal, F (1,44) = 2.13, for sex X Cognitive Failures, F (1,44) = 1.40, for Cognitive Failures X Arousal, F (1,44) = .05, or for Sex X Cognitive Failures X Arousal, F (1,44) = .77.

Table 2
Low and High Cognitive Failures (CFQ): Stroop Color-Word Interference scores, means and standard deviations

<table>
<thead>
<tr>
<th>Group</th>
<th>M</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low CFQ</td>
<td>83.24</td>
<td>10.20</td>
<td>29</td>
</tr>
<tr>
<td>High CFQ</td>
<td>80.52</td>
<td>15.29</td>
<td>23</td>
</tr>
</tbody>
</table>
DISCUSSION

Overall, the startle response (SR) as measured by mean amplitude and mean latency was not differentially impacted by the attend and ignore conditions. Only when individual differences in sex, distractibility level or arousability level were considered did differences of SR amplitude and latency emerge. The results of this study showed that physiological responsivity as assessed by the mean SR amplitude was moderated by self reported individual differences in attentional processing when attention was directed towards and away from the startle probes. The mean SR onset latency was found to be moderated by both attention and arousal only when sex was included as a factor. Individual differences in attentional processing did not moderate responses on the Stroop Color-Word Interference task.

Cognitive Failures Made a Difference

Individuals who were easily distractible (High Cognitive Failures) showed different SR amplitudes than did those who were not easily distractible (Low Cognitive Failures) in the conditions of ignore and attend, as evidenced by a significant interaction between groups and condition. As shown in Figures 9 and 10, High CF participants showed a greater SR amplitude when ignoring the stimulus whereas Low CF participants showed greater SR amplitude when attending to the stimulus. The extent to which individuals react to sudden, intense external stimuli is moderated by the degree to which they are distractible. In other words, if an individual is not easily distracted, then he might startle less when he is involved in a task and more when he is expecting to be startled. Whereas, an individual who is easily distracted might show the opposite pattern: when he is involved in a task he might startle more and when he is expecting to be startled he might startle less.

From a neuroanatomical interpretation of top-down controlled processing, Skinner and Yingling (1977) proposed that the suppression of "irrelevant responses" could occur due to "prefrontal activation of GABA-ergic neurons in the thalamic reticular nucleus, thus inhibiting the thalamo-cortical transmission of sensory activity" (Blenner & Yingling,
1994, p.146). Previous research has been successful in providing some support for this hypothesis. For example, people with prefrontal lesions are easily distractible and cannot inhibit responses to irrelevant stimuli (Blenner & Yingling, 1994).

Brunia (1993) has extended the Skinner and Yingling selective attentional hypothesis of fronto-thalamic sensory gating to include the motor system. Thus, he proposed that motor preparation and selective attention have similar mechanisms. In support of this extension of the hypothesis, populations with hypothesized Supervisory Attentional System (SAS) dysfunction, such as schizophrenics (Dawson, et al., 1993) have been shown to have abnormal SR. In a preliminary study (Goldstein & Blumenthal, 1995), children with attentional deficit disorder, a disorder also thought to be associated with SAS dysfunction, were found to show faster onset latency than controls. This latter example is of particular relevance to the findings in the present study that High CF men resembled those with attentional deficit disorder in that they had significantly faster overall onset latency than High CF Women and Low CF Men\(^5\). However, because four of the seven children with attentional deficit disorder also were diagnosed with posttraumatic stress disorder, future research needs to more systematically address if those with attentional deficit disorder have more facilitated SR. Furthermore, it would be of interest to examine if there is a relationship between cognitive failures and attention deficit.

Moreover, conclusions reached about the effectiveness of the directed attention manipulations and their relationship to attentional processing can only be tentative because, contrary to the hypotheses, no single group showed significant differences between the attend and ignore conditions. Besides using a self report screening or possible experimenter error, another explanation is that the instructions to ignore were relatively weak. Strong suggestions to ignore were not given. Also, the task of counting back by threes might not have been engaging enough to be considered a foreground modality.

\(^5\) One possible reason men and women differed in SR latencies could have been attributed to men in one group, (i.e. High CF) scoring significantly different from women in that same group. Post hoc t-tests (p < .05) revealed that within groups, men and women did not differ from each other on the CFQ (refer to TABLE 1).
different from that of the acoustic startle probes. If a more absorbing mental task had been required of the participants, perhaps more attenuating effects would have been found among the low distractible participants and not the high distractible participants.

As reported earlier, several studies have found that directing attention to a modality other than that of the startle probe can cause SR attenuation (Anthony, et al., 1978; Hackley & Graham, 1983) and directing attention to a modality that is the same as the startle probe can cause SR facilitation (Bohlin & Graham, 1977; Anthony, 1985). However, Simons and Zelson (1985) found that simply directing attention to a stimulus of another modality did not in and of itself produce attenuation, the foreground needed to be interesting, as in the case of the nude photos. Also, Blumenthal and Flaten (1994) found that directing attention to another modality, in this case to a tactile stimulus given to the hand, actually caused startle response facilitation. The present study suggests eliciting SR attenuation or facilitation might not only be a function of the direction of attention, but also be related to the degree to which individuals allocate their attention.

Of particular relevance to the present findings is Wegner's (1994) theory of "ironic processes of mental control" which states that when most people try to consciously suppress a thought they invariably think more about it than they would have otherwise. For example, when participants were instructed to suppress thoughts about a white bear they actually showed more preoccupation with white bears than before they were given the instructions. This "rebound effect" might provide an alternative interpretation of the effects found with Low and High CF. For example, the Low CF participants showed the typical pattern of having an attenuated SR amplitude when directing attention away from the startle probes. However, the High CF participants showed the opposite pattern - the amplitude during the ignore condition actually was facilitated. Thus, it is possible that those who were easily distractible, when instructed to ignore the probes, actually showed the "rebound effect" and attended more to them. The same may be said of the participants from the Blumenthal and Flaten (1994) study who also had a facilitated acoustic SR when given
instructions to ignore the startle probes and attend to the tactile modality. Perhaps the instructions to ignore caused a rebound effect and participants attended to the startle probes instead. It would be of interest if future research addressed this issue of “ironic processes of mental control” in relationship to the startle response.

Although Cognitive Failures Questionnaire (CFQ) scores were reflected by differences in mean SR amplitudes when condition was included, unlike prior research conducted by Tipper and Baylis (1987), the CFQ scores were not reflected by differences of scores on the Stroop Color-Word Interference task. One potential confound is that the present study did not employ the same Stroop test as Tipper and Baylis. Another reason for this lack of replication may be a methodological one. In their study, only after performing the Stroop task did participants complete the CFQ. In the present study, the CFQ was administered prior to, and on a different day from, the Stroop Color-Word Interference task. Thus, in the present study Stroop Color-Word Interference effect scores were not grouped post hoc on based performance of the CFQ. The participants from the former study may have experienced demand effects or experimental bias in that they might have rated themselves on the CFQ based upon their perception of how well they did on the Stroop task.

In light of these findings, it is possible that more attenuation of the SR during the ignore condition was not found amongst Low CF individuals due to the nature of relying on a self report to determine high and low attention. It is possible that a more objective behavioral measure of focused attention, such as a test of hypnotizability, might have been more adequate in obtaining individuals who were more extreme in their attentional abilities (Crawford, Brown, & Moon, 1993). High hypnotizables are thought to possess greater abilities of focused attention and inhibition than lows (Crawford, et al., 1993; Crawford, Gur, Skolnick, Gur & Benson, 1993). To explore the possible effects that individual differences in selective attention might have on auditory processing, the N1 and P2 amplitude and latency components of the event-related potentials of low and high
hypnotizables were examined (Crawford, Corby, & Kopell, 1996). Participants were presented with 50 msec pure tones with decibel levels ranging from 50-80. During ignore conditions, low hypnotizables showed higher N1 and P2 amplitudes and shorter latencies at higher intensities than highs. This suggests that low hypnotizables are not as efficient at filtering out irrelevant information or that, conversely, highs give "less attentional allocation to the irrelevant stimuli" (Crawford, et al., 1996).

Presently, we are assessing individual differences of the SR by using different manipulations of directed attention with participants who have indeed been screened for high and low hypnotic susceptibility on two standardized measures. Such research needs to be conducted to more conclusively determine the extent to which top-down controlled processing may or may not mediate the brain stem startle reflex.

Arousal Made a Difference

Self reported arousal levels did not appear to be directly related to the effects of directed attention on SR. This was surprising because Coren and Mah (1993) used acoustic stimulus parameters that were classified as startle probe parameters (two second durations of 105 dB white noise). Perhaps no differences were found between Low and High Arousal participants because the stimuli we used were less intense (50 msec durations of 96 dB white noise). Another possibility is that for their study, the participant sample constituted the top and bottom 15% of the screened population, thus individuals were more extreme in their arousability levels than those in the present study.

However, there was one significant finding which suggests that self-reported arousal level was related to the SR. As shown in Figures 6 and 7, the High APS/High CF showed facilitated mean SR amplitude during the Ignore condition and the High APS/Low CF showed facilitated mean SR amplitude during the Attend condition. On the other hand, the Low APS/Low CF group did not differ between conditions. The High APS/Low CF group might be seen as being more similar to the Type As who showed more SR attenuation during task performance than did Type Bs (Simons & Zelson, 1985). Type As
are also considered to have higher arousal levels than Type Bs. Taken together, these findings provide very weak support for the idea that arousal and attentional processes interact (Posner, 1993; Posner, & Peterson, 1990; Pribram & McGuinness, 1992): Without a higher level of arousal, direction of attention does not influence the SR. With a higher level of arousal, the direction of attention does influence the SR, except that the level of attentional processing interacts with arousal to produce different outcomes. Future research should manipulate arousal levels and the direction of attention to more accurately assess this interaction.

**Sex Made a Difference**

Mean startle response latency but not mean amplitude was found to be moderated by sex. Unlike the Latah of Southeastern Asia, women did not exhibit significantly more overall startling than men. However, as shown in Figures 11 and 12, when looking at the dimensions of attention and arousal separately, it became apparent that men were more extreme in their onset latency than women. Highly distractible men responded faster than highly distractible women even though they did not differ significantly on their CFQ scores (refer to TABLE 1). Similarly, highly arousable men responded faster than highly arousable women. Furthermore, men who were not easily arousable responded more slowly than women who were not easily arousable. When conditions of directed attention were included in analysis, this effect between men and women disappeared. One possible reason men and women differed in SR latencies could have been attributed to men and women within one group (i.e. men and women in the Low APS group) scoring significantly differently on the self-report questionnaires. Post hoc t-tests (p < .05) revealed that men and women did not differ from each other on the APS or the CFQ (refer to TABLE 1).

Swerdlow, et al. (1993, 1995) systematically evaluated human sex differences in the laboratory. Overall, they found that men had significantly more prepulse inhibition than women. These men may be more similar to the Low APS and Low CF men in our study.
who responded significantly slower than the women. In accordance with the present study, they also did not find sex differences on the Stroop task (Swerdlow, et al., 1995).

Simons (1985, 1996) indicated that Latah are usually women. Hyperstartlers in the West are also often found to be women. He speculated that this could be due in part to social differences in status and marginalization such that women are more vulnerable to being “teased”. He also speculated that hormonal biological differences between men and women could contribute to sex differences. From a biopsychosocial perspective, sex differences in SR could be attributed to an interaction of biological differences and social status differences (in which women might have collectively different SR histories than men).

In the present study, many participants, when discussing the SR in the post-experimental interview, indicated that the only person in the family whom they ever noted as having an exaggerated startle response was the mother. The ethnographic research of the Latah points to the issue of the development of SR facilitation. Latah are known to be able to even startle themselves (by turning their head suddenly and shouting "eh") in order to continue their Latah role (Simons, 1985; 1996). Indeed, an interesting study (Hamm & Stark, 1993) examined the effects of aversive conditioning on the SR only among women participants. Vibrotactile shocks were paired with one type of visual stimuli (positive, negative or neutral) but not with a second set of visual stimuli (positive negative or neutral). Regardless of whether the CS was positive, negative or neutral, women showed a facilitated SR (amplitude and response probability) when they were exposed to the CS+ but not to the CS-.

In American society, adolescent boys also are known for playing the “flinching” game in which they get punished (punched) if they flinch (Simons, 1985). A similar development of SR inhibition was revealed to me by two participants from the Low APS/Low CF group, both of whom happened to be the only two participants with 83% response probability. One participant said she learned to control her SR because her older
siblings enjoyed scaring her. The other participant said he could control his SR because of bicycle racing; it was not adaptable for him to be startled by a competitor who came up suddenly on him or in other circumstances when it was necessary to react very quickly. Thus, the role of SR histories appears to be relevant when discussing individual differences and should be examined in future research.

Conclusion

The present study suggests that overall startle onset latency was a function of sex differences, with low arousable and low distractible men exhibiting slower responding and high arousable and high distractible men exhibiting faster responding. When the conditions of directed attention were included, differences between men and women were no longer evident. However, the conditions of directed attention resulted in mean amplitude differences between those with low and high attentional abilities. This suggests that individual differences of attention may interact with the direction of attention and these processes may be reflected by the acoustically elicited SR.

Taken together, future research needs to address more systematically the issues of controlled top-down processing, its interaction with arousal, startle response histories and sex differences as they relate to the startle response. Presenting startle probes to low and highly hypnotizable subjects may be one strategy to further address the theory of controlled top-down processing. The present findings indicate that there is a need to determine if a possible relationship exists between cognitive failures and attention deficit disorder. Also, it would be of interest if future research addressed how the “ironic processes of mental control” and instructions of directed attention related to the SR. Future research should manipulate arousal levels and the direction of attention to more accurately assess the interaction between the two dimensions. Furthermore, it is of vital importance that future research examine the role of past SR experience as it relates to individual

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6 Blumenthal (personal communication, 1996) has indicated that the two components of the startle response, latency and amplitude, are considered to be independent. Future research needs to address their function.
differences. Understanding if and how individuals develop extreme startle responses has promising applicative potential.
REFERENCES


Appendix A - Cognitive Failures Questionnaire (Broadbent et al., 1982)

The following questions are about minor mistakes which everyone makes from time to time, but some of which happen more often than others. We want to know how often these things have happened to you in the last six months. Please indicate frequency where \textit{Never}=0 and where \textit{Always}=4:

\begin{tabular}{cccc}
\textbf{Never} & \textbf{Almost} & \textbf{Occasionally} & \textbf{Almost} & \textbf{Always} \\
0 & 1 & 2 & 3 & 4 \\
\end{tabular}

1. Do you read something and find you have not been thinking about it and must read it again?

2. Do you find you forget why you went from one part of the house to the other?

3. Do you fail to notice signposts on the road?

4. Do you find you confuse right and left when giving directions?

5. Do you bump into people?

6. Do you find you forget whether you’ve turned off a light or the stove or locked the door?

7. Do you fail to listen to people’s names when you are meeting them?

8. Do you say something and realize afterwards that it might be taken as insulting?

9. Do you fail to hear people speaking to you when you are doing something else?

10. Do you lose your temper and regret it?

11. Do you leave important letters unanswered for days?

12. Do you find you forget which way to turn on a road you know well but rarely use?

13. Do you fail to see what you want in a supermarket (although it’s there)?

14. Do you find yourself suddenly wondering whether you’ve used a word correctly?

15. Do you have trouble making up your mind?

16. Do you find you forget appointments?

17. Do you forget where you put something like a newspaper or a book?

18. Do you find you accidentally throw away the thing you want and keep what you meant to throw away—as in the example of throwing away the matchbook and putting the used match in your pocket?

19. Do you daydream when you ought to be listening to something?

20. Do you find you forget people’s names?
21. Do you start doing one thing at home and get distracted into doing something else (unintentionally)?

22. Do you find you can’t quite remember something although it’s ‘on the tip of your tongue’?

23. Do you find you forget what you came to the shops to buy?

24. Do you drop things?

25. Do you find you can’t think of anything to say?
Appendix B - Arousal Predisposition Scale (Coren, 1990)

The following questions are to assess your overall reactions to events. Please indicate how you react to these events by filling in the appropriate number on your answer sheet, using the following scale where Never=1 and where Always=5:

<table>
<thead>
<tr>
<th>Never</th>
<th>Almost</th>
<th>Occasionally</th>
<th>Almost</th>
<th>Always</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

1. I am a calm person.
2. I get flustered if I have several things to do at once.
3. Sudden changes of any kind produce an immediate emotional effect on me.
4. Strong emotions carry over for one or two hours after I leave the situation which caused them.
5. I am restless and angry.
6. My mood is quickly influenced by entering new places.
7. I get excited easily.
8. I find that my heart keeps beating fast for a while after I have been "stirred up."
9. I can be emotionally moved by what other people consider to be simple things.
10. I startle easily.
11. I am easily frustrated.
12. I tend to remain excited or moved for a long period of time after seeing a good movie.
Appendix C - Consent Form [Screening]

TITLE OF EXPERIMENT: Individual Differences in Cognitive Styles

1. PURPOSE OF EXPERIMENT

You are invited to participate in a group prescreening for a study that is examining how people differ in regards to their cognitive styles. A series of questionnaires taking less than one hour will be administered. Some of you may be invited to come to a subsequent study.

2. PROCEDURE TO BE FOLLOWED IN THE STUDY

You will come to the assigned room at the assigned hour and complete the questionnaires given to you. The process should take less than an hour. The questions will ask you about styles of information processing.

3. ANONYMITY OF SUBJECTS AND CONFIDENTIALITY OF RESULTS

Your participation in this study will be kept strictly confidential. At no time will the researchers release your results to anyone without your prior written consent. Your names will be removed from the forms and will be coded only with an identification number that the experimenter assigns.

4. DISCOMFORTS AND RISKS FROM PARTICIPATING IN THE STUDY

There are no risks to you from participating in this study.

5. BENEFITS OF THIS STUDY

Your participation in this study will greatly help advance the knowledge of the variables that may influence individual differences in cognitive styles. You may receive one extra credit towards your psychology course. Please check with your instructor for alternative ways by which you may receive extra credit in the course.

6. FREEDOM TO WITHDRAW

You may skip questions you do not want to answer and you are free to withdraw from this study at any time and still receive full credit.

7. USE OF RESEARCH DATA

The information from this study may be used for scientific or educational purposes. It may be presented at scientific meetings and/or published or reproduced in professional journals or books, or used for any other purpose that Virginia Tech's Department of Psychology considers proper in the interest of education, knowledge or research.

8. APPROVAL OF RESEARCH

This research project has been approved by the Human Subjects Committee of the Department of Psychology and by the Institutional Review Board of Virginia Tech. All subjects involved in any part of this project will receive written consent forms in which will be detailed all aspects of the study in which they are participating.
9. SUBJECT'S PERMISSION

I have read and understand the above description of the study. I have had an opportunity to ask questions and have had them all answered. I hereby acknowledge the above and give my voluntary consent for participation in this study.

I understand that if I participate I may withdraw at any time without penalty.

I understand that should I have any questions regarding this research and its conduct, I should contact any of the persons named below:

Primary Researcher: Lyla J. Kaplan 951-1925
Research Advisor: Helen J. Crawford, Ph.D. 231-6520
Chair, Human Subjects Committee: R. Eisler, Ph.D. 231-7001
Chair, Institutional Review Board: Ernest Stout, Ph.D. 231-6077

SUBJECT'S SIGNATURE

SUBJECT'S I.D.

DATE EXPERIMENTER

You will receive a copy of this form
Appendix D - Consent Form [Main Procedure]

TITLE OF EXPERIMENT: Individual Differences of Physiological Reactivity

1. PURPOSE OF EXPERIMENT

You are invited to participate in a study about how people differ in regards to their physiological reactivity. We will look at your heart rate and your muscle tone under your left eye. This data will be correlated with questionnaires that you previously filled out.

2. PROCEDURE TO BE FOLLOWED IN THE STUDY

Six sterilized electrodes will be placed on your body, three for measuring the muscle tone and three for measuring the heart rate. For the muscle tone, two electrodes will be placed under your left eye and the third on your forehead. For the heart rate, one electrode will be placed about two inches to the right of your belly button, one electrode will be placed just below your clavicle bone on the left side (this is the long bone that goes across from shoulder to shoulder). The third electrode will be placed on your left arm. You will then put on earphones and sit back comfortably in the chair.

You will be alone in a room with a window for about 15 minutes the experimenter is outside of the room. There will be three conditions during which you will be occasionally presented with a very short, loud burst of static noise. Before the conditions, the experimenter will provide some information. Afterwards, you be asked several questions about the study and you will be given a brief task to perform. The whole process should take no longer than an hour.

3. ANONYMITY OF SUBJECTS AND CONFIDENTIALITY OF RESULTS

Your participation in this study will be kept strictly confidential. At no time will the researchers release your results to anyone without your prior written consent. The data will be coded only with an identification number that the experimenter assigns.

4. DISCOMFORTS AND RISKS FROM PARTICIPATING IN THE STUDY

There are few, if any, risks to you from participating in this study. Doctors, physiologists and psychologists have widely accepted the use of this short, loud noise that you will hear (with a specific duration and decibel level) and they report that there is no risk to your hearing. Before the study the experimenter will check the systems to make sure the settings did not change. During the study, the experimenter will monitor the noise on the computer monitor to insure that there is no deviation from the settings. If, for any unforeseen reason there is a deviation, the experimenter will immediately terminate the study and you will receive full credit for participating.

In regards to electrode application, adherence to FDA regulations will be maintained, such as using only sterilized electrodes, wearing rubber gloves during application of the electrodes and disposing of applicators, such as cotton or swabs, immediately after use. These steps insure against transmission of any human germs or diseases. Using standardized procedures, your skin will be cleaned with Nuprep, a mildly abrasive skin lotion, and wiped with alcohol. This cleanses your skin of oils that would otherwise prevent the natural electrical conductance from your skin to reach the silver part of the electrode. An electrode gel is then dabbed into the electrode before placement in order to bridge the gap between your skin and the electrode.
Consent form, Main procedure, continued

5. BENEFITS OF THIS STUDY

Your participation in this study will greatly help advance the knowledge of the variables that may influence individual differences in physiological reactivity. You may receive one extra credit towards your psychology course. Please check with your instructors for alternative ways by which you may receive extra credit in the course.

6. FREEDOM TO WITHDRAW

You are free to withdraw from this study at any time and still receive full credit.

7. USE OF RESEARCH DATA

The information from this study may be used for scientific or educational purposes. It may be presented at scientific meetings and/or published or reproduced in professional journals or books, or used for any other purpose that Virginia Tech's Department of Psychology considers proper in the interest of education, knowledge or research.

8. APPROVAL OF RESEARCH

This research project has been approved by the Human Subjects Committee of the Department of Psychology and by the Institutional Review Board of Virginia Tech. All subjects involved in any part of this project will receive written consent forms in which will be detailed all aspects of the study in which they are participating.

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Chair, Institutional Review Board: Ernest Stout, Ph.D. 231-6077

SUBJECT'S
SIGNATURE__________________________________________________________

SUBJECT'S
I.D._______________________________________________________________

DATE______________EXPERIMENTER____________________________________

You will receive a copy of this form
Appendix E - Post-experimental questions

1. What were the noises like?

2. Do you startle a lot in general [or not very much at all]?

3. What do you do when you are startled (behaviors, movements, etc)?

4. Would you describe it as a more [less] exaggerated response than you have observed in others?

5. What are you doing when you are most easily startled?

6. How long have you [not] been easily startled?

7. Why do you think you [do not] startle?

8. Are there other members of your family or friends that startle easily [or don't at all]?

9. What do you think startles you the easiest, for example, a noise, a flash of light, a touch?

10. Do you have any phobias or intense fears?
Lyla Kaplan
Curriculum Vitae

Educational History

8/94 - present  Virginia Polytechnic Institute and State University
Graduate student, Ph.D. program in Psychology

1989 - 93  Ohio State University - Honors Arts and Sciences
Russian and Personalized Study Program "Cultural Psychology"
Graduated with Honors and with Distinction in December, 1993

1992 summer  Moscow State University
Russian language program

8/88 - 8/89  Rotary International Exchange Student
Esternato High School
Pindamonhangaba, Sao Paulo, Brazil

Research and Professional History

7/96 - present  Biocynernaut Institute
Supervisor - Dr. Jim Hardt
Neurofeedback technician

8/94 - 6/96  Virginia Polytechnic Institute and State University
Research Assistant funded by NASA Langley, PI Helen Crawford, Ph.D.
EEG data collection and analysis

Virginia Polytechnic Institute and State University
Research Assistant funded by NIH, PI Helen Crawford, Ph.D.
EEG and evoked potential data collection and analysis, and hypnosis

1995 summer  Center for Behavioral Medicine, Radford Community Hospital
Internship with Dr. Bruce Walker
Assisted with pain interview of biofeedback candidates,
collected EMG for biofeedback

1995 summer  Montgomery Regional Hospital
Observed various brain imaging techniques - MRI, CT and nuclear medicine

1/93 - 6/93  Ohio State University
Research Assistant in psycholinguistics, PI Mark Pitt, Ph.D.

2/87 - 6/87  Ohio State University, Newark
Research Assistant in Social Psychology - Dr. John Skowronske
Mentorship program for gifted and talented students

Teaching History

8/94-6/96  Virginia Polytechnic Institute & State University
Teaching Assistant of Introductory Psychology
1994 summer  Columbus City Department of Parks and Recreation
    Taught arts and crafts

11/92 - 12/93  Ohio State University, Minority Affairs: Office of Retention Services
    Tutor - Psychology and Anthropology introductory courses

1/89-4/89  Yazigi in Pindamonhangaba, Brasil
    English teacher

Honors and Awards

1996  Milla Alihan Scholarship, Society for Clinical and Experimental Hypnosis

1995  Graduate Student Association Grant for Master Thesis, Virginia Polytechnic Institute & State University

1994  Arts & Sciences Grant for Honor Thesis, Ohio State University

1992  Nominated for Pushkin Award, Ohio State University

1989  Banc Ohio award for best pottery

1988  Governor's award for pottery

Presented papers:


**Published papers:**


[Signature]
April 22, 1997